5.0 Surface Flow and Flooding, Subterranean (Groundwater) Flow and Land Stability

The following document has been prepared by Soiltechnics Environmental & Geotechnical Consultants in accordance with the requirements of CPG4. The content is as follows, giving section numbering as used within Soiltechnics's Report.

	Section
Site History	3.1
Geology and Geohydrology	3.2
Quarrying and Mining	3.3
Flood Risk	3.4
Ground Investigation	4.0
Ground Movements	5.0
Screening and Scoping	11.0 - 14.0

Proposed basement and extension
44 Goldhurst Terrace
Hampstead
London
NW3 3HT

BASEMENT IMPACT ASSESSMENT REPORT Rev02

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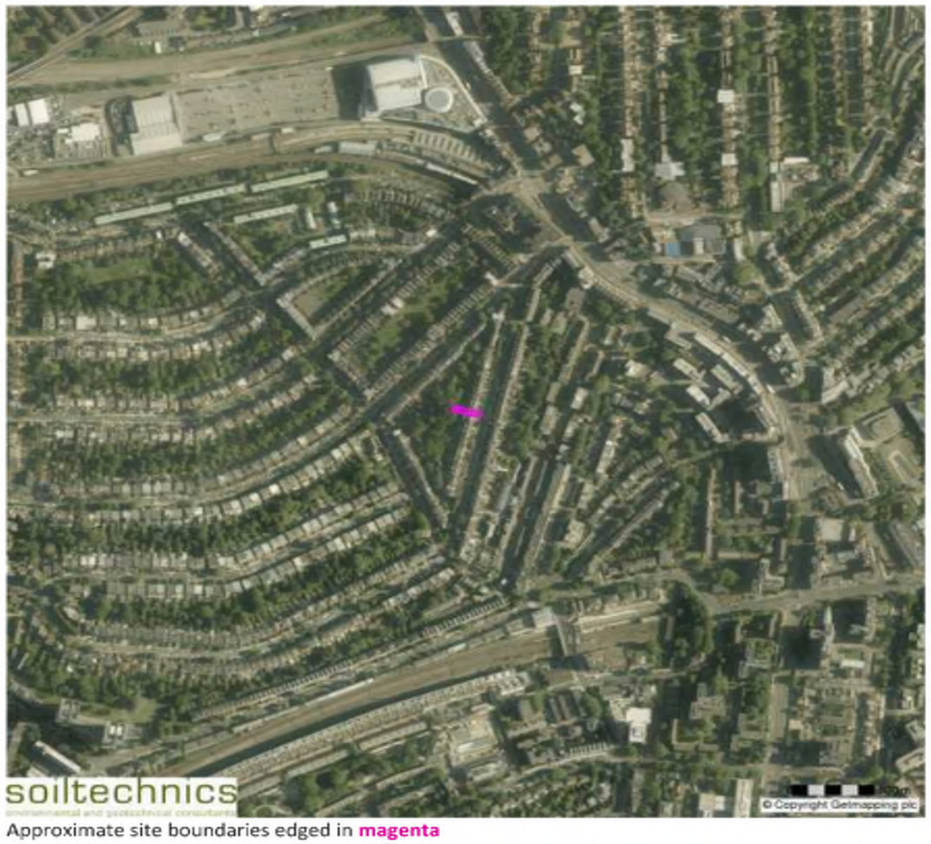
Proposed basement and extension,
44 Goldhurst Terrace, Hampstead

soiltechnics
environmental and geotechnical consultants

Aerial photograph of site



Approximate site boundaries edged in **magenta**

Report status and format

Report section	Principal coverage	Report status	
		Revision	Comments
0	Contents page		
1	Introduction and brief		
2	Description of the property and project proposals		
3	Desk study information and site observations		
4	Ground Investigations		
5	External ground movements around the basement	02	Revised following comments from client
6	Hardened areas		
7	Tree removal	01	Revised following comments from client
8	Existing damage to adjacent buildings		
9	Railway tunnels		
10	Summary of screening		
11	Subterranean (groundwater flow) screening	02	Revised following comments from client
12	Stability impact identification		
13	Surface flow and flooding impact identification		
14	Summary and Conclusion	01	Revised following comments from client

List of drawings

Drawing	Principal coverage	Status	
		Revision	Comments
01	Site location plan		
02	Plan showing existing site features, development proposals and location of exploratory points		
03a	Plan showing estimated contours of inward yielding as a result of basement excavations		
03b	Plan showing estimated contours of settlement at surface as a result of basement excavations		
04	Plot summarising insitu density testing		
05	Section showing construction of ground water monitoring standpipe installed in borehole DTS01 and subsequent groundwater monitoring records		

List of appendices

Appendix	Content
A	Copy of drawings provided by Architect / Engineers illustrating proposal
B	Copy of CV of Nigel Thornton and examples of Soiltechnics commissions on basement investigations and analysis
C	Copy of comments on this report by Chartered Geologist
D	Borehole records (driven tube sampling techniques)
E	Trial pit records
F	Copy of calculations to estimate stain and resultant likely categorisation of damage to adjacent properties resulting from basement excavations
G	Copy of historical maps produced by Envirocheck
H	Arboricultural Survey produced by Quaife Woodlands

Proposed basement and extension,
44 Goldhurst Terrace, Hampstead

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1 Introduction and brief

1.1 Objectives

1.1.1 This report presents a Basement Impact Assessment (BIA) for a proposed basement at 44 Goldhurst Terrace, Hampstead, London.

1.1.2 The principal objective of the assessment is to present evidence to support a planning application for the project as required by Camden Planning Guidance (CPG4) *'Basements and lightwells'*.

1.1.3 This report is final based on current instructions. This report is Revision 02 following amendments requested by the client.

1.1.4 00 to 01 – Revised following comment by our client. Revised sections changed within Revision 01 are indicated by a vertical line in the left-hand margin – as shown here.

1.1.5 01 – 02 – Revised following additional comments by our client following their own initial consultation with Camden Borough Council. Revised sections changed within Revision 02 are indicated by a dashed vertical line in the left-hand margin – as shown here.

1.2 Client instructions and confidentiality

1.2.1 This report has been produced following instructions received from Solid Geometry on behalf of our mutual clients; Ayelet Aperling and Nir Agam.

1.2.2 This report has been prepared for the sole benefit of our above named instructing clients, but this report, and its contents, remains the property of Soiltechnics Limited until payment in full of our invoices in connection with production of this report.

1.3 Author qualifications

1.3.1 This report is final based upon current instructions. The report has been reviewed by a Chartered Civil Engineer, (C.Eng., M.I.C.E) who is also a Fellow of the Geological Society (FGS) and a practising Civil Engineer with specialist experience (35 years) in geotechnical engineering (including basement construction), flood risk and drainage. The report has also been reviewed by a Chartered Geologist who is a geologist and hydrogeologist who has a BSc. in geology from the University of Bristol, a MSc. in hydrogeology from the University of East Anglia and who has been a hydrogeologist for 20 years.

1.4 Guidance used for scoping exercise

1.4.1 As described in paragraph 1.1.2 above we have followed Camden Planning Guidance (CPG4) *'Basements and lightwells'*, and Camden geological, hydrogeological and hydrological study report *'Guidance for subterranean development,'* produced by Arup on behalf of the London Borough of Camden. We have also referred to the

'Strategic Flood Risk Assessment Report for North London' dated August 2008 prepared by Mouchel, as well as other readily available information on websites. This report has considered all four stages of the BIA process as described in CPG4. This report has also been prepared to satisfy the following parts of Camden's policy DP27, on basements and lightwells:

a) Maintain the structural stability of the building and neighbouring properties;

b) Avoid adversely affecting drainage and run-off or causing other damage to the water environment;

c) Avoid cumulative impacts upon structural stability or the water environment in the local area;

1.4.2 In order to satisfy part a) a construction method statement has been prepared by a Structural Engineer which will be separately presented.

1.5 Format of this report in relation to CPG4

1.5.1 Sections 3 to 9 of this report describe project proposals and present desk study and investigation data, information required to answer flow chart questions posed in figures 1, 2 and 3 of CPG4. Answers for these flow chart questions are provided in Sections 10 to 12.

2 Description of the property and project proposals

2.1 Description of the property

2.1.1 The site is currently occupied by a four-storey terraced dwelling, comprising lower ground floor level, ground floor and two floors above within an urban area of Hampstead. Based on inspection of old Ordnance Survey maps the building was probably constructed in the late 1800s. The building is situated toward the east of the plot with front access from Goldhurst Terrace and rear garden to the west. External paved areas are located to the front/east and to the west within the garden area. General topographical levels fall in a southerly direction.

2.2 Project proposals

2.2.1 It is understood that the property does not yet have the benefit of planning permission for a basement extension beneath the development. The proposal is for a single-storey deep basement across the existing building footprint, and extending slightly into the rear garden area. The proposed scheme will include lightwells to the front and rear of the property.

2.2.2 Underpinning will be required to perimeter load bearing walls to the existing building and new foundations below the existing lower ground floor allowing basement excavation.

2.2.3 Copies of our client's Engineer's drawings showing project proposals outlining construction details are presented in Appendix A.

3 Desk study information and site observations

3.1 Site history

3.1.1 Review of Ordnance Survey and London town maps dating back to 1870s indicate the property and immediately surrounding properties were first recorded on the 1896 map. Properties fronting Fairhazel Gardens to the west were first recorded in 1915. Extract copies of key mapping is presented below with property position defined by the magenta marker. The full set of historical maps are presented in Appendix G.

Extract copy of 1871 map

Extract copy of 1896 map

Extract copy of 1915 map

3.1.2 At this stage it is important to note there are no water courses recorded on the 1871 map close to the property, and no evidence of any opencast quarrying activities in the locality.

3.2 Geology and geohydrology of the area

3.2.1 Geology of the area

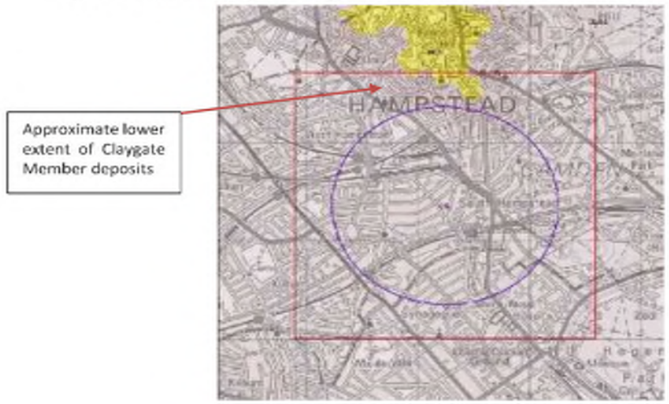
3.2.1.1 Inspection of the geological map of the area published by the British Geological Survey (BGS) indicates the following sequence of strata. The thickness of the strata has been obtained from a combination borehole record data formed within 500m of the property available on the BGS website, and geological sections shown on the BGS map.

Summary of Geology and likely aquifer containing strata					
Strata	**Bedrock or drift**	**Approximate thickness**	**Typical soil type**	**Likely permeability**	**Likely aquifer designation**
London Clay Formation	Bedrock	80	Clays	Low	Unproductive strata
Lambeth Group	Bedrock	15	Clays, occasionally sands	Low	Unproductive strata
Thanet Sands	Bedrock	10	Fine sands	Low/moderate	Secondary Aquifer
Chalk	Bedrock	200	Chalk	High	Principal Aquifer

Table 3.2.1.1

3.2.1.2 Soil types and assessments of permeability are based on geological memoirs, in combination with our experience of investigations in these soil types.

3.2.1.3 An extract copy of the geological map is presented below, with grey shading representing the outcrop of the London Clay Formation. Claygate beds are recorded at crop in the north however, these are a component member of the London Clay Formation and the colouration on the map extract below is not easily distinguished. Yellow represents Bagshot Beds (on higher ground to the north). The property position is shown by the magenta marker.



3.2.1.4 Based on the above any excavations within the property will be located within London Clays.

3.2.2 Geohydrology

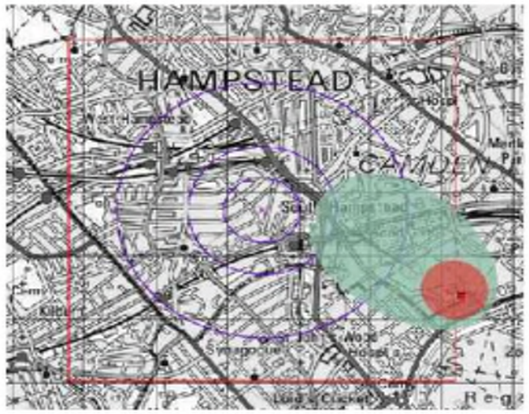
3.2.2.1 The Environment Agency website reports the London Clay Formation deposits (bedrock) at the site are designated Unproductive Strata.

3.2.2.2 Unproductive Strata are defined as deposits exhibiting low permeability with negligible significance for water supply or river base flow. Unproductive Strata are generally regarded as not containing groundwater in exploitable quantities.

3.2.2.3 Chalk is classified a Principal Aquifer. Principal aquifers are defined as deposits exhibiting high permeability capable of high levels of groundwater storage. Such deposits are able to support water supply and river base flows on a strategic scale.

3.2.3 Source protection zone

3.2.3.1 The site is not recorded as being within a source protection zone. The nearest source protection zone is recorded located within a source protection zone 2 (outer zone) 335m to the east. An extract of the plan recording source protection zones is presented below, with green shading representing outer protection zones and red inner protection zones.



3.2.3.2 This abstraction will be from the Chalk aquifer located at least 100m below the property. The basement extending to about 3.5m below lower ground floor levels in London Clays and will have no influence on the underlying strata including the Chalk aquifer.

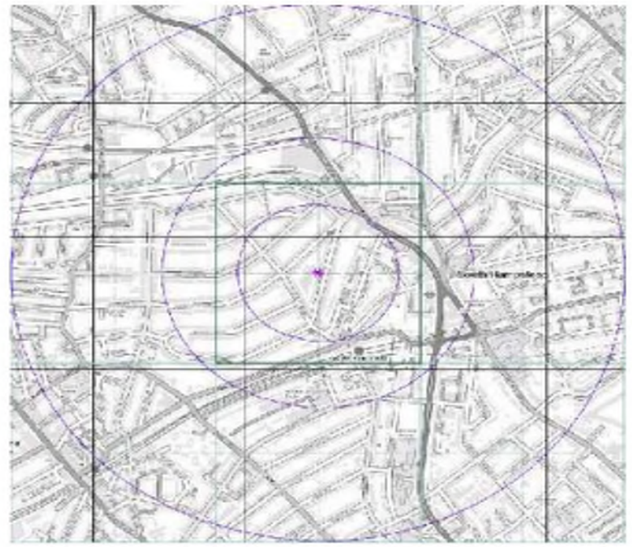
3.3 Quarrying/mining

3.3.1 With reference to the coal mining and brine subsidence claims gazetteer for England and Wales, available on the Coal Authority web site, the area has not been subject to exploitation of coal or brine. Inspection of old Ordnance Survey maps dating back to the first editions (late 1800s) does not record any quarrying activities within 250m of the property.

3.4 Flood risk

3.4.1 Fluvial/tidal flooding

3.4.1 Envirocheck report the site is not located within a fluvial or tidal flood plain. An extract copy of the flood risk map is presented below which shows no blue shading representative of flooding. The property is located centrally and outlined in magenta.



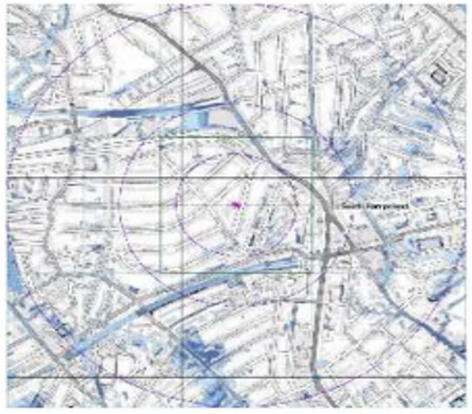
3.4.2 Flooding from Reservoirs, Canals and other Artificial Sources

3.4.2.1 The Environment Agency website indicates the site is not located within an area considered at risk of flooding from breach of reservoir containment systems. An extract copy of the flood risk map is presented below which shows no blue shading representative of flooding as a result of failure of containment systems close to the site. The property location is marked in red.

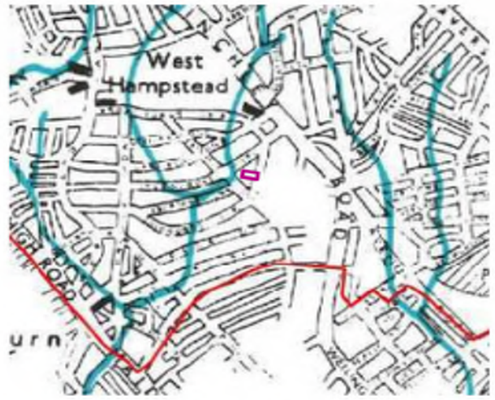
3.4.3 Flooding from Groundwater and surface waters

3.4.3.1 The site is underlain with a substantial thickness (80m) of relatively impermeable London Clay Formation. On this basis groundwater is not likely to be available at the site and thus is unlikely to present a risk of causing groundwater flooding.

3.4.3.2 We have reviewed information presented by Envirocheck, which provides maps showing areas at risk of flooding from surface waters. An extract of the map is presented below. The property is located within the magenta square and blue shading represents areas at risk of surface water flooding. The property is located in an area not considered to be at risk from surface water flooding (with at risk areas indicated by light blue shading).



3.4.3.3 An extract of figure 11 from the Camden Geological, Hydrogeological and Hydrological Study (referenced in Section 1.4) is presented below. The blue lines show the locations of branches of former streams in the area. The property is located within the magenta box and seems to be within close proximity to an upper branch of the West Bourne.



3.4.3.4 With reference to old mapping of the area described in section 3.1 above, the 1871 map (predevelopment) does not record any water courses close to or within the immediate area of the property. Development of London has resulted in original watercourses being culverted, with culverts following, in the majority of cases, road infrastructure routes.

3.4.3.5 There is a 965 x 610 sewer in Goldhurst Terrace recorded on Thames Water Asset register, an extract copy of which is presented below. The sewer follows a south-westerly route from the property and leads toward a 1626 x 1067 culvert in Fairhazel Gardens to the south-west, which could house the West Bourne upper branch described in 3.4.3.2 above.

3.4.3.6 An extract of figure 15 from the Camden Geological, Hydrogeological and Hydrological Study (referenced in Section 1.4) is presented below (property marked with a magenta box). The site is not located within an area considered to have the potential to be at risk of surface water flooding. The map does however record Goldhurst Terrace has been subject to flooding within the streets in 2002 only.

3.4.3.7 The cause of the surface flooding is not identified, but assumed to be related to severe weather in August.

3.4.3.8 We also note that a 125mm below ground water supply pipe operated by Thames Water in Goldhurst Terrace to the east of the property is reported to have ruptured (see below), further surface water pipes in the local area have also ruptured which could have contributed to localised surface water flooding.

3.4.3.8 With the supply having ruptured, it is likely that remedial works have been undertake to limit future flooding as the result of ruptures in the potable water supply system in the immediate area.

3.4.4 Conclusions

3.4.4.1 The evidence presented demonstrates the property is not at an enhanced risk of being affected by tidal or fluvial flooding. The site is not shown as an area at risk of surface flooding and no flooding events were recorded save that noted occurring in 2002. The EA data that the maps are based on includes the period up to July 2010. Assuming that remedial works have been undertaken since the previously recorded rupture to the local water supply as anticipated, in our opinion, the property is unlikely to be at enhanced risk of flooding due to exceedances in the capacity of sewers. The risk from artificial sources cannot be discounted however and we advise that this is considered in the detailed drainage design of the proposed development.

4 Ground investigations

4.1 Scope

4.1.1 One borehole has been excavated at the property; in the rear garden area, to 5.75m depth. One hand dug trial pit was also excavated externally to expose foundation arrangements to the house in the vicinity of the proposed basement. The fieldwork positions were determined by our Client's Structural Engineer.

4.1.2 Fieldwork records are presented in Appendix C. Drawing 02 (also presented in Appendix C) shows the location of the exploratory points.

4.2 Ground conditions encountered

4.2.1 The borehole (excavated on 21st August 2017) encountered Made Ground to 1.1m overlying naturally deposited London Clay Formation. The London Clays essentially comprised firm, medium strength light brown silty clay to around 2.0m. Beyond this depth the London Clay became high strength, brown mottled light grey silty clay. No groundwater or seepages were observed within the London Clay.

4.2.2 The investigations confirmed published geological maps for the near surface geology.

4.3 Existing foundations.

4.3.1 The trial pit excavation exposed brickwork foundations to the house extending to 0.75m below ground levels constructed on London Clays. Full details are provided in our ground investigation report (ref STP4034B-G01).

4.4 Summary of basement retaining wall design parameters

4.4.1 The following table provides soil parameters for foundation design purposes

Parameter	Value	Origin
Presumed bearing value for underpin L section (as proposed) assuming 1m wide base (temporary scenario)	110kN/m²	Based on undrained shear strength measurements and section of underpinning
Critical state angle of shearing resistance	22°	Based on plasticity measurements and with reference to BS8002:2015
Earth pressure at rest (London Clay)	1	CIRIA report C760 (over consolidated clays)
Earth pressure at rest (Made Ground)	0.65	CIRIA report C760 (normally consolidated clays)
Characteristic weight density of soils above the groundwater table	17-20kN/m³	Derived from BS8002:2015
Plastic index range	46-49	Measured
Moisture content	30-33%	Measured

5 External ground movements around basement

5.1 Construction proposals

5.1.1 It is understood that the property does not yet have the benefit of planning permission for a basement extension beneath the development. The proposal is for a single-storey deep basement across the existing building footprint, and extending slightly into the rear garden area, resulting in an excavation of around 3m deep. Our client's Structural Engineer proposes to underpin load bearing walls to the existing building and install new foundations outside the existing building footprint.

5.1.2 It is noted that there are several proposed basements in the surrounding areas that already have the benefit of planning permission or are currently in the process of applying for such permissions. The nearest of these is located at No 58 Goldhurst Terrace, some 40m south. As such none of the proposed basements in the area are considered likely to impact upon the stability of the proposed basement at the property in question and are not considered as part of the following analysis.

5.2 Settlement around and inward yielding of basement excavations

5.2.1 The following analysis is based on observations of ground movements around basement excavations in clays as reported in Tomlinson 'Foundation design and construction' (seventh Edition) and CIRIA report C760; 'Guidance on embedded retaining wall design' (2017).

5.2.2 It is recognised that some inward yielding of supported sides of strutted excavations and accompanying settlement of the retained ground surface adjacent to the excavation will occur even if structurally very stiff piles and props / strutting is employed. The amount of yielding for any given depth of excavation is a function of the characteristics of the supported soils and not the stiffness of the supports.

5.2.3 Based on observations for excavations in over consolidated clay soils (which will be the case at this site) the average maximum yield / excavation depth (%) as reported by CIRIA C760 is 0.15%. Assuming an excavation depth of 3.4m then the likely inward yield will be in the order of 3.4 x 0.15/100 x1000 = 5.1mm. Coincidental with the inward yield of the embedded piles, some settlement of the retained soils around the excavation will occur. Again, based on published observations, the ratio of surface settlement to excavation depth in stiff, over consolidated clays is about 0.1% (following CIRIA C760). Adopting then 0.1%, and a 3.4m deep excavation, then surface settlement in the order of 3.4 x 0.1/100 x 1000 = 3.4mm will occur. Importantly, whilst some surface settlement will occur around the excavation, this settlement profile will extend for a distance of up to 4 times the depth of excavation in a reasonably linear fashion. Clearly there will be some variation in this based on the variation in ground conditions and as reported values are based on observations within excavations in excess of 8m deep, but have adopted in the absence of current published data for shallow excavations.

5.2.4 Whilst it is acknowledged that settlement and inward yielding movement observations are generally for embedded piled or diaphragm retaining walls, we are not aware of any published observational data for underpinning walls and insitu concrete retaining walls, but consider a propped embedded piled wall would afford more onerous movements. The value of making a finite element analysis to determine the amount of inward yielding of excavation supports in all routine cases of basement excavations is questionable, requiring estimates of soil moduli and other factors such as poisons ratio.

5.2.5 Engineering appraisal (Analysis of ground movements due to construction of basement and prediction of damage on adjacent (nearby) buildings)

5.2.5.1 In view of the radial influence of stiff clays, we have considered the effect of surface settlement (as differential settlement) on panels of masonry forming facades to adjacent properties, subject to the most significant potential movements. We have determined panel sizes from estimate measurements based on site reconnaissance. Assuming the panel of masonry is rectangular and ignoring the effects of openings, but allowing for possible movement joints, we have determined strains on the diagonal and horizontal and thus established damage categories with reference to Burland's Table 6.4 in CIRIA report C760. Our calculations are presented in Appendix E.

Extract copy of Burland's classification of damage (extract from CIRIA report C760)

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain, ε_{lim} (%)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible	<0.1	0.0 to 0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection	<1	0.05 to 0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weather tightness. Doors and windows may stick slightly.	<5	0.075 to 0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable lining. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weather tightness often impaired.	5 to 15 or a number of cracks >3	0.1 to 0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Services pipes disrupted.	15 to 25, but also depends on number of cracks	>0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	Usually >25, but depends on numbers of cracks	

Notes
1 In assessing the degree of damage, account must be taken of its location in the building or structure.
2 Crack width is only one aspect of damage and in most cases it should not be used on its own as a direct measure of it.

5.2.6 Prediction of damage on adjacent highways/footpath

5.2.6.1 The pedestrian footpath for Goldhurst Terrace is located 4m distant from the eastern face of the proposed basement. In view of the radial influence of stiff clays (ref Drawing 03), we have considered the effect of surface settlement on the pedestrian footway. With reference to 5.2.3 above, we anticipate surface settlement, which will reach a maximum of say 3.4mm at the excavation face, will decrease in a reasonably linear fashion, extending away from the basement excavation. We thus anticipate a maximum potential surface settlement at the footpath adjacent to 44 Goldhurst Terrace to be in the region of 2.4mm, reducing further toward the east. Such movement will not result in damage to the existing pathway.

5.2.7 Conclusion and risk reduction

5.2.7.1 Adjacent structures and buildings will be affected to by basement excavations, potentially resulting in damage which could fall into Burland's Category 1 (very slight).

5.2.7.2 Such damage is considered very minor, but in order to limit this risk of damage to adjacent (neighbouring) properties, it is proposed to monitor inward yielding (horizontal movement) of basement walls (retaining walls) which will be propped with adjustable props. If horizontal movement exceeds 5mm (considered unlikely) then props will require adjustment to compensate for this movement and maintain potential damage to adjacent properties within damage Category 1/0. It should be noted that monitoring (and subsequent compensatory works as descibed above) will negate the effects of worst case inward yield movements.

5.2.7.3 In addition to the above and with reference to CIRIA report C760 Section 6.5, there are a number of prescribed protective measures, which generally fall into six broad groups:

- Strengthening of the ground (eg by means of grout injection, by pin piles or by ground freezing)
- Strengthening of the building to safely sustain the additional stresses or accommodate deformations induced by ground movements.
- Structural jacking.
- Underpinning.
- Installation of a physical barrier between the building and the excavation to modify and reduce ground movements adjacent to and beneath the building.
- Compensation grouting.

5.2.7.4 Based on proposed temporary construction works the above protective measures are unlikely to be applicable.

5.2.7.5 Damage to the existing footpath as the rersult fo the basement excavtion is again considered to be negligable (<3mm).

6 Hardened areas

6.1 We understand there will be an increase in hardened and drained areas resulting from the extension of the basement into the rear and front garden areas. The property is underlain with a substantial thickness of relatively impermeable London Clay, which is not amenable to disposal of stormwater using soakaways. We understand that drainage proposals will be developed in detail during technical design of the project.

Proposed basement and extension,
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7 Tree removal

7.1 No major vegetation will be removed to accommodate the extension of the building. The existing shrubbery group will be retained the front garden area which includes a cherry, laurel and mahonia up to 4m in height. We understand these will be pruned to accommodate construction of the basement. A number of trees are present on adjacent land to the west of the property which comprise sycamore tress up to 15m in height and a silver birch, 16m high. (Tree species and heights are based on information provided within the arboricultural report for the site, ref AR/3684/rg undertaken by Quaife Woodlands in May 2017).

7.2 It is likely that foundation arrangements to the subject property and the attached houses at 42 and 46 Goldhurst Terrace will be similar on the basis that the houses were constructed at the same time with foundations constructed on fine grained (cohesive) soils which will exhibit plasticity. The volume of plastic soils will change with changes in water content. Changes in water content are promoted by seasonal weather conditions but also water demands of trees.

7.3 Following National House Building Standards (chapter 4.2) which provides a good guide to the influence of trees on plastic soils, a sycamore tree is classified as moderate water demand and the theoretical root radius of such a tree is 75% of its theoretical mature height i.e. 0.75 x 22m = 16.5m. The closest sycamore trees (T1 and T2 as outlined on drawing AR/3684/rg produced by Quaife Woodlands) are 11m from the proposed western extent of the basement to 44 Goldhurst Terrace and 15m from the existing western elevation. On this basis, if the sycamore trees are left to reach mature height, new foundation will need to extend to a depth of 1.3m below ground in accordance with NHBC Standards Chapter 4.2. The proposed basement founding levels greatly exceed this and are therefore beyond the zone of shrinkage caused by the trees.

7.4 Again following National House Building Standards (chapter 4.2) a cherry tree (considered worst case scenario for the tree cluster to the front of the property) is classified as moderate water demand and the theoretical root radius of such a tree is 75% of its height (where the tree has not reached 50% of its theoretical maximum height) i.e. 0.75 x 4m = 3m. Again, it is possible that the cherry could reach a mature height of 12m and thus have a future theoretical root radius of 9m. The trees are located within 2m of the front elevation of the 44 Goldhurst Terrace. Following NHBC Chapter 4.2 and based on current height (4m) foundations will need to extend to a depth of 1.3m to extend beyond the zone of shrinkage and swelling. If left to grow to 50% of the maximum theoretical height (more than 6m) the foundations will need to extend in excess of 1.75m to extend beyond the zone of shrinkage and swelling. The proposed basement will extend significantly beyond this depth.

8 Existing damage to adjacent buildings

8.1 We are not aware of any subsidence damage to existing buildings.

9 Railway Tunnels

9.1 We have contacted Network Rail and obtained a plan showing the location of rail tunnels in the area. An extract is presented below, with the full plan provided in Appendix F.

9.2 The closest tunnel; the tunnel carrying the Jubilee Line, runs north to south some 240m to the east of the site.

9.3 On this basis, the basement construction will not affect identified rail tunnels.

10 Summary of screening

10.1 The above report sections present factual data to demonstrate there are no areas of concern which require investigation to support a planning application.

11 Subterranean (Groundwater) flow screening

11.1 General overview

11.1.1 The property is positioned on gently sloping ground (approximately 3°) to the north west of central London. The property is outside areas considered to be at risk of being affected by tidal and fluvial flooding associated with the Thames or its tributaries, or artificial water sources (canals/reservoirs). In addition, the property is not considered to be at significantly enhanced risk of flooding from sewers or water supply pipes.

11.1.2 Geological records indicate the site is underlain by deposits of London Clay Formation extending to depths in excess of 50m. The borehole excavation within the property confirms published geological records. The property (being underlain with a substantial thickness of London Clay Formation) is not considered to be at risk of flooding from groundwater and the proposals will not affect any groundwater flows.

11.1.3 Cumulative impact of basement developments

11.1.3.1 As per requirement outlined in Section 4.34 of the Camden Planning Guideline for Basements and as discussed in Section 3.3.4 of the Camden geological, hydrogeological and hydrological study report *'Guidance for subterranean development'*, the cumulative effects of basements on groundwater flow should be taken into account. Figure 23 from the Camden geological guidance referenced above illustrates the cumulative effects of basement on groundwater flow which can alter the groundwater flow regime to a significantly greater degree than the initial "pilot" basement within any geographical area.

11.1.3.2 The geology of the area is formed in London Clay Formation, which is likely to extend to some 80m below the site and thus all of the basement in the local vicinity are likely to be formed solely within London Clay deposits. No groundwater was encountered during the investigation or during the subsequent monitoring visit. Our report has undergone review by a chartered geologist and hydrologist and it is confirmed within this report (report presented within Appendix C) that "the well-known low permeability of the London Clay prevents it from transmitting groundwater flow or supporting a water table however localised pockets of groundwater may be encountered within impersistent relatively permeable horizons". Such permeable horizons were not encountered on site and such localised pockets would not contribute to groundwater flow in a wider context but would remain as effectively immobile pocket / lenses of localised groundwater.

11.1.3.3 We have been advised that there are in total twelve potential basements in the vicinity of the site. Ten basements along Goldhurst Terrace which has already been granted planning permission with a further two pending applications for basement. Some of basement may have now completed construction, however, all known basements either granted or proposed have been considered. The likely geology in the vicinity of the basements, the hydraulic gradient (if appropriate) and the likely effect of the basement on the groundwater flow is considered and summarised in Table 11.1.3.3 below;

Table of indicative infiltration rates

Property	Planning permission status	Geological unit(s) at location of basement	Hydraulic gradient (From 44 Goldhurst to proposed basement)	Likelihood of cumulative effect on groundwater flow
No. 58 Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 60 Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 61 Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 65 Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 66 Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 67 Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 101 Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 109 Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 115-119 (Maryon House) Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 146 Goldhurst Terrace	Granted	London Clay Formation	None	None
No. 59 Goldhurst Terrace	Pending	London Clay Formation	None	None
No. 71 Goldhurst Terrace	Pending	London Clay Formation	None	None

Table 7.3.2

11.1.3.3 On the above basis there is not likely to be any cumulative effect on groundwater flow due to completed or proposed basements in the vicinity of the site as no groundwater table is contained within the London Clay Formation deposits.

11.2 Responses to flow chart questions

The following provides site specific responses to questions posed in figure 1 of CPG4

Question and response			Text reference
Question 1a	**Is the site located directly above an aquifer?**		
Response.	No. The property is directly underlain by over 50m thickness of London Clays which are classified Unproductive Strata (formerly Non-Aquifer) by the Environment Agency.		3.2
Question 1b	**Will the proposed basement extend beneath the water table surface?**		

Response	No. The London Clay Formation comprises reasonably homogenous relatively impermeable clays which are not able to transmit groundwater under normal hydraulic gradients.	3.2
Question 2	**Is the site within 100m of a watercourse, well or potential spring line?**	
Response	No. Although the property is recorded to be relatively close to a tributary of the West Bourne, (based on historical maps) Ordnance Survey records of the area prior to development do not record any watercourses in the area. Based on Thames Water asset maps it is likely that the stream is culverted off site to the west. Additionally, the geology of the area is not conducive to spring lines or wells for extraction of water. Based on this there are no matters of concern.	3.4.3
Question 3	**Is the site within the catchment of the pond chains on Hampstead Heath?**	
Response	No. Based on figure 14 within the Camden geological, hydrogeological and hydrological study report, the property is not within the catchment of the pond chains on Hampstead Heath. The property is located in excess of 2km distance from the pond chains on Hampstead Heath	3.4.2
Question 4	**Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?**	
Response	Yes. The extensions to the property will marginally increase the hardened area of the site, however it is understood that proposals are to manage on site stormwater collected by the development so as not to increase the rate of stormwater discharge to sewers off site.	5
Question 5	**As part of the site drainage, will more surface water (e.g. rainfall and run off) than present be discharged to the ground (e.g. via soakaways/SUDS)?**	
Response	No. The site is underlain by London Clays which are not amenable to disposal of stormwater using infiltration systems. It is envisaged that rainwater falling onto the garden area will be disposed of using natural absorption and natural run off (which is currently the case).	5

Question 6	**Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to or lower than the mean water level in any local pond (not just the pond chains on Hampstead Heath) or spring line?**	
Response	No. The London Clay Formation comprises reasonably homogenous relatively impermeable clays which are not able to transmit groundwater under normal hydraulic gradient. Basement excavations will be formed in the London Clays. Based on this there are no matters of concern.	3.4.3

12 Stability impact identification

12.1 General overview

12.1.1 The property is positioned on gently sloping ground in the north west of central London. Ground levels in the area fall in a general south westerly direction at a slope of approximately 2 degrees.

12.1.2 No significant trees will be removed as part of the development.

12.2 Responses to flow chart questions

The following provides site specific responses to questions posed in figure 2 of CPG4

Question and response		Text reference
Question 1	**Does the existing site include slopes, natural or manmade greater than 7° (approximately 1 in 8).**	
Response	No. The topography of the area falls by about 3 degrees in a south-westerly direction. Based on this there are no matters of concern.	2.1 2.2
Question 2	**Will the proposed profiling of landscaping at the site change slopes at the property boundary to more than 7°?**	
Response	No. The proposed basement will not change the current topographical conditions. Based on this there are no matters of concern.	
Question 3	**Does the development neighbour land including railway cuttings and the like with slopes greater than 7° (approximately 1 in 8)?**	

Response	No. The topography of the area falls by about 3 degrees in a south-westerly direction, and there are no manmade cuttings in the area. Based on this there are no matters of concern.	2.2
Question 4	**Is the site within a wider hillside setting in which the slope is greater than 7°?**	
Response	No. The topography of the area falls by about 3 degrees in a south-westerly direction with the slope (to the south of Goldhurst Terrace) being reasonably uniform. Based on this there are no matters of concern.	2.1
Question 5	**Is the London Clay the shallowest strata at the site?**	
Response	Yes. The property is underlain with London Clays, extending to depths of over 50m in the area. Given the shallow (natural) slope angles in the area, the property is not considered to be at risk of slope instability. Based on this there are no matters of concern.	2.1
Question 6	**Will any trees be felled as part of the development and/or are there any works proposed within any tree protection zones where trees are to be retained?**	
Response	No works are proposed within current tree protection zones. We understand that the tree cluster to the front of the property will be pruned to accommodate access for basement construction. Tree protection measures are outlined in the Aboricultural report for site provided in Appendix H. Based on this there are no matters of concern.	7
Question 7	**Is there a history of any seasonal shrink swell subsidence in the local area and/or evidence of such effects on site?**	
Response	No. We are aware that London Clay Formation deposits exhibit shrink/swell characteristics. We are not aware of, or seen any evidence of damage attributable to subsidence either on the subject property or on adjacent properties. Based on this there are no matters of concern.	

Question 8	**Is the site within 100m of a watercourse, well or potential spring line?**	
Response	No. Although the property is recorded to be relatively close to a tributary of the West Bourne, (based on historical maps) Ordnance Survey records of the area prior to development do not record any watercourses in the area. Based on Thames Asset maps it is possible that the stream is culverted off site beneath Fairhazel Gardens some 100m west of the site. Addtionally, the geology of the area is not conducive to spring lines or wells for extraction of water. Based on this there are no matters of concern.	3.4.3
Question 9	**Is the site within an area of previously worked ground?**	
Response	No. There is no evidence to indicate the site has been subject to quarrying activities in the area. Based on this there are no matters of concern.	3.3.1
Question 10	**Is the site located above an aquifer? If so will the proposed basement extend beneath the water table such that dewatering may be required during construction?**	
Response	No. The property is directly underlain by over 50m thickness of London Clays which are classified Unproductive Strata (formerly Non Aquifer) by the Environment Agency. The London Clay Formation comprises reasonably homogenous relatively impermeable clays which are not able to transmit groundwater under normal hydraulic gradient. New basement excavations will be formed in the London Clays. Based on this there are no matters of concern.	3.2
Question 11	**Is the site within 50m of Hampstead Heath ponds?**	
Response	No. The property is located about 2km distant from the pond chain on Hampstead Heath. Based on this there are no matters of concern.	3.4.2

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Question 12	**Is the site within 5m of a public highway or pedestrian right of way?**	
Response	The proposed basement is 4m distant from the public footway of Goldhurst Terrace. Our calculations suggest that up to 2.4mm of movement could occur at the footpath adjacent to no.44, which will reduce further toward the east. Movement will be further reduced by protection measures utilised during construction. Such levels of movement are considered insignificant and will not cause noticeable or detrimental damage to the footpath. Based on this there are no matters of concern.	5.2.6
Question 13	**Will the proposed basement significantly increase the differential depth of foundations relative to adjacent properties?**	
Response	No. Traditional underpinning will be used to extend existing foundations down to proposed basement floor levels. Although there will be differences in ground / basement level floors between the new build and adjacent properties, the proposed basement construction solution will not affect neighbouring properties, and estimates of movements which may occur during the construction phase are described in section 5 which indicate acceptable levels of differential movement. Based on this there are no matters for concern. A copy of the project Engineer's drawings illustrating proposed foundations for the basement are presented in Appendix A. Tree removal will not influence the differential depth of foundations.	5
Question 14	**Is the site over (or within the exclusion zone of) any tunnels e.g. Railway lines?**	
Response	We have contacted Network Rail and obtained a plan showing the location of rail tunnels in the area. A copy of the plan is presented in Appendix G. There are no tunnels within 200m of the site. Based on this there are no mattes for concern.	9

13 Surface flow and flooding impact identification

13.1 General overview

13.1.1 There will be an increase in hardened and drained areas resulting from the development. The property is underlain with a substantial thickness of relatively impermeable London Clays, which is not amenable to disposal of stormwater using soakaways. We understand that drainage proposals will be developed in detail during technical design of the project..

13.2 Responses to flow chart questions

The following provides site specific responses to questions posed in figure 3 of CPG4

Question and response		Text reference
Question 1	**Is the site within the catchment of the pond chains on Hampstead Heath?**	
Response	No. The property is not located within the catchment of the pond chains.	3.4.2
Question 2	**As part of the site drainage, will surface water flows (e.g. rainfall and run off) be materially changed from the existing route?**	
Response	No. Proposals will not have a material impact on surface water flows.	5
Question 3	**Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?**	
Response	Yes. Refer 13.1 above.	13.1
Question 4	**Will the proposed basement result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream water courses?**	
Response	No. Proposals will have no impact on surface water received by adjacent properties or downstream watercourses.	11.1

Question 5	**Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream water courses?**	
Response	No. Proposals will have no impact on surface water flows to adjacent properties or downstream water courses.	11.1

14 Summary and Conclusions

14.1 Proposals are to redevelop the existing development to include a single storey basement beneath the existing building footprint including the rear garden area, the proposed scheme will adopt lightwells to the front and rear of the basement.

14.2 Ordnance Survey mapping of the area records the site undeveloped prior to 1896, after which residential property is recorded.

14.3 Published BGS maps of the area record topography local to the property is formed in deposits of London Clays which probably extend depths of over 50m in the area. Borehole excavations on site confirm London Clays below a thin covering of Made Ground. The London Clays are classified as unproductive strata by the Environment Agency. The London Clay Formation comprises reasonably homogenous relatively impermeable clays which are not able to transmit groundwater under normal hydraulic gradient. Basement excavations will be formed in the London Clays and based on the above, not affected by groundwater. Similarly, installation of the proposed basement will not affect any subterranean ground water flows.

14.4 Ground levels fall in a south-westerly direction by about 3 degrees, and slope instability is not considered to present a risk. Installation of the basement will not induce any slope instability.

14.5 There is no evidence of any subsidence to any adjacent properties or indeed the existing buildings on the site.

14.6 No major vegetation will be removed to accommodate the extension of the building.

14.7 It is likely that foundation arrangements to the subject property and the attached properties (42 and 46 Goldhurst Terrace) will be similar on the basis that the houses were constructed at the same time with foundations constructed on fine grained (cohesive) soils which will exhibit plasticity. The volume of plastic soils will change with changes in water content. Changes in water content are promoted by seasonal weather conditions but also water demands of trees. Following National House Building Standards (chapter 4.2) which provides a good guide to the influence of trees on plastic soils. The proposed basement and new foundations extend beyond the zone of shrinkage of the trees in the local area. An aboricultural survey has been carried out for site (presented in Appendix H) which describes tree protection measures which will be carried out during construction.

14.8 Installation of the basement will generate some ground movement close to the perimeter of the basement excavation. The amount of movement has been predicted based on records of observed movement in other basements during construction. If both surface settlement and inward yielding movements are taken in combination there is a risk that damage could fall into category 1 (very slight damage). We anticipate settlement of the adjacent footpath to Goldhurst Terrace will be no more than 2.4mm which will present a negligible risk to the footway. In order to reduce this further risk monitoring of the basement walls will be required during basement excavation works and the walls propped with adjustable props.

14.9 The property is not considered to be at enhanced risk of being subject to flooding.

14.10 There will be a minor increase in hardened and drained areas resulting from the development. The property is underlain with a substantial thickness of relatively impermeable London Clays, which is not amenable to disposal of stormwater using soakaways. At this stage we have not been presented with a drainage proposal scheme for the development.

14.11 We have contacted Network Rail and obtained a plan showing the location of rail tunnels in the area. A copy of the plan is presented in Appendix G. The site is considered remote from tunnels and thus the planned development will not affect Network Rail holdings.

14.12 In overall conclusion there are no outstanding issues of concern (singularly or cumulatively) from a stability, groundwater or surface water perspective.

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Neighbourhood extract from Ordnance Survey map

Town extract from Ordnance Survey map

Detail extract from Ordnance Survey map

Title	Scale	Drawing number
Site location plan	Not to scale	01

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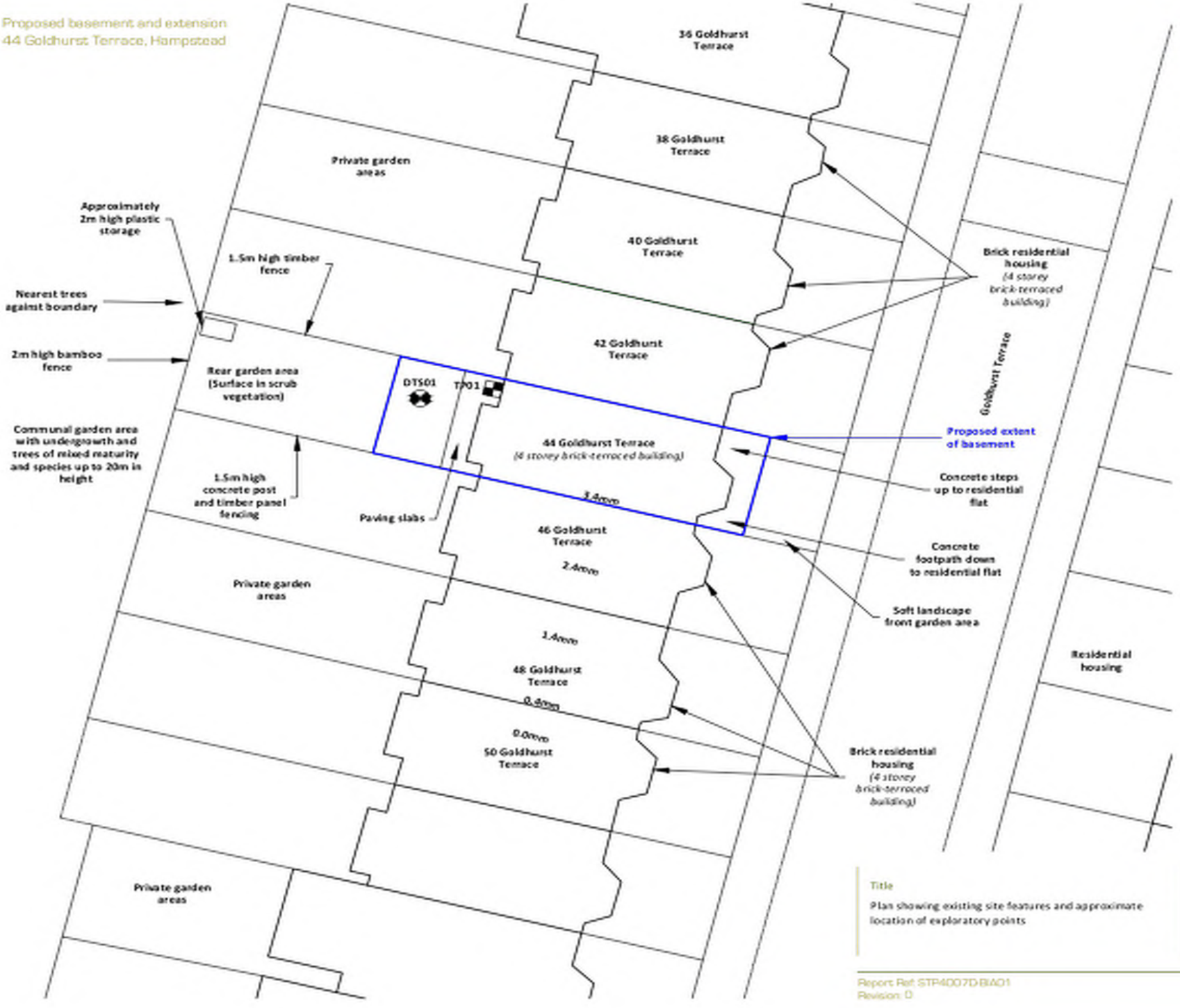

Key

DTS — Approximate location of borehole formed by Driven Tube Sampling techniques

TP — Approximate location of trial pit excavation

Title	Scale	Drawing number
Plan showing existing site features and approximate location of exploratory points	1:200 at A3	02

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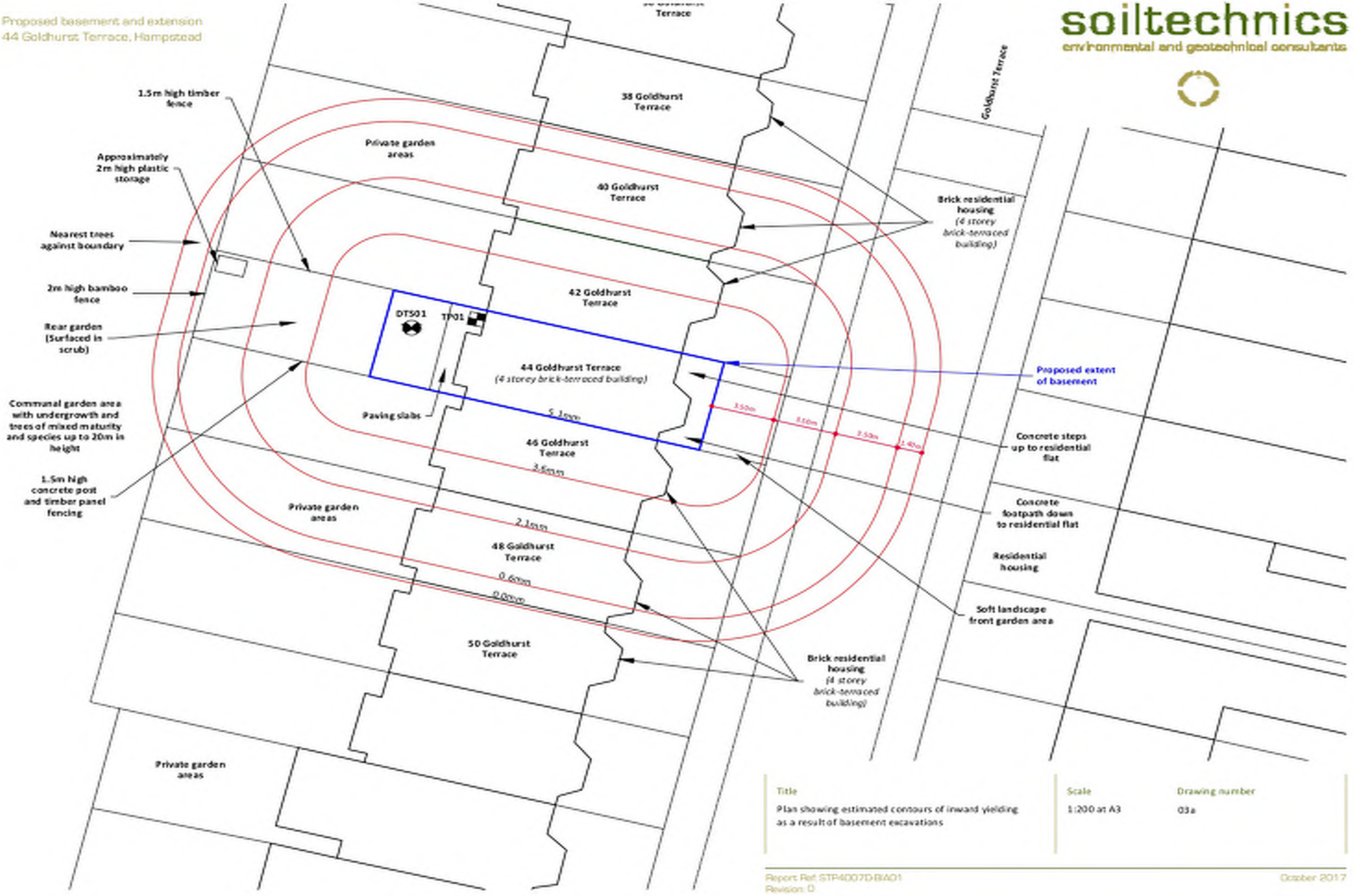

Title	Scale	Drawing number
Plan showing estimated contours of inward yielding as a result of basement excavations	1:200 at A3	03a

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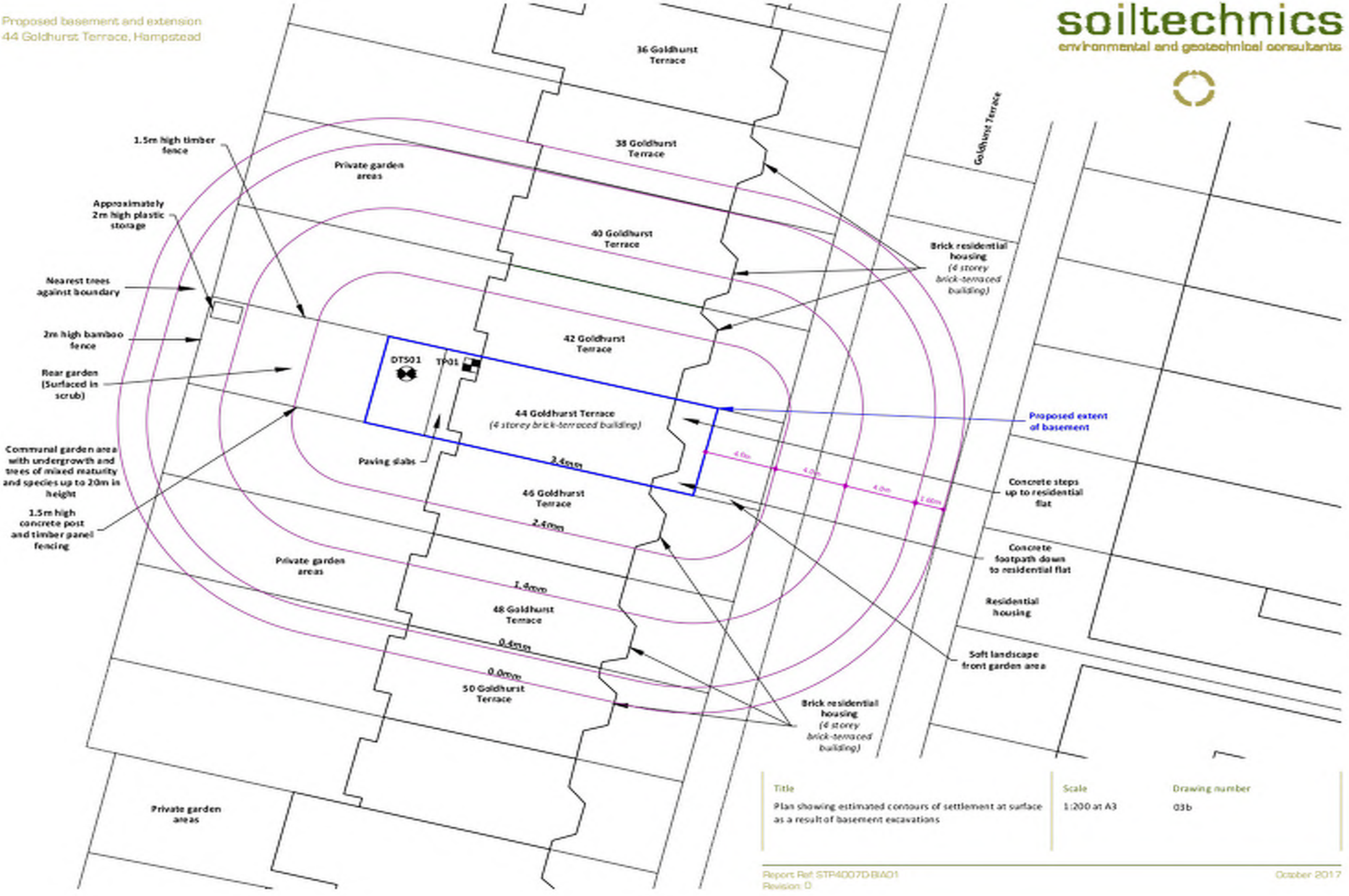

Title	Scale	Drawing number
Plan showing estimated contours of settlement at surface as a result of basement excavations	1:200 at A3	03b

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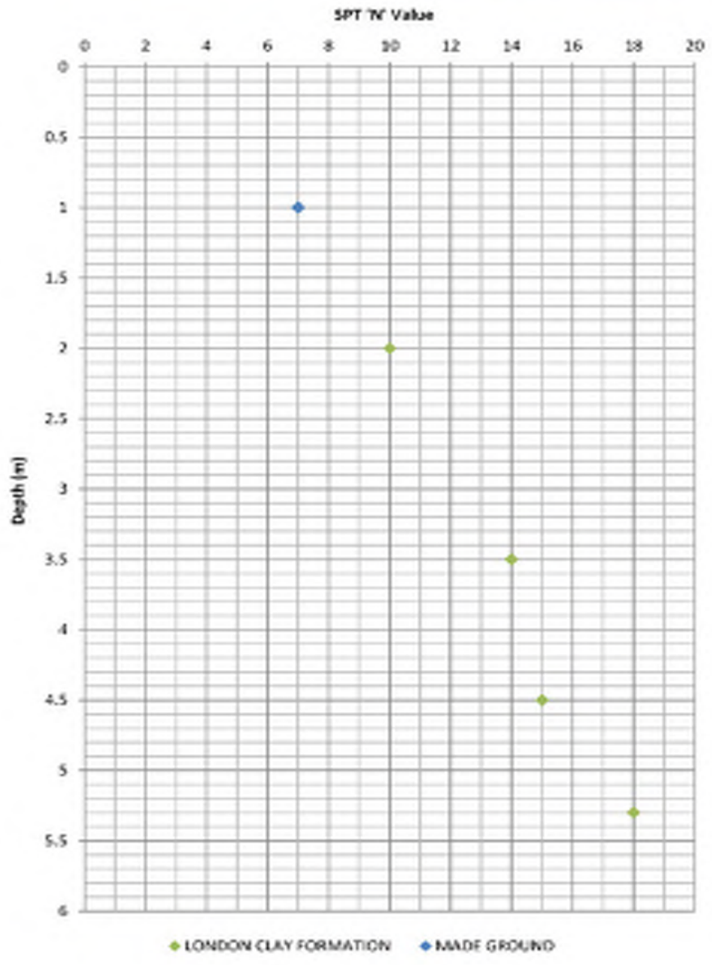

Title	Scale	Drawing number
Plot summarising results of standard penetration testing by geology	As shown	04

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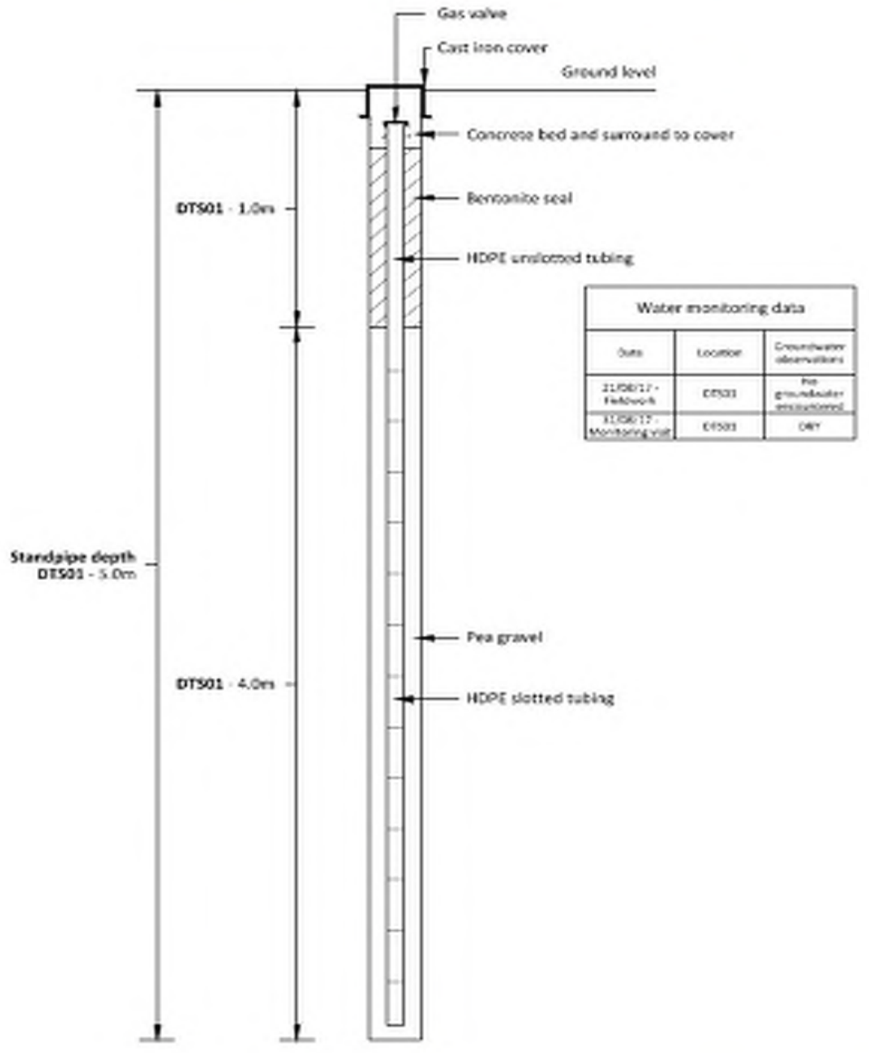

Title	Scale	Drawing number
Section showing construction of groundwater monitoring standpipe installed in borehole DTS01 and subsequent groundwater monitoring records	Not to scale	05

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