Card Geotechnics Limited
Providing Ground Solutions

Cranbrook Basements

6a North End, Camden

Basement Impact Assessment

December, 2013

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1. INTRODUCTION

Cranbrook Basements, acting on behalf of the landowner, is proposing to construct a single storey basement beneath the existing residential dwelling at 6A North End, London, NW3 7HL. Card Geotechnics Limited (CGL) has been instructed 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 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 Cranbrook Basements at the adjacent site "Hogarth House". As such, the scoping process will form a review of this existing site investigation data (and other publically available ground investigation data in the immediate area) , an assessment of its suitability for use in the BIA and the establishment of a conceptual site model.

The report also provides an impact assessment of geoenvironmental and geotechnical impacts on adjacent structures and the surrounding area based on available site investigation data and structural details. This comprises an assessment of ground movements resulting from the basement excavation, including heave, underpin settlement 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 6a North End, London, NW3 7HL, in the north of the London Borough of Camden and to the northwest of Hampstead Heath. The National Grid Reference for the approximate centre of the site is 526008, 186980. The site location is shown in Figure 1.

2.2 Site description

The site comprises a two-storey residential property with a garden adjacent to the western elevation and a garage in the northwest corner of the site, adjacent to the northern boundary of the garden. The property is effectively an apartment within the larger building that contains both 6a and 8 North End (6a North End shares party walls with neighbouring properties to the north, east and south). The first floor of 6a North End extends to the south, within the greater property, and is larger in plan than the existing ground floor. The northern party wall is shared with the L-shaped building *Hogarth House* (also known as 6 North End), which has a semi-detached garage attached to its eastern boundary. Planning permission has been granted for a new single storey basement beneath *Hogarth House*.

The eastern and southern party walls are shared with No. 8 North End. The garage, located in the northwestern corner of the garden, shares its eastern party wall with another garage that is understood to belong to a neighbouring property.

The neighbouring property at No. 10 North End, some 11m northeast of the site, is understood to have a basement. Four houses with basements are currently being constructed 4 North End, adjacent to the western boundary of the site garden.

A site layout plan including the location of the surrounding buildings and associated basements is presented as Figure 2.

2.3 Proposed development

The proposed development is to comprise a single storey basement that will underlie the current footprint of 6a North End and extend out to the west, under the property garden. New lightwells will be formed at the eastern boundary of the garden, adjacent to the western elevation of the existing property.

Preliminary drawings indicate the basement formation level will be approximately 4m below ground level (mbgl). The above ground structures are to be retained. It is understood that the existing foundations and party walls are to be underpinned.

Development plans and structural drawings provided by Cranbrook, showing the site in the existing and proposed condition, are included in Appendix A.

2.4 Site history

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

- Mapping from the 1870s indicates a building to have been present in the northern half of the site. The southern half of the site is shown to be undeveloped.
- Mapping from 1896 shows the site to be vacant.
- By 1915 the site is shown in its current plan, along with adjoining properties.

The historical maps are provided in Appendix B.

2.5 Topography

The site lies at an approximate elevation of 113mOD and is situated on a gentle northwards dipping hillside slope that peaks some 300m south-southeast of the site at around 130mOD.Hampstead Ponds are located approximately 1.3km to the southeast of the site at an approximate elevation of 75.0mOD. The area has a general slope of around 1:18 (5%), though this may steepen to 1:10 (10%) in areas and the site is near to the highest topographical point in the locale.

2.6 Published geology

With reference to the British Geological Survey (BGS) sheet[3] for the local area, the site is shown to be underlain by the Bagshot Formation, which is in turn underlain by the Claygate Member over the London Clay Formation.

The Bagshot Formation generally comprises fine grained sand with thin clay horizons. The Claygate Member, which forms the upper unit of the London Clay Formation, is typically inter-bedded sands and clays. The Claygate Member is shown to outcrop approximately 250m to the northwest of the site, at an elevation of around 95mOD. Ground level at the

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

site is approximately 113mOD and, as such, it is anticipated that the base of the Bagshot Formation is present some 18m below the site and in turn underlain by the Claygate Member.

The London Clay Formation is an over consolidated firm to very stiff, becoming hard with depth, fissured, blue to grey silty clay of low to very high plasticity. The upper and lower parts may contain silty or fine grained sand partings. It also contains within it, laminated structured, nodular claystone and rare sand partings. The London Clay Formation is anticipated to be present from around 60mOD.

BGS and Environment Agency (EA) records indicate that no worked ground or recorded landfill sites are present within 250m of the site.

2.7 Unpublished geology

Logs of historic boreholes are freely available from the British Geological Survey (BGS). Those within 200m of the site have been reviewed and are summarised in Table 1 below.

Relevant BGS borehole records and a location plan are provided in Appendix C.

Table 1. BGS Borehole Records with 200m

Borehole Ref.	**Distance from site**	**Direction**	**Ground level**
TQ28NE423	10m	East	Unknown
TQ28NE424	10m	East	Unknown
TQ28NE257	35m	West	112.54mOD
TQ28NE258	55m	East	112.87mOD
TQ28NE20	75m	North	Unknown
TQ28NE256	100m	North	108.61mOD

The ground conditions encountered in the nearest borehole, TQ28NE423, are summarised in Table 2 below:

Table 2. Ground Conditions in borehole TQ28NE423

Description	Depth to top of stratum (mbgl)	Thickness of stratum (m)
MADE GROUND. Concrete overlying grey brown clayey silty sand.	GL	0.80
Firm to stiff becoming stiff mottled brown, orange brown and light grey silty sandy CLAY with pockets and partings of orange brown silty fine sand. [BAGSHOT FORMATION]	0.80	4.40
Firm to stiff grey silty sandy CLAY with some partings and pockets of light brown silty fine sand. [CLAYGATE MEMBER]	5.20	4.80
Stiff grey silty sandy CLAY with some partings and pockets of light brown and beige silty fine sand. [CLAYGATE MEMBER]	10.00	3.70
Stiff dark grey brown fissured silty CLAY with occasional partings of light brown silty fine sand and scattered small gypsum crystals. [CLAYGATE MEMBER]	13.70	6.30

The ground conditions between BGS boreholes are relatively consistent with those described in Table 2.

2.8 Hydrogeology

The Environment Agency[4] (EA) has produced an aquifer designation system consistent with the requirements of the Water Framework Directive. The Bagshot Formation is classed as a 'Secondary A' aquifer. These aquifers comprise permeable layers capable of supporting water supplies at a local scale and in some cases forming a source of base flow for rivers.

The BGS borehole records TQ28NE423 and TQ28NE424, located approximately 10m to the east of the site, indicate groundwater seepages to have been encountered at depths of 5.10mbgl and 5.80mbgl, respectively. This corresponds to the boundary between the Bagshot Formation and Claygate Member, at an approximate elevation of 108.0mOD in these boreholes. Similar depths of groundwater were encountered in the additional BGS borehole records referenced in Table 1.

[4] http://www.environment-agency.gov.uk/wiyby (accessed 26th November 2013)

In the general area of the site, the high ground of Hampstead Heath is comprised of the predominantly granular Bagshot Beds. This stratum rests above the relatively impermeable Claygate Member and London Clay Formation. As such, rainwater percolates through the Bagshot Formation and becomes perched above the impermeable clays where it then travels downhill, forming springs around the base of Hampstead Heath.

A hydrogeological review[5] has been carried out at the adjacent site *Hogarth House*. Salient points from this report are outlined below.

- The base of the Bagshot Formation is shown on geological mapping to dip to the north, suggesting groundwater is likely following topography at the site and flowing to the north.
- No ancient rivers are located directly under the site.
- Numerous spring lines surround the site but none within 100m.

The site is not within a groundwater source protection zone.

2.9 Hydrology

The nearest recorded surface water feature is located some 190m to the southwest of the site and is denoted on Ordnance Survey mapping as a *Pond* within the grounds of the *The Hill* Garden and Pergola.

A number of springs are shown to surround the site, although none within 250m of the site. The nearest spring is located some 350m northeast of the site. A number of spring networks feed into ponds, which are common in the local area. This network then feeds into watercourses including the River Westbourne, Brent, Tyburn and Fleet, most of which are now diverted underground. The closest pond is located approximately 330m to the west of the site.

With reference to Figure 14 of the Arup *Hampstead Heath Surface Water Catchments and Drainage of the Camden Geological, Hydrogeological and Hydrological report*2, it can be seen that the site is not within the catchment of pond chains located on Hampstead Heath.

[5] Geotechnical Consulting Group (2012). Hogarth House, North End, London. *Hydrogeological Review.* January 2012.

2.10 Flood risk

The site is not within an Environment Agency Flood Risk Zone. Furthermore, reference to Figure 15 (Flood Map) of the Arup CGHHS report[2] confirms the road adjacent to the site was not flooded during the flooding events of 1975 and 2002.

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. These are included in Appendix D for ease of reference. 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 3. Responses to Figure 1, CPG4 (see Appendix D)

Question	Response	Action required
1a. Is the site located directly above an aquifer?	Yes. The site is located above a Secondary A Aquifer (Bagshot Formation).	Investigation and assessment
1b. Will the proposed basement extend beneath the water table surface?	Not anticipated. BGS borehole records indicate that groundwater should be encountered approximately 1m below the proposed basement formation level. Some slight groundwater seepages may be encountered during excavations and underpinning depending on season and rainfall levels.	Confirm by investigation and assessment
2. Is the site within 100m of a watercourse, well or potential spring line?	No. The nearest surface water feature is located approximately 200m to the southwest 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.	None
4. Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	No. The majority of the garden is understood to be paved, restricting infiltration. As such, the proposed basement with overlying garden will not change the current infiltration regime.	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. All surface water will be discharged to the sewer network through existing connections. The volume of water will not be greater than the existing condition.	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. The nearest surface water feature is at a significantly lower elevation than the lowest point of the proposed excavation.	None

In summary, it is considered unlikely that the basement excavation will encounter any more than slight groundwater seepages.

It is considered that the basement excavation will not affect any surface water feature, including the pond chains on Hampstead Heath, and that no additional run-off or water discharge to ground will be created by this development.

There are a number of existing and proposed basements at the neighbouring properties of No. 10 and No. 4 North End, respectively. The combined effect of these basements on the local groundwater regime will need to be assessed.

3.3 Slope/land stability

This section answers questions posed by Figure 2 in CPG4.

Table 4. Responses to Figure 2, CPG4 (See Appendix D)

Question	Response	Action required
1. Does the site include slopes, natural or man made, greater than approximately 1:8?	No. Slopes are generally 1:18 with no greater than 1:10 locally.	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. No re-profiling or landscaping of significance is planned.	None
3. Does the development neighbour land including railway cuttings and the like with a slope greater than approximately1:8?	No There are no significant artificial cuttings or embankments in the area.	None
4. Is the site within a wider hillside setting in which the general slope is greater than approximately 1:8?	No. Slopes are generally 1:18 with no greater then 1:10 locally.	None
5. Is the London Clay the shallowest stratum on site?	No. The Bagshot Formation is the shallowest stratum on site.	None

Question	Response	Action required
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. No trees are present in the existing garden.	None
7. Is there a history of seasonal shrink-swell subsidence in the local area and/or evidence of such at the site?	No. Shrink/swell movements are considered unlikely due to the expected granular or low shrinkability cohesive deposits.	None
8. Is the site within 100m of a watercourse or a potential spring line?	No. The nearest surface water feature is located approximately 200m to the southwest of the site.	None
9. Is the site within an area of previously worked ground?	No. No known areas of worked ground are present and no significant Made Ground was encountered in BGS borehole records.	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?	Yes. The site is located above a Secondary A Aquifer (Bagshot Formation). BGS borehole records indicate that groundwater should be encountered approximately 1m below the proposed basement level. Some slight groundwater seepages may be encountered during excavations and underpinning depending on season and rainfall levels. Running sands may be present if groundwater seepages are encountered within sand deposits.	Investigation and assessment
11. Is the site within 50m of the Hampstead Heath ponds?	No. The nearest pond is located some 330m to the west of the site.	None
12. Is the site within 5m of a highway or pedestrian right of way?	No. The site is located further than 5m from the nearest highway or pedestrian right of way (North End).	None
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes. The basement will increase the depth of foundations relative to the adjacent property (Hogarth House) to the north, two semi-detached domestic garages to the north and to 8 North End to the south. However, a single storey basement is proposed for Hogarth House and, as such, the proposed basement will not increase the differential depth of foundations with respect to this property.	Investigation and assessment
14. Is the site over (or within the exclusion zone of) any tunnels?	No. None present.	None

In summary, it is considered unlikely that the basement excavation will encounter any more than slight groundwater seepages, though this may result in running sands if encountered within sand deposits.

A number of basements are known to exist or be proposed in the immediate vicinity of 6a North End. The proposed basement excavation will increase the depth of foundations relative to the adjacent property Hogarth House, to the north of the site. However, it is understood that a basement is to be constructed under Hogarth House, thus negating any potential differential foundation depth with this one property. 10 North End is understood to have an existing single storey basement, indicating the proposed basement will not cause differential foundation depth with that property either.

It is understood 8 North End, and the garages associated with 6a North End and *Hogarth House*, do not have basements and that the proposed basement excavation will increase the differential foundation depth relative to these buildings. It is noted that the garage of No. 6a will have been underpinned during the redevelopment of No. 4 North End to the west. An assessment is required to investigate the impact of ground movements resulting from underpin retaining wall deflections and long term structural loading through perimeter walls, particularly the southern, eastern and western perimeter walls where these are shared with neighbouring properties.

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 5. Responses to Figure 3, CPG4 (See Appendix D)

Question	**Response**	**Action required**
1. 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.	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 It is understood all surface water will be discharged to the sewer network through existing connections.	None
3. Will the proposed development result in a change in the proportion of hard surfaced/paved external areas?	No. The majority of the garden is understood to be paved, restricting infiltration. As such, the proposed basement with overlying garden will not change the current infiltration regime.	None

Question	Response	Action required
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. The proposed basement will not alter present surface water conditions.	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 proposed basement will not alter present surface water conditions.	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 The site is not in a Flood Risk Zone, identified as a street that flooded in 1975 and 2002 and not within close proximity to any significant surface water feature.	None

In summary, the proposed basement will not alter present surface water conditions as no additional hardstanding or paved surfaces will be created and no existing surface water routes will be altered. The site is not within a Flood Risk Zone.

3.5 Conclusion

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

Table 6. Summary of Basement Impact Assessment requirements

Item	Description
	Subterranean (Groundwater flow)
1.	The impact of the basement on groundwater flows in and around the proposed structure and implications for construction.
2.	Short term and long term groundwater control methods and establishment of Design Groundwater Levels for retaining wall design in accordance with *BS8102*.
	Slope stability
3.	Movements associated with construction in the Bagshot Formation including foundation settlements and ground movements around the basement perimeter resulting retaining wall deflections.
4.	Impact assessment on adjacent residential properties and infrastructure.
	Surface flow and flooding
5.	Proposed basement will not notably impact on surface water or materially change infiltration to the ground.

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. However, ground investigations have already been undertaken at the adjacent sites Hogarth House and 4 North End. As such, this report will assess the suitability of the existing site investigation data to inform the impact assessment (Stage 4).

The findings of the existing intrusive site investigation are summarised below.

4.2 Existing Site Investigation

Information on two ground investigations carried out adjacent to the site has been reviewed to inform the likely ground conditions underlying the 6a North End. Borehole locations are included in Figure 2.

4.2.1 Chelmer ground investigation

A ground investigation comprising a single hand augered borehole to a depth of 5.7m was completed by Chelmer Site Investigations[6] in January 2012. The borehole was excavated in the garden of *Hogarth House*, immediately to the northeast of that building. The works comprised in-situ testing using either a hand shear vane or a Mackintosh dynamic probe at metre intervals. The full report is provided in Appendix E.

The investigation revealed the following ground conditions:

Table 7. Summary of ground conditions from Chelmer Site Investigation

Strata description	**Depth to top of strata (mbgl)**	**Thickness of strata (m)**
TOPSOIL (Driller's description)	0.00	0.30
MADE GROUND. medium compact mid brown silty very sandy gravelly clay with numerous brick and concrete fragments.	0.30	0.60

[6] Chelmer Site Investigations (October 2011) *A factual report on the site investigation undertaken for Cranbrook Basements at 4 Hampstead Square.* CSI Ref: 2829

Strata description	Depth to top of strata (mbgl)	Thickness of strata (m)
Stiff mid brown/orange silty very sandy CLAY. **[BAGSHOT FORMATION]**	0.90	2.30
Stiff mid brown grey veined silty CLAY with partings of orange and brown silt and fine sand and crystals (sic). **[BAGSHOT FORMATION]**	3.20	0.60
Dense mid brown orange silty fine SAND. **[BAGSHOT FORMATION]**	3.80	0.90
Stiff/medium dense to dense mid brown orange laminated CLAY, SILT and fine SAND. **[BAGSHOT FORMATION]**	4.70	0.60
Medium dense mid brown slightly clayey very silty fine SAND. **[BAGSHOT FORMATION]**	5.30	Proven to 5.70

4.2.2 MRH Geotechnical ground investigation

A ground investigation comprising three boreholes and a trial pit was carried out at the adjacent site 4 North End in January 2011. The nearest borehole to 6a North End was borehole BH2, bored close to the garden wall the forms the western boundary of 6a North End.

The works included the measurement of SPT N values and in-situ undrained shear strength. A copy of borehole BH2 is provided in Appendix F.

A summary of the ground conditions is presented in Table 8 below.

Table 8. Summary of ground conditions from BH2 of MRH Geotechnical investigation

Strata description	Depth to top of strata (mbgl)	Thickness of strata (m)
TOPSOIL /FILL.	0.0	0.35
Soft to firm brown sandy CLAY.	1.4	1.05
Firm brown sandy CLAY.	2.7	1.3
Medium dense clayey fine SAND.	3.3	0.6
Medium dense orange brown SILT.	3.6	0.3
Medium dense orange brown clayey fine SAND with lenses of clay.	4.2	0.6

Medium dense brown SILT.	4.6	0.4
Firm dark grey silty CLAY.	7.7	3.1

4.3 Groundwater

Chelmer SI

Water seepage was noted at a depth of 5.40mbgl, within the Bagshot Formation. There was no standpipe installation and, therefore, no further water level monitoring was undertaken.

MRH Geotechnical

Within BH2, water seepage was noted from 5.1mbgl, within the Bagshot Formation. A piezometer was installed in this borehole and recorded standing water at 6.32mbgl (upon completion of the borehole).

Most recent monitoring of the groundwater at 4 North End (2012) indicates a standing level of 108.32mOD, some 5.3mbgl.

Reference has been made to the hydrogeological report[5] for *Hogarth House*. The report indicates that groundwater is likely to be present at around 110 to 109mOD and that, assuming ground level is around 113.5mOD, the proposed basement could potentially intercept groundwater level. However, the report goes on to detail that, given the nature of the ground and the depth of the proposed basement, this is unlikely to create a significant barrier to groundwater.

It is considered from the available ground investigation information that groundwater seepage may occur from 5.4mbgl and, given the maximum basement excavation proposed is 4mbgl, only limited seepage might be encountered during basement construction.

4.4 Geotechnical Parameters

Geotechnical design parameters for the ground conditions encountered have been derived based on the soil descriptions and SPT N values in local boreholes records and are outlined in Table 9 below.

Table 9. Geotechnical design parameters

Stratum	Design level (mOD)	Bulk Unit weight γ_b (kN/m^3)	Undrained Cohesion c_u (kPa) [c']	Friction angle Φ' (°)	Young's modulus E_u (MPa) [E']
Topsoil/Made Ground (cohesive)	113.0	18	20[a] [0]	28	10[d]
Bagshot Formation (cohesive)	112.1	20	55 [0]	55	27.5[d] 20.625[e]
Bagshot Formation (granular)	110.3	20	-	32[b]	[27]
Claygate Beds (cohesive)	108.4	18	68+3.4z [0]	29[c]	34+1.7z[d] [25+1.3z][e]

a. Burland, J., Standing, J. and Jardine, F. (2001). Building Response to Tunnelling, CIRIA.
b. Forster A The Engineering Geology of the London Area TR WN/97/27 British Geological Survey August 1997.
c. Peck, R.B., Hanson, W.E., and Thornburn, T.H., Foundation Engineering, 2nd Edn, John Wiley, New York, 1967, p.310.
d. Based on 500 Cu
e. Based on 0.75E
f. Based on in-situ shear vane tests

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

5. CONCEPTUAL SITE MODEL (STAGE 3)

5.1 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].

5.1.1 Existing

A CSM showing existing conditions on site is presented in Figure 3a and salient points are summarised below.

1. Gently sloping site, dipping from southeast to northwest.
2. Topsoil/Made Ground deposits to depths of approximately 0.90m.
3. Party walls with Hogarth House to the north, 8 North End to the east and Pitt House to the south.
4. Groundwater flow within the Bagshot Formation at depths greater than 5.40mbgl.

5.1.2 Proposed

A CSM showing conditions on site on completion of the proposed basement development is presented in Figure 3b. Salient points of the CSM are summarised below:

1. Made Ground is mostly removed from site.
2. New basement extends out beyond the basement footprint, under the property garden.
3. Groundwater likely to be present below level of proposed basement excavation, though some small seepages may be present at shallower depths, and may potentially generate running sands.
4. Underpins acting as gravity retaining walls in temporary condition.
5. Potential deflections and settlement of underpin walls and effect on adjacent structures.

6. SUBTERRANEAN (GROUNDWATER) FLOW

6.1 Introduction

This section addresses outstanding issues raised by the screening process regarding groundwater flow (see Table 3).

6.2 Impact on groundwater flow

Whilst the proposed basement is to extend out beyond the existing building footprint, a garden is proposed above it in the same location as the current garden. A minimum of 1m Topsoil will be present below the garden, both as a growth medium and to facilitate infiltration and drainage. As such there is no significant increase in the proportion of hardstanding/impermeable surfacing. The provision of a topsoil layer above the proposed basement will actually provide betterment in terms of surface water run-off by providing drainage attenuation that does not exist in the current condition.

It is anticipated that groundwater will be flowing towards the north within the Bagshot Formation (present from a depth of approximately 5.4mgbl). This is considered to represent an unconfined perched aquifer above the Claygate Member. Groundwater is likely to be approximately 1.10m beneath the underside of the proposed basement slab.

It is anticipated that groundwater will be able to flow freely beneath and around the basement perimeter within the relatively permeable Bagshot Formation. On the presumption that the existing and proposed basements associated with the surrounding properties are single storey, groundwater will also be able to flow freely beneath them.

Additionally, the adjacent proposed basements are not connected, allowing drainage both below and between the basements, thus avoiding becoming an impermeable barrier to 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. Should shallower groundwater levels be encountered, there remains a risk of running sands being generated in the sandy deposits encountered at a depth of 3.80mbgl during the Chelmer site investigation. Water or moisture was not reported in this horizon in the recent site investigation. Running sands could potentially generate voids beneath adjacent structures and cause collapse of the excavated wall if unsupported. An effective contingency plan for running sand conditions will need to 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. A temporary pumping strategy will then need to be implemented to enable the underpins to be cast. This could take the form of a permeable sump chamber.

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. BASEMENT IMPACT ASSESSMENT – LAND STABILITY (STAGE 4)

7.1 Introduction

This section provides calculations to assess ground movements that may result from the construction of the proposed basement and how these may affect the adjacent structures. It is understood that an underpinning construction method will be adopted throughout to form the basement walls and support to the existing foundations. Possible ground movement mechanisms based on the above assumption are outlined below.

- Heave movements: During excavation the soils at formation level will be subject to stress relief as some 4m of overburden are removed. Given that the soils are predicted to behave as drained materials, any minor heave movements in the form of elastic recovery will be removed during levelling for casting of the basement slab. No long term heave is predicted.

- Global stability of the underpins: This relates to an ultimate limit state failure (i.e. sliding/overturning/bearing capacity) of the underpins when they are acting as gravity retaining walls. The stability of underpins, therefore, needs to be considered in the design.

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

- Underpin deflection: Underpins will be acting as stiff concrete retaining walls, which limits the potential for wall deflection. However, deflections that do occur may generate surface settlements that could impact adjacent properties.

7.2 Assumed construction sequence

It is assumed that the basement will be constructed using underpinning techniques excavated sequentially in typically 1.2m wide bays. Given the relatively shallow depth of the proposed basement, it has been assumed that the underpins will be constructed in a single lift. A toe projection will be cast at the base, forming an L-shaped reinforced retaining wall in the temporary condition to resist sliding, overturning and excessive bearing pressures. The underpins will be constructed in supported trenches with a central soil mass retained to provide support for temporary props and formwork. Sacrificial trench sheeting should be used to provide support to the rear face of the underpin excavations as there is the potential for instability in the Bagshot Formation sands during excavation. The underpins will be generally supported in the permanent condition by the ground floor and basement slab, which should be cast before removing the temporary propping.

A plan layout of the external party and internal load bearing walls showing various line loads has been provided by the client and can be found in Appendix A.

7.3 Ground movements arising from basement excavation

During excavation the soils at formation level will be subject to stress relief as some 4m of overburden is removed. Due to the cohesive nature of some Bagshot Formation horizons and the underlying Claygate Member, it is considered likely that some seasonal shrink-swell will occur, causing some volume change during unloading and loading.

A ground movement assessment has been undertaken using OASYS Limited VDISP (***V****ertical* ***DISP****lacement*) analysis software. VDISP assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness (E_u and E') for each stratum input by the user.

The proposed development gives rise to a net unloading of the Bagshot Formation and underlying Claygate Member, both during construction and over the long term. The excavation will unload the soils at formation level by some 80kPa (assuming an excavation depth of 4m and an overburden unit weight of 20kN/m^3). The combined effect of both the immediate undrained unloading and the long-term drained recovery of pore pressures have been analysed.

A contour plot summarising the VDISP displacement output for both short and long term ground movement is provided in Figures 4 and 5, respectively. Full VDISP output can be provided upon request.

7.3.1 Assessment of short-term heave/settlement

Maximum short term heave is of the order of some 8mm and will occur under the centre of both the existing building footprint and property garden. This decreases to an average of some 2mm of heave around the perimeter of the part of the excavation underlying the garden, including adjacent to the garages in the northwest corner of the site. Along the eastern party wall, negligible movement is anticipated to occur in the short term. In the northeast corner of the site, and along the northern party wall shared with Hogarth House, settlement in the order of some 4mm is anticipated.

Short term heave in the central excavation areas will be removed during construction by re-levelling to achieve foundation/slab formation levels.

A contour plot showing the variation of short term ground movements across the basement excavation is presented within Figure 4.

7.3.2 Assessment of long-term heave/settlement beneath basement slab

Maximum long term heave is in the order of 11mm and will occur in the same locations as the maximum short term heave. Maximum heave along the south and eastern party walls is anticipated to be some 2mm whilst movement along the party wall shared with Hogarth House (to the north) are anticipated to be negligible. Along the northern party wall adjacent to garages, heave will be in the order of some 5mm.

Bearing pressures below underpins should be limited to 175kPa to control ground movements. This assumes that formations are within the Bagshot Formation.

A contour plot showing the variation of long term ground movements across the basement excavation is presented within Figure 5.

7.3.3 Settlement due to workmanship

The heave/settlement assessment undertaken within VDISP assumes perfect workmanship in the underpin construction and does not allow for settlement of the dry pack between existing footings and the new concrete. With good construction practice, these would be expected to not exceed 5mm. This value will be applied to the overall ground movement and corresponding impact assessment to give a worst case damage category for the adjacent party wall properties. A temporary works strategy should be developed as part of the structural design to ensure the underpins are stable prior to casting of the basement and ground floor slabs.

7.4 Ground movement due to underpin wall deflection

7.4.1 General

One representative section was analysed, on the eastern site boundary, which forms the party wall with 8 North End, to assess the lateral movements resulting from the construction of the underpin retaining structures. It is understood that four properties with single storey basement are under construction on the site located adjacent to the eastern boundary of the property garden. These proposed buildings are considered outside the zone of influence from the predicted heave and settlement movements (see Figure 3) associated with the proposed basement at 6a North End.

The underpin walls have been modelled as 300mm thick concrete walls in Geosolve WALLAP embedded retaining wall analysis software to assess wall displacements. Although WALLAP is designed to analyse embedded walls, underpin deflections can be reasonably modelled as a cantilever beam by modelling a prop at the base of the wall to mimic the reinforced L-section between the wall and basement slab.

Early propping at ground floor level has been assumed in the analysis. A conservative 10kPa surcharge has been included to model the live loads and dead loads (from ground floor slabs etc.) of the adjacent properties.

7.4.2 Analysis

On the basis of the WALLAP assessment a maximum horizontal wall deflection of 1.5mm has been calculated. This could translate to an effectively negligible 0.75mm of additional settlement behind the party wall foundation with 8 North End[7].

The amount of ground movement will depend largely on the quality of the underpinning workmanship, particularly with the implementation of the dry pack. The WALLAP analysis has assumed a ‘continuous’ un-reinforced mass concrete retaining wall has been installed instantaneously. The detailing and construction of the reinforcement and connections between underpin sections will be important in controlling deflections.

High level temporary propping will be required at the top of the excavation (some 0.3mbgl) to control wall deflection during construction. The analysis results indicate that prop loads will bear the order of 32kN/m. Full WALLAP output is provided in Appendix G.

[7] CIRIA, *Embedded retaining walls-guidance for economic design* - C580, London, 2003.

8. DAMAGE CATEGORY ASSESSMENT

Ground movements have been analysed based on the construction scheme as currently envisaged to provide an indication of the potential damage that may be caused to neighbouring structures and infrastructure due to lateral and vertical ground movements.

The calculated ground movements have been used to assess potential 'damage categories' to the neighbouring properties. The methodology proposed by Burland and Wroth[8] and later supplemented by the work of Boscardin and Cording[9] has been used, as described in CIRIA Special Publication 200[10] and CIRIA C580.

Assumed damage categories are summarised in Table 10.

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 party wall section the combined impact of short term heave, settlement due to underpin loading, assumed settlement due to workmanship and corresponding ground movement due to underpin deflection have been combined to determine the

[8] 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

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

[10] Burland, J.B., 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.

overall ground movement of the underpins and adjacent properties due to the construction of the basement.

For the critical party wall section between 6a and 8 North End, lateral movements have been calculated to not exceed 1.5mm. Again, good quality workmanship with staged propping of the underpins is essential in controlling movement. Worst case maximum combined vertical movements have been calculated to be approximately 3mm of heave below party walls.

Table 11 incorporates superimposed horizontal and vertical movements derived from both the underpin wall construction (i.e. workmanship), wall deflection, short term heave due to excavation and heave/settlement over the long term due to the reapplication of structural loads. The method of deriving these values and establishing an appropriate deflection ratio for the neighbouring structure is illustrated graphically in Figure 6. The width of the adjacent structure 8 North End has been assumed from development plans to be approximately 9m.

Table 11. Summary of ground movements and corresponding damage category

Party Wall Reference	Horizontal movements (mm)	Maximum deflection (mm)	Horizontal Strain Δ/L^b (%)	Deflection ratio δ_h/L^a (%)	Damage category
6a and 8 North End	1.5	0.7	0.02	0.008	0 - Negligible

a. See Figure 2.18 (a) CIRIA C580 (2003) Embedded retaining walls guidance for economic design. (L = length of adjacent structure in metres, perpendicular to basement; Δ = relative deflection)

b. See Box 2.5 (v) CIRIA C580 (2003) Embedded retaining walls guidance for economic design. (δ_h = horizontal movement in metres

The predicted damage category imposed on the neighbouring party wall properties due to the proposed basement development and assuming a good standard of workmanship will be ‘Category 0’ corresponding to negligible damage. The building interaction chart for the adjacent party wall structure is presented in Figure 7.

9. SURFACE FLOW AND FLOODING

It is noted in Section 3.4 of this report that the proposed basement will not alter present surface water conditions as no additional hardstanding or paved surfaces will be created and no existing surface water routes will be altered.

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 regulations and the provision of a 1m thick topsoil layer above the proposed basement..

10. CONCLUSIONS

The findings of this Basement Impact Assessment are informed by site investigation data at the adjacent Hogarth House, 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.
- Bearing pressures below underpins should be limited to 175kPa to control ground movements. This assumes that formations are within the Bagshot Formation.
- The construction of the basement will generate ground movements due to a variety of causes including; heave, underpin settlement and underpin wall deflection during and after excavation. Preliminary calculations indicate that these will give rise to a damage category within 'Category 0' (negligible damage) for the adjacent properties assuming a good standard of workmanship.
- 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, a temporary pumping strategy will need to be implemented to allow the underpins to be cast. 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.