CampbellReith
consulting engineers

24 Heath Drive, London, NW3 7SB

Basement Impact Assessment Audit

For

London Borough of Camden

Project Number: 12727-71

Revision: F1

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1.0 NON-TECHNICAL SUMMARY

1.1. CampbellReith was instructed by London Borough of Camden, (LBC) to carry out an audit on the Basement Impact Assessment submitted as part of the Planning Submission documentation for 24 Heath Drive, London NW3 7SB (planning reference 2018/0914/P). The basement is considered to fall within Category C as defined by the Terms of Reference.

1.2. The Audit reviewed the Basement Impact Assessment for potential impact on land stability and local ground and surface water conditions arising from basement development in accordance with LBC's policies and technical procedures.

1.3. CampbellReith was able to access LBC's Planning Portal and gain access to the latest revision of submitted documentation and reviewed it against an agreed audit check list.

1.4. The proposed development comprises an extension to the existing basement to include excavation beneath the full footprint of the main part of the existing Grade II listed house and into the rear garden. Basement formation level varied between 4.3m and 6.6m below ground level.

1.5. The BIA has been prepared by Gabriel GeoConsulting Ltd with supporting documents provided by Form Structural Design Ltd and Studio Kyson. The authors' qualifications are in accordance with LBC guidance.

1.6. A desk study has been presented, broadly in accordance with aspects recommended by LBC guidance.

1.7. The site investigation undertaken identifies the London Clay as the bearing formation for the proposed foundations, underlying Made Ground. Interpretative geotechnical information in accordance with LBC guidance is presented.

1.8. The BIA considers the underlying geology, including proximity to the mapped Claygate Member, and proximity to the historic route of a tributary of the River Westbourne. The proposed development will not impact upon the wider hydrogeological environment.

1.9. The construction methodology indicates use of reinforced concrete underpinning for the construction of the basement together with a bored pile wall for the basement which extends to the rear of the existing house. The BIA makes recommendation for the design of both the permanent retaining structure and the temporary support for the underpin excavations.

1.10. The BIA considers the proposed development in the context of the slope across the site. The proposed development will not impact upon slope stability.

1.11. A ground movement assessment (GMA) has been undertaken that indicates damage to neighbouring properties will be a maximum of Category 1 (Very Slight), in accordance with the Burland Scale. Following discussion with the BIA author, and the submission of the additional calculations requested, this is accepted.

1.12. The BIA presents an outline structural monitoring methodology, including visual condition surveys, measured survey using total station and crack monitoring, if applicable. Frequency of survey, trigger levels and contingency actions are considered appropriate and should be agreed under the Party Wall Act.

1.13. The Environment Agency indicates that the risk of flooding from surface water at 24 Heath Drive is 'Very Low'. Flood resistance measures to protect the basement from local surface water flooding are discussed within the BIA in addition to mitigation measures to protect against sewer surcharging.

1.14. An attenuated drainage scheme involving permeable paving is proposed. The final drainage design should be agreed with LBC and Thames Water. There is no impact to the wider hydrological environment.

1.15. Our comments on the BIA are presented in Section 4. The BIA meets the requirements of CPG Basements.

2.0 INTRODUCTION

2.1. CampbellReith was instructed by London Borough of Camden (LBC) on 13 March 2018 to carry out a Category C Audit on the Basement Impact Assessment (BIA) submitted as part of the Planning Submission documentation for 24 Heath Drive, London NW3 7SB, Camden Reference 2018/0914/P.

2.2. The Audit was carried out in accordance with the Terms of Reference set by LBC. It reviewed the Basement Impact Assessment for potential impact on land stability and local ground and surface water conditions arising from basement development.

2.3. A BIA is required for all planning applications with basements in Camden in general accordance with policies and technical procedures contained within:

- Guidance for Subterranean Development (GSD). Issue 01. November 2010. Ove Arup & Partners.
- Camden Planning Guidance (CPG): Basements.
- Camden Development Policy (DP) 27: Basements and Lightwells.
- Camden Development Policy (DP) 23: Water.
- The Local Plan (2017): Policy A5 (Basements).

2.4. The BIA should demonstrate that schemes:

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; and,

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

and evaluate the impacts of the proposed basement considering the issues of hydrology, hydrogeology and land stability via the process described by the GSD and to make recommendations for the detailed design.

2.5. LBC's Planning Portal described the planning proposal as: "*Demolition of 2 storey side garage and utility room; lowering of the ground levels of the existing basement and new basement extension; erection of single storey garage replacement; part double, part single storey side extension to north east elevation; rear glazed extension following removal of the bay window; front and side dormers and roof lights; internal alterations; tree works and landscaping including wooden shed to the rear.*"

LBC's Planning Portal confirmed that the site is a Grade II Listed building and lies within the Redington and Frognal Conservation area.

2.6. CampbellReith accessed LBC's Planning Portal on 24 April 2018 and gained access to the following relevant documents for audit purposes:

- Basement Impact Assessment dated March 2018 (ref GGC17597/R2.3) by Gabriel GeoConsulting Limited including:
    - Factual report on Ground Investigation dated February 2017 (ref 17597/R1) by Gabriel GeoConsulting Limited.
- Proposed and Existing Drawings dated January 2018 by Kyson.
- Structural Engineer's Construction Method Statement dated 30 January 2018 (ref 162637) by Form Structural Design Ltd.
- Suggested Sequence of Construction dated December 2017 by Form Structural Design Ltd.
- Mechanical and Public Engineering Services Specification dated January 2018 (ref 16117) by Edward Pearce LLP.
- Planning Brochure dated January 2018 by Kyson.
- Tree Survey dated October 2017 (ref 1948 24 Heath Drive Tree Survey Report 1610-31sc.docx), Arboricultural Implication Assessment dated February 2018 (ref 1948 24 Heath Drive AIA 1802-06rc.docx) and Arboricultural Method Statement dated February 2018 (ref 1948 24 Heath Drive AMS 1802-06rc.docx) by Eight Associates.
- Addendum to BIA by Gabriel GeoConsulting Limited, reference GGL17597/R2.3/Add.1.1, dated 19 July 2018. (presented in Appendix 3).
- Comments and objections to the proposed development from local residents.

3.0 BASEMENT IMPACT ASSESSMENT AUDIT CHECK LIST

Item	Yes/No/NA	Comment
Are BIA Author(s) credentials satisfactory?	Yes	
Is data required by Cl.233 of the GSD presented?	Yes	
Does the description of the proposed development include all aspects of temporary and permanent works which might impact upon geology, hydrogeology and hydrology?	Yes	
Are suitable plans/maps included?	Yes	
Do the plans/maps show the whole of the relevant area of study and do they show it in sufficient detail?	Yes	
Land Stability Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	BIA report, Section 7.3.
Hydrogeology Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	BIA report, Section 7.2.
Hydrology Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	BIA report, Section 7.4.
Is a conceptual model presented?	Yes	BIA report, Section 10.1.
Land Stability Scoping Provided? Is scoping consistent with screening outcome?	Yes	BIA report, Section 8.3.

Item	Yes/No/NA	Comment
Hydrogeology Scoping Provided? Is scoping consistent with screening outcome?	Yes	BIA report, Section 8.2.
Hydrology Scoping Provided? Is scoping consistent with screening outcome?	Yes	BIA report, Section 8.4.
Is factual ground investigation data provided?	Yes	BIA report, Section 9 and Appendix C.
Is monitoring data presented?	Yes	Groundwater monitoring discussed in BIA report, section 9.3 and presented in Section 5.7 of Appendix C (Factual Report on Ground Investigation).
Is the ground investigation informed by a desk study?	Yes	
Has a site walkover been undertaken?	Yes	
Is the presence/absence of adjacent or nearby basements confirmed?	Yes	BIA report, Section 10.2.
Is a geotechnical interpretation presented?	Yes	BIA report, Section 10.
Does the geotechnical interpretation include information on retaining wall design?	Yes	BIA report, Section 10.4; Structural Engineer's Construction Method Statement, Appendix C.
Are reports on other investigations required by screening and scoping presented?	Yes	Arboricultural Impact Assessment and Damage Category assessment provided.
Are baseline conditions described, based on the GSD?	Yes	
Do the base line conditions consider adjacent or nearby basements?	Yes	
Is an Impact Assessment provided?	Yes	BIA report, Section 10.

Item	Yes/No/NA	Comment
Are estimates of ground movement and structural impact presented?	Yes	BIA and updated within additional submissions.
Is the Impact Assessment appropriate to the matters identified by screening and scoping?	Yes	
Has the need for mitigation been considered and are appropriate mitigation methods incorporated in the scheme?	Yes	BIA Report, Section 10.9.
Has the need for monitoring during construction been considered?	Yes	BIA Report, Section 10.7.
Have the residual (after mitigation) impacts been clearly identified?	Yes	None
Has the scheme demonstrated that the structural stability of the building and neighbouring properties and infrastructure will be maintained?	Yes	Structural Calculations and GMA provided, updated within additional submissions.
Has the scheme avoided adversely affecting drainage and run-off or causing other damage to the water environment?	Yes	
Has the scheme avoided cumulative impacts upon structural stability or the water environment in the local area?	Yes	BIA Report GMA and Addendum
Does report state that damage to surrounding buildings will be no worse than Burland Category 1?	Yes	
Are non-technical summaries provided?	Yes	

4.0 DISCUSSION

4.1. The BIA has been prepared by Gabriel GeoConsulting Ltd with supporting documents provided by Form Structural Design Ltd and Studio Kyson. The authors' qualifications are in accordance with CPG4 guidelines for all sections.

4.2. The BIA indicates that the proposed development comprises an extension to the existing basement to include excavation for increased ceiling height and lateral expansion beneath the full footprint of the main part of the existing Grade II listed house. The proposed development includes a swimming pool on the north eastern side which will extend beyond the rear wall of the house beneath the rear garden and will be set below the main basement level. A 'sunken pit' level will be created beneath the northern corner of the basement with a suspended floor slab above at the level of the main basement, which will house a plant room and pool attenuation tank. The basement level will be excavated to a depth of 4.30m, the pool level to 6.39m and the 'sunken pit' to a depth of 6.62m below ground level (bgl). The site lies within the Redington and Frognal Conservation area.

4.3. The site investigation undertaken identifies the London Clay as the bearing formation for the proposed foundations, underlying Made Ground. The Made Ground was encountered within all of the exploratory holes with a maximum thickness of 2.25m in the front parking area with thicknesses of 0.25 to 0.30m recorded in the rear garden. Interpretative geotechnical information in accordance with the GSD Appendix G3 is presented.

4.4. The site investigation and BIA have been informed by a desk study broadly in accordance with the GSD Appendix G1.

4.5. No groundwater entries were recorded in either TP1 or TP2, but groundwater was standing at 0.36m below the level of the cellar on completion of TP3. Groundwater was monitored on 3 occasions during November and December 2016 and January 2017. The highest groundwater level recorded was 0.36m bgl in BH3 (in the rear garden).

4.6. Notwithstanding the groundwater monitoring undertaken, the BIA does confirm that use of a design groundwater level at ground level is recommended for the whole basement and that the basement will need to be fully waterproofed in order to provide adequate long-term control of moisture ingress.

4.7. The BIA states that the construction of the proposed basement at no. 24 is not expected to create any 'unacceptable cumulative obstruction or adverse impact on groundwater seepage/flows, because the seepage/flow in any water-bearing permeable horizons intersected by the basement, is likely to be able to continue around the basement, between it and the adjacent cellars to numbers 23 and 25 Heath Drive'.

4.8. The BIA considers the underlying geology, including proximity to the mapped Claygate Member, and proximity to the historic route of a tributary of the River Westbourne. Considering the existing foundation and cellar depths on site and in the adjacent properties, the proposed development into low permeability London Clay does not increase the likelihood of intercepting any shallow groundwater flow (if present). The proposed development will not impact upon the wider hydrogeological environment.

4.9. The construction methodology indicates use of reinforced concrete underpinning for the construction of the basement together with secant bored pile wall for the section of the swimming pool which extends to the rear of the existing house. Structural calculations and retaining wall design are provided in the Structural Engineer's Construction Method Statement.

4.10. The overall slope angle from the rear wall of the house to the rear site boundary is up to 9.1° and slope angles of up to 19° are present locally. The BIA therefore recommends for the rear wall of the basement that the design of both the permanent retaining structure and the temporary support for the underpin excavations should be based on 'effective residual' shear strength parameters for the Weathered London Clay and the underpin pits to be excavated in the rear wall of the basement should be inspected by an engineering geologist who is experienced in logging soliflucted clay textures.

4.11. The BIA considers the proposed development in the context of the slope across the site. The proposed development will not impact upon slope stability.

4.12. A ground movement assessment (GMA) has been undertaken that indicates damage to neighbouring properties will be a maximum of Category 1 (Very Slight), in accordance with the Burland Scale. The original GMA did not consider the impacts from the bored pile wall or from two stages of underpinning. Following discussion with the BIA author, additional calculations were submitted to consider impacts to 23 and 25 Heath Drive from both underpinning and piling. The assessment, which is based on conservative assumptions with respect to the geometry of the affected buildings and the magnitude of movement anticipated, results in a prediction of Category 2 damage for the rear wall of No. 23 Heath Drive. However, the author notes that the rear wall of No. 23 is over 2m from the end of the bored pile wall and will therefore be subject to lesser ground movements that suggested by the CIRIA data, resulting in no worse than Category 1 damage. This is accepted on the proviso that a suitable monitoring scheme is implemented with appropriate trigger values and mitigation measures.

4.13. The BIA presents an outline structural monitoring methodology, including visual condition surveys, measured survey using total station and crack monitoring, if applicable. Frequency of survey, trigger levels and contingency actions are considered appropriate and should be agreed under the Party Wall Act.

4.14. A former course of one of the tributaries of the River Westbourne once flowed in the base of the valley which is now Heath Drive. The stream flowed from north-east to south-west in this area. The 1870 Ordnance Survey map shows this stream flowing just to the north-west of the site along with two tributaries (one to the northwest merging with the main stream downslope of the site and another a short distance to the northeast of the site). None of the streams are shown on the 1894 Ordnance Survey map and therefore it is assumed that they have been culverted or diverted into the sewer system.

4.15. Heath Road is within Critical Drainage Area (Group 3-010) but is not located within a Local Flood Risk Zone. The Environment Agency indicates that the risk of flooding from surface water at 24 Heath Drive is 'Very Low'. Heath Drive was not subject to surface water flooding during 1975 or 2002 events. Within the Heath Drive carriageway an area at 'Low' risk of flooding from surface water is shown extending the full length of the road, becoming 'Medium' risk further downslope. Flood resistance measures to protect the basement from local surface water flooding are discussed within the BIA (section 10.8) in addition to mitigation measures to protect against sewer surcharging.

4.16. The proposed scheme will increase the proportion of hardstanding at the site by approximately 150m^2. The SuDS assessment recommends the replacement of paving and asphalt with resin-bound gravel to create permeable paving, resulting in a net increase in permeable site area, linked to an attenuated drainage system. The final drainage design should be agreed with LBC and Thames Water. There is no impact to the wider hydrological environment.

5.0 CONCLUSIONS

5.1. The qualifications of the authors are in accordance with LBC requirements.

5.2. Desk Study information within the BIA is broadly in line with aspects recommended in the GSD Appendix G1.

5.3. A site investigation has confirmed the underlying ground conditions to comprise Made Ground over the London Clay. The data is presented in an interpretative report in accordance with GSD Appendix G3. The proposed development will not impact the wider hydrogeological environment.

5.4. The construction methodology, structural scheme and temporary works proposed are generally accepted.

5.5. The BIA considers the proposed development in the context of the slope across the site. The proposed development will not impact upon slope stability.

5.6. A ground movement assessment (GMA) has been undertaken that indicates damage to neighbouring properties will be a maximum of Category 1 (Very Slight), in accordance with the Burland Scale. Following discussion with the BIA author, and the submission of the additional calculations requested, this is accepted.

5.7. The BIA presents an outline structural monitoring methodology, including visual condition surveys, measured survey using total station and crack monitoring, if applicable. Frequency of survey, trigger levels and contingency actions are considered appropriate and should be agreed under the Party Wall Act.

5.8. The risk of flooding from surface water at 24 Heath Drive is 'Very Low'. Flood resistance measures to protect the basement from local surface water flooding are discussed within the BIA in addition to mitigation measures to protect against sewer surcharging.

5.9. An attenuated drainage scheme involving permeable paving is proposed. The final drainage design should be agreed with LBC and Thames Water. There is no impact to the wider hydrological environment.

5.10. Discussion is presented in Section 4. The BIA meets the requirements of CPG Basements.

Appendix 1: Residents' Consultation Comments

Residents' Consultation Comments

Surname	Address	Date	Issue raised	Response
Alaghband	23 Heath Drive	21/03/18	The residents of 23 Heath Drive have employed the services of Professor de Freitas of First Steps Ltd to assess the BIA written by Gabriel GeoConsulting Ltd. His main concerns are: - The groundwater regime is not fully understood - Groundwater levels should be confirmed prior to construction works - Mitigation measure should be part of the detailed design - The likely presence of shear surfaces within Head Deposits/weathered London Clay has implications for the stability of neighbouring properties. - The calculations presented to demonstrate the predicted outcomes will be within the prescribed limits required by Camden use values for mechanical properties that are not site specific because the method of investigation used did not permit site specific values to be obtained.	Section 4
	Heath and Hampstead Society	09/03/18	N/A to BIA audit criteria	N/A
	Thames Water	27/02/1	Thames Water requests that the Applicant should incorporate within their proposal, protection to the property by installing for example, a non-return valve or other suitable device to avoid the risk of backflow at a later date, on the assumption that the sewerage network may surcharge to ground level during storm conditions. We would expect the developer to demonstrate what measures he will undertake to minimise groundwater discharges into the public sewer: "A Groundwater Risk Management Permit from Thames Water will be required for discharging groundwater into a public sewer. Any discharge made without a permit is deemed illegal and may result in prosecution under the provisions of the Water Industry Act 1991. We would expect the developer to demonstrate what measures he will undertake to minimise groundwater discharges into the public sewer.	Section 4

Appendix 2: Audit Query Tracker

None

Appendix 3: Supplementary Supporting Documents

- Addendum to BIA by Gabriel GeoConsulting Limited, reference GGL17597/R2.3/Add.1.1, dated 11 July 2018

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Our Ref: GGC17597/R2.3/Add.1.1

19th July 2018

Addendum to Basement Impact Assessment
24 Heath Drive, London, NW3 7SB

This addendum is supplementary to, and should be read in conjunction with, our Basement Impact Assessment (BIA) report dated 2nd March 2018 (Ref: GGC17597/R2.3).

1 Introduction

1.1 In section 10.6 of our Basement Impact Assessment (BIA, Ref: GGC17597/R2.3), No.25 Heath Drive was identified as the more susceptible to damage from the construction of the proposed basement beneath No.24 (compared with the adjacent No.23), due to both its proximity to the proposed basement, and the results of the PDISP analyses, which indicated that maximum settlement will occur alongside No.25. As a result, separate damage categories were previously carried out for both the front wall of No.25's garage, and the main rear/internal wall of No.25.

1.2 Camden's auditors for BIAs, Campbell Reith Hill LLP, have asked for additional assessments to be carried out in order to confirm that the potential for damage to No.23 Heath Drive as a result of the construction of the proposed basement beneath No.24 would also be within acceptable limits. These damage category assessments have considered movements arising from the two-storey part of the proposed basement beneath the north-east side of No.24, as well as movements arising from the proposed perimeter Bored Pile Wall (BPW) at the rear of the house.

2 Additional Damage Category Assessments

2.1 As outlined in our BIA (Ref: GGC17597/R2.3), the neighbouring properties of No's 23 and 25 Heath Drive do not adjoin No.24. The superstructure of No.23 is broadly similar to No.24, and both No's 23 and 25 have attached single-storey garages on their north-eastern sides. No.25 has a broadly similar cellar to No.24, which is located beneath the northern corner of the main part of the house (plan available). No.23 is also thought to have a cellar, but its exact location and dimensions are unknown; based on the location of the stairs on the ground floor plan taken from Camden Council's planning website (see paragraph 2.10 of GGC17597/R2.3), it is also likely to be located beneath the northern corner of the main part of the house, similar to No.24's (this interpretation of the location of the cellar beneath No.23 is a correction of paragraph 10.6.3 of our original BIA). No.24's proposed basement will be located within approximately 3.70m of No.23 at its closest point, based on Form SD's Proposed Basement Plan (Drg No.162637/L(17)02/P3). At No.23, the worst case

scenarios will occur at the property's front and rear walls, since these walls are approximately perpendicular to the proposed basement beneath No.24 and are closest, respectively, to the double depth part of No.24's basement and to the BPW. Since the exact position of No.23's cellar is unknown, the beneficial effect it will create by decreasing the differential foundation depth between No's 23 & 24 has been ignored, resulting in a 'worst case' scenario being analysed.

2.2 For the front wall of No.23, the PDISP analyses indicated that the settlements will radiate further from the proposed footprint of No.24's basement towards No.23's footprint in Stage 1, which therefore represents the worst case stage. Although the PDISP analyses indicated that settlement movements were greatest alongside the front wall of No.23, a damage category assessment has also been carried out for the rear wall of No.23, to analyse movements associated with the installation of the BPW at the rear of No.24. For the rear wall of No.23, the PDISP analyses indicate that Stage 4 represents the worst case stage, since the beneficial heave movements were shown to radiate a shorter distance from the proposed footprint of No.24's basement towards No.23's footprint.

2.3 Separate damage category assessments have been undertaken for both the front and rear walls, which considered:

- ground movements arising from the vertical stress changes, as assessed by the PDISP analyses (see BIA Section 10.5);
- ground movements alongside both the proposed underpins and the bored pile wall caused by relaxation of the ground in response to the excavations; and
- Ground movements alongside the proposed BPW from installation (rear wall only).

Ground movements associated with the construction of retaining walls in clay soils have been shown to extend to a distance up to 4 times the depth of the excavation.

<u>Front wall of No.23:</u>

2.4 The front wall of No.23 includes two two-storey bays, located either side of the front entrance, however these were ignored for this damage category assessment. As a result, a single wall extending the full width of the property was modelled, so that a worst case scenario was analysed. The relevant geometries are summarised below:

Depth of foundations = 1.0m (assumed) below ground level at front of No.23.
Ground level at front of No.23 = 88.74m AOD (scaled from drawings)
Depth of excavation beneath ground level at No.23 = 88.74 – 81.48 = **7.26m**
Width of zone of affected soils = 7.26 x 4 = **29.04m**
Width of No.23's front wall (L) = **14.94m** (closest point located **4.30m** from No.24's basement; see Figure 1 below)
Height (H) = 6.70 + 1.00 = **7.70m** (wall height + foundation)
Hence L/H = **1.94**.

2.5 Thus, for the anticipated (theoretical) horizontal displacement of **10mm** (increased pro rata for a typical two-storey deep basement, as a worst case scenario, based on a typical value of 5mm for a single-storey basement, with a depth of around 3.5m), the strain beneath the front wall of No.23 would be in the order of $\varepsilon_h = 3.44 \times 10^{-4}$ (0.034%).

2.6 The maximum settlement predicted by the PDISP analysis adjacent to the front wall of No.23 was 4mm in Stage 1, though very similar movements were also predicated in stages 2 & 3 (see Figure G3 in Appendix G). This must be combined with the settlement caused by relaxation of the ground alongside the basement in response to excavation of the underpins, which can be estimated using the settlement profile for the worst case (low stiffness) scenario presented in Figure 6.13(b) of CIRIA Report C760. The settlement profiles are then summed to find the maximum deflection, Δ. Figure 1 presents these settlement profiles for No.23's front wall. The maximum Δ = 1.94mm, which represents a deflection ratio, $\Delta/L = 1.30 \times 10^{-4}$ (0.013%).

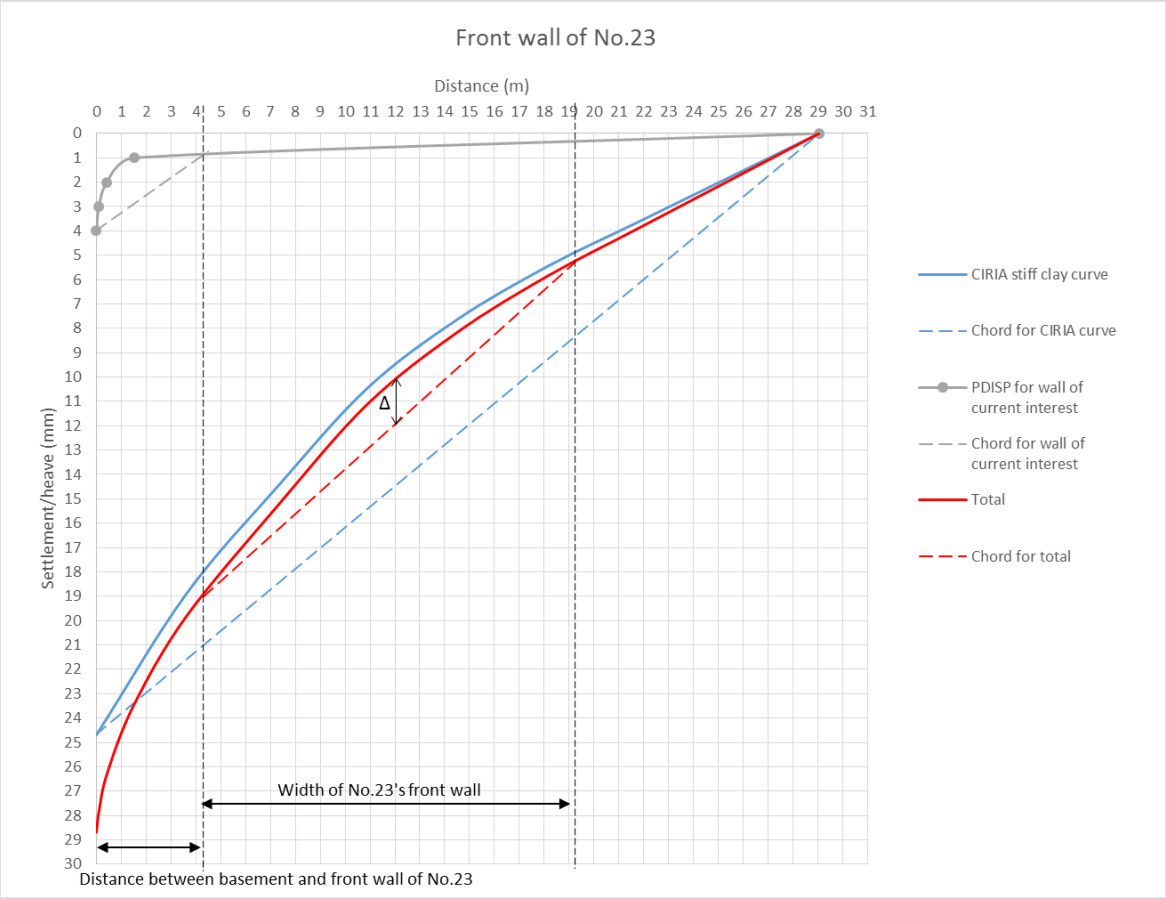

Figure 1: Displacement profile for front wall of No.23.

2.7 Using the graphs for L/H = 2.0, these deformations represent a damage category on the boundary between 'very slight' (Burland Category 1, ε_{lim} = 0.05-0.075%) and 'negligible' (Burland Category 0, ε_{lim} = 0.00-0.05%), as given in CIRIA SP200, Table 3.1, and illustrated in Figure 2 below.

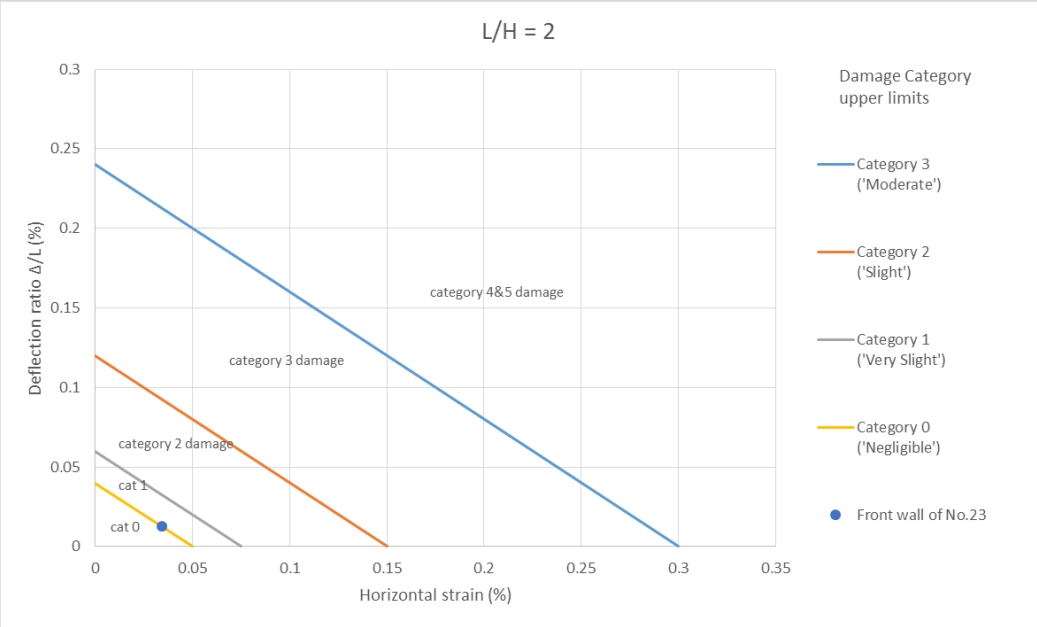

Figure 2: Damage category assessment for front wall of No.23.

<u>Rear wall of No.23:</u>

2.8 At the rear of No.23 is a two storey rear projection on its north-east side, and a small single storey bay on its south-west side. For this damage category assessment, the rear wall of No.23 has been modelled as extending the full width of the property, including the rear projection, to reflect a possible 'worst case' scenario. The relevant geometries, using a similar methodology as above, are summarised below:

Depth of foundations = 1.0m (assumed) below ground level at rear of No.23.

Ground level at rear of No.23 = 89.45m AOD (scaled from drawings)

Depth of excavation beneath ground level at No.23 = 89.45 – 82.61 = **6.84m**

Width of zone of affected soils – pile installation = 13.0 x 1.5 = **19.5m**

Width of zone of affected soils – excavation = 6.84 x 4 = **27.36m**

Width of No.23's rear wall (L) = **14.94m** (located **4.50-19.44m** from nearest bored pile around No.24's basement pool)

Height (H) = 6.20 + 1.00 = **7.20m** (wall height + foundation)

Hence L/H = **2.08**

Bored Pile Walls:

2.9 Some ground movement is inevitable when basements are constructed, even when using bored pile walls. Ground movements alongside the piles have been assessed using relationships developed from empirical case history data published in CIRIA's report C760 (Gaba et al, 2003). That report noted that "*ground movements cannot be predicted accurately, but it is possible to estimate them based on … an empirical approach …*" as presented in the following paragraphs. The movements in ground supported by a bored pile wall are highly dependent on the stiffness of the support system as a whole. For the proposed 'bottom-up' construction method to be classified as 'High support stiffness' (as used for the damage category assessment below), an appropriate construction sequence will need to be followed, with temporary props installed at high level that can equal the stiffness of the RC roof slab. Alternatively a 'top-down' construction method could be implemented, with the RC roof slab cast prior to excavation.

2.10 CIRIA Report C760 presents charts which relate measured ground surface movements alongside bored pile retaining walls in stiff clays to pile installation (Figure 6.6 therein) and excavation in front of the wall (Figure 6.13). These charts are based on measurements taken perpendicular to a continuous run of BPW, whereas No.23's rear wall is offset by approximately 2.1m (closer to Heath Drive) from the end of the bored pile wall. While the basement does continue forward from the BPW, the offset from the BPW means that the displacements likely to be experienced are expected to be lower than the values predicted from the CIRIA charts.

2.11 As the site is underlain by London Clay, use of a full secant BPW will not be necessary; a combination secant/contiguous wall, with the female piles taken down only as far as the formation level, would provide a significant cost saving so that wall configuration has been analysed. For 'high support stiffness' walls designed and constructed in accordance with best practice, the estimated ground surface movements resulting from installing a secant/contiguous bored pile wall to an estimated depth of 13.0/7.0m below the ground level at the rear of No.23, and then excavating to a depth of 6.84m below the ground level at the rear of No.23, would be as given in Table 1 (allowing for the 4.5m offset between No.24's proposed basement and the rear wall of No.23). Mean values between the secant and contiguous BPWs were used for the installation displacements. Where the CIRIA data gave linear design 'curves' the predicted displacements were calculated pro-rata to the length of No.23's rear wall. The 13.0m pile depth has been estimated because, under standard UK practice, the design analyses for bearing piles are undertaken by the piling contractor.

Table 1: Potential approximate ground movements below rear wall of No.23 (at 4.5-19.44m from bored pile wall)		
High support stiffness – 6.84m depth of excavation / 13.0m deep wall		
Ground surface movements due to:	**Horizontal movement**	**Vertical movement**
Bored pile wall installation:	Reading from graphs: 0.039% of wall depth = 5.07mm	0.045% x 14.94/(2*13.0) = 0.026% of wall depth = 3.36mm
Excavation in front of wall:	0.15% x (14.94/27.36) = 0.082% of excavation depth = 5.61mm	Max 0.075% of excavation depth = 5.13mm
Totals:	**10.68mm**	**8.49mm**

2.12 Following the same methodology as used for the underpins (in paragraphs 2.5 to 2.7) the strain beneath No.23's rear wall would be in the order of ε_h = 7.15 x 10^{-4} (0.072%).

2.13 The upper bound lines for vertical movements in response to installation of a bored pile wall (secant or contiguous) in stiff clays are linear, so will generate no deflection (Δ, as defined in paragraph 2.6). The High support stiffness graph was used to estimate the deflection likely to occur in response to excavation of the basement alongside the bored pile wall; this graph predicts a settlement trough alongside the retaining wall, though as No.23's rear wall will be 4.5m from the end of the BPW, the nearest corner of No.23's rear wall will be in the base of the trough, beyond which the curve is almost linear. When the separation between the bored pile wall and No.23's rear wall is taken into account (4.5 to 19.44m), the maximum deflection Δ = 0.68mm, which represents a deflection ratio, Δ/L = 4.55 x 10^{-5} (0.005%).

2.14 Using the graphs for L/H = 2.0, these deformations represent a damage category of on the boundary between 'slight' (Burland Category 2, ε_{lim} = 0.075-0.15%) and 'very slight' (Burland Category 1, ε_{lim} = 0.05-0.075%), as given in CIRIA SP200, Table 3.1, and illustrated in Figure 3 below. In practice, as these analyses have not allowed for the offset between the rear wall of No.23 and the nearest end of the BPW, it is considered that Category 1 will be applicable to No.23's rear wall.

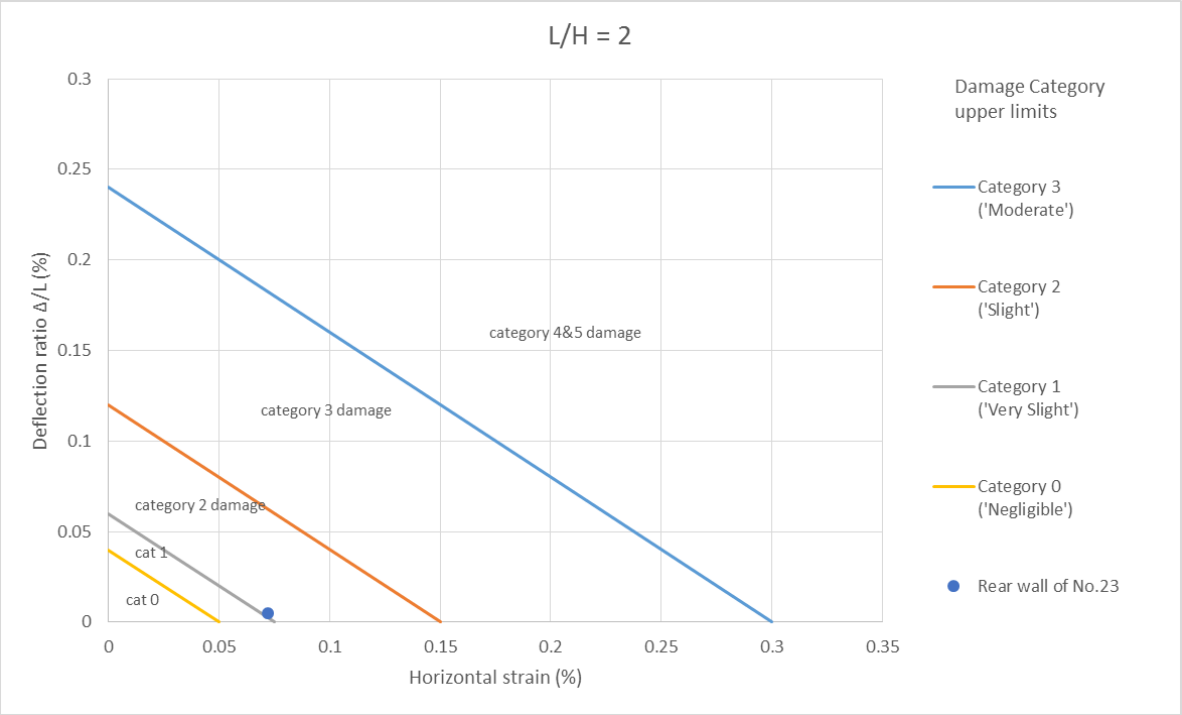

Figure 3: Damage category assessment for rear wall of No.23.

2.15 Use of best practice construction methods, as outlined in Section 10.4 of our BIA, will be essential in order to ensure that the ground movements are kept in line with the above predictions.

- END -

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