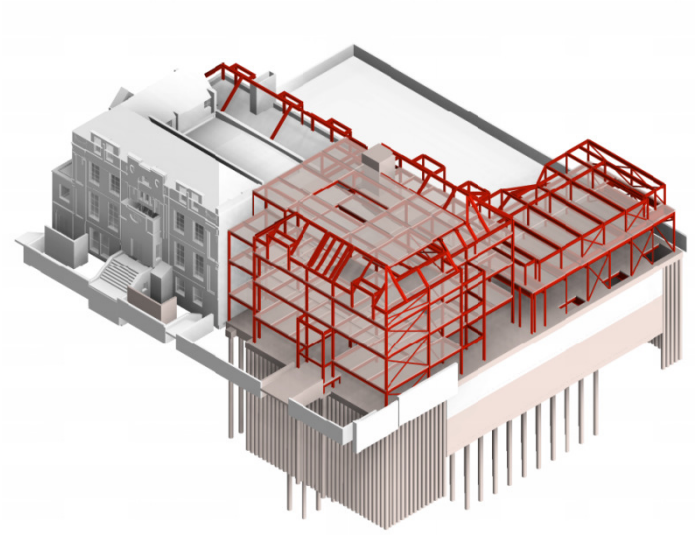

The Hall School
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The Hall School

Response to Eldred Geotechnics Report: Technical Advice G1701-TA-01-EA EW Comments

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Executive Summary

This document is a technical review of a report commissioned by a local group who are opposed to the proposed Hall School development. The report is written by Eldred Geotechnics Ltd (ref: G1701-TA-01-E1, dated February 2017). The entirety of the Eldred report is included within this document with relevant Elliott Wood (EW) comments. The below is a summary of the three main discussion points.

1. Eldred damage assessment

Eldred have provided alternative Burland Scale damage category assessments for each of the neighbouring buildings, and concluded that the proposal as a result does not comply with Camden Council Planning Policies DP27(a) and CPG4. No calculations or explanation of their methodology have been provided to support their assessment. It appears that Eldred have increased the submitted damage category by 1 for all adjacent buildings without supporting calculations or analysis. EW disagrees with the assessment; the method of Ground Movement Analysis (GMA) submitted has been conducted in a thorough and conservative manner.

2. Eldred's review of damage assessment analysis (Eldred text is in *italic,* EW response is in standard text).

Cumulative impacts of existing and proposed not accounted for. This is not a requirement of the GMA as building distress is determined in terms of strain or deformation (not stress), further the soil and existing buildings will have reached equilibrium in the intervening years. It is considered less onerous to construct a basement in two stages split by over 30 years rather than in a single construction stage. Condition surveys will be undertaken to establish if structural damage to the neighbouring buildings exists and if found mitigation measure will be reviewed.

Overly optimistic computer input values used. This is incorrect; the analysis method is inherently conservative. This is further explained within the main body of the document.

Sub-station and Hereward School not included. The Hereward classroom referred to is included within the assessment and the sub-station forms part of the 24 Crossfield Road buildings.

Comments in the BIA which seek to enhance the proposal are unjustified, line loads less than stated and workmanship will be so good as to improve the calculated risk assessment results in favour of the applicant. The above statement has been made out of context. The GMA assumes the quality of workmanship is average. The loads provided by EW are based on outline designs and will be reviewed following detailed design; any significant differences will be reviewed with the Ground Movement Analysis.

3. Eldred comments on permanent and temporary safety

Eldred state that the application provides no information to justify either the permanent or temporary safety or construction sequencing. EW disagrees in that the BIA covers these topics and that further information has been provided to Camden Council to augment the package. This includes possible methods of sequencing the basement construction and outline permanent works calculations for the retaining structures.

Conclusion

EW, GEA and an independent ground specialist all agree that the points raised in the Eldred report have all been considered within the application for the Hall School development. The approach taken has been both conservative and rigorous.

Contents

Introduction

We have reviewed the Eldred Geotechnics Technical Advice report (ref: G1701-TA-01-E1, dated February 2017) and have responded below with our comments.

We have endeavoured to answer the concerns raised as succinctly as possible without causing any further confusion over the main issues associated with The Hall School redevelopment proposals.

For clarity we have copied out the entire report in '*italic text*' and included our comments below each of the sections in standard text.

Eldred Report:

1 Introduction and summary of conclusions

1.1 Introduction

1. *This advice comprises a limited review of the subterranean elements of planning application 2016/6319/P to Camden Council, and my opinion of its compliance with the Council's planning policy DP27(a). It has been prepared for the Hall School Opposition Group comprising the owners of the majority of houses in the 24-30 Crossfield Road terrace, Nos. 50 and 52 Eton Avenue and garages serving Eton Court and others. My instructions to prepare the advice for the group were given by Mr Kay of 26 Crossfield Road.*

2. *I am specifically required to consider the risk that the development proposed by the application will cause unacceptable levels of damage to Nos. 24-30 Crossfield Road Nos. 50 and 52 Eton Avenue, garages serving Eton Court and a classroom in the grounds of Hereward House School, Strathay Gardens. The advice is limited to those matters.*

3. *I advise as a Chartered Civil and Structural Engineer with more than 40 years' experience of practicing independently as a Consultant in the disciplines of Geotechnical, Geo environmental, Civil and Structural engineering. Dr M.H. de Freitas has reported separately on issues pertaining to geology and groundwater [1} and I have relied upon that information.*

EW Response: No comment

1.2 Summary of conclusions

4. *DP27(a) states that Camden Council will require developers to demonstrate by methods appropriate to the site that schemes maintain the structural stability of the building and neighbouring properties. CPG4 describes ways in which that might be done and the Category 1 risk of damage that will be tolerated.*

EW Response:

This statement is not strictly correct; Category 1 and 2 are permitted provided mitigation measures have been taken into consideration and included within the proposals. The majority of the results of the ground movement analysis are deemed 'negligible – category 0'. For the neighbouring properties there are two results that fall into 'slight-category 2' both are for No. 24 Crossfield Street, the report states that in these location the results are only just within category 2. With this in mind and the conservative nature of the analysis the risk of damage to neighbouring properties is considered to be in line with Camden Council's guidance documents.

The analysis undertaken by GEA is considered conservative for a number of reasons:

- Underpinned section modelled as planar concrete walls.
- The predicted movements are based on the worst case of individually analysed segments in hogging and sagging that have been combined.
- The software does not include any lateral propping or corner stiffening, although the movement curves used within Ciria 580 are based on measured movements, derived from propped walls.

Based on the above it can be argued that the category 2 results would more likely result in movements associated with category 1 due to GEA's rightly conservative approach.

See below extract of CPG4, list of mitigation measures and extract from GEA report.

Extract from CPG4:

"In line with policy DP27 the Council will ensure that harm is not caused to neighbouring properties by basement development. Burland states that it is a major objective of design and construction to maintain a level of risk to buildings no higher than category 2, where there is only risk of aesthetic damage to buildings (see Burland, J. , Imperial College London, 1995). However the Council considers that neighbouring residential properties are particularly sensitive to damage, where relatively minor internal damage to a person's home can incur cost and considerable inconvenience to repair and redecorate. The Council therefore will expect BIAs to provide mitigation measures where any risk of damage is identified of Burland category 1 'very slight' or higher.

Following inclusion of mitigation measures into the proposed scheme the changes in attributes are to be re-evaluated and new net consequences determined."

Mitigation measured to reduce or control ground movements:

1) Propping in the temporary case.
2) Propping by structure in the permanent case by structure at floor levels.
3) Movement Monitoring.

Extract from GEA SI Report:

"Additional analysis shows that a reduction in the difference in horizontal displacements along the two elevations of No 24 Crossfield Street would reduce the building damage to Category 1. As the movements are expected to be less than those currently predicted, and will be controlled through the use of suitable propping, it is therefore considered likely that the damage sustained along these elevations will be less than Category 2."

5. *I conclude that the application fails to demonstrate that the scheme complies with DP27(a) and CPG4 insofar as the risk of damage to Nos. 24 to 27 Crossfield Road, an electrical substation in No.24 Crossfield Road, Eton Court garages and a classroom in the garden of Hereward School are concerned.*

EW Response:

We disagree with this statement because the application follows industry standards and complies with both DP27(a) and CPG4.

6. *Construction sequences have not evidently been thought through in practical terms in that the effect on proposed construction methods of temporary support elements that are likely to have remained following construction of the existing basement have not been considered.*

EW Response:

We disagree with this statement. The construction sequences have been considered in sufficient detail. Additional information has been provided to Camden Council to further support the application.

7. *The potential cumulative impact of the original and proposed basement excavations on structural damage risk for neighbouring property have not been accounted for.*

EW Response:

It is not the case that damage assessments should consider previous history unless there is an existing observable defect in the structure in its present condition. However, we will provide a brief commentary on this.

Building a double basement in two stages over a 30 year period is the same if not less onerous, for the adjacent buildings, than building the double basement in a single stage. Building distress is determined in terms of strain or deformation, not stress. Deformations resulting from the original build are considered to have been minimal and non-structural. In the intervening 30 years it is expected that the buildings will have reached a state of equilibrium with the soil. A third party specialist has been consulted and agrees with this assessment.

There are no major-structural defects visible in the neighbouring buildings. A condition survey of the various neighbouring elevation will be carried out. If any major-structural damage is identified the GMA will be revisited to determine the requirement for mitigation measures.

8. *Assessment of damage risk for neighbouring property has been made using overly optimistic computer input values, which have the effect of appearing to reduce the impact of the proposal.*

EW Response:

We disagree with this statement. GEA have based their analysis on an inherently conservative approach; please see comment under section 4 for further clarification.

9. *Risk of damage to an electrical substation and a classroom in Hereward School have been ignored.*

EW Response:

The Hereward School classroom building is included in the ground movement analysis. The substation building is considered as part of the buildings associated with No. 24 Crossfield Road. Refer to GEA report for more information.

10. *Camden planning guidance CPG4 permits schemes to evince damage risk for neighbouring property no greater than Category 1.*

EW Response: See comment to clause 4.

11. *I find that the following risks currently exist.*

    (a) 24-27 Crossfield Road Category 2
    (b) Eton Court garages Category 3
    (c) Hereward House classroom Category 2
    (d) Electrical substation Category 2 (building only, risk to power lines unknown)

EW Response:

These damage category assessment levels appear to have been based on the author's judgment rather than a detailed calculation model. Without further data or evidence to back up these claims these readings should be

discounted. The Hall School BIA and planning application have been based on a detailed set of calculations and a conservative ground movement assessment.

12. *Comments in the BIA which seek to enhance the proposal are unjustified. The BIA states that building loads will differ from those provided by the structural engineers so as to reduce ground heave caused by the excavation. It also states that the contractor's workmanship will be so good as to improve the calculated risk assessment results in favour of the applicant. There is no evidence of the first and the design team have no way of knowing what an as yet unknown contractor will do.*

EW Response:

The current loads are outline loads that are subject to detailed design. We have discussed the implications of increased loadings with GEA. They have used the line loads given, if there are any significant changes we will review again.

The GMA and associated data assumes that workmanship is considered to be average. However due to the size of the project it is likely to attract an established main contractor who will employee more reliable ground workers than if this was a smaller project. On this basis the analysis could be considered conservative. To confirm, superior workmanship has not been used to reduce the calculated movement. The underpinning section has been modelled using movement curves for planar concrete walls, this is a conservative approach. The only mention of workmanship in GEA's report is regarding the underpinning works see below extract, this is to ensure that standard practice is followed and has not influenced the analysis.

Extract from GEA Report:

There is a wealth of experience with respect to the construction of underpinned retaining walls that suggests that ground movements should remain typically within the range of 2 mm to 5 mm following completion of the works, provided that they are installed by a reputable and experienced contractor in accordance with the guidelines published by the Association of Specialist Underpinning Contractors, which indicates that the predicted movements represent a conservative assessment of the likely movements.

13. *DP27(a) also requires applications to demonstrate the stability of the proposed basement. The application provides no information to justify the permanent safety of the proposed subterranean scheme.*

EW Response:

We disagree with this statement. The permanent structural design has been progressed to a more than adequate level for this stage in the design process. Outline calculations have been submitted to Camden Council for both construction types.

14. *The engineers' drawings provide no information either about how the works might be sequenced to provide continuity of support adequate to prevent unacceptable ground movement and damage beyond the excavation during the construction process.*

EW Response: Refer to comment to clause 6.

15. *In effect, the application provides no information to justify either the permanent or temporary safety of the proposed subterranean scheme or its ability to prevent damaging ground movement.*

EW Response:

The permanent structure has been designed in order to provide 'safety' of the proposed subterranean scheme. Outline calculations have been provided to Camden Council to further support the application. Detailed design will be completed in the next stage.

In the temporary case propping has been indicated at multiple heights, additional information has been provided to Camden Council for a possible method of sequencing the construction. However the final temporary works will be undertaken by the contractor. In our role as 'Basement Engineer' Elliott Wood will ensure that the final proposals align with the BIA in terms of ground movement and if possible improve the current assessment.

For both permanent and temporary cases a conservative analysis of the ground movements has been undertaken.

16. *Absence of such information is a fundamental failure of the application. It is not excused by the decision in the 2015 revision of CPG4 to allow final information about working sequence and temporary support to be delayed until a contractor has been appointed subject to a Section 106 agreement. Design engineers are required by legislation to ensure that their designs can be constructed safely and that includes consideration of practicable methods of temporary as well as permanent support.*

EW Response: Refer to comment to clause 15.

17. *My overall conclusion is that matters affecting compliance with DP27(a) and CPG4 need to be reconsidered by the applicant's advisers without use of criteria that falsely minimise the potential impact of the basement proposal.*

EW Response:

We fundamentally disagree with this statement. The information provided within the submission for both the temporary and permanent cases have been progressed sufficiently to align with the requirements in DP27(a) and CPG4.

2 Hall School – Relevant development history and proposal

2.1 Topography

18. *The application lacks topographical survey information. Lidar DTM data indicates that the school is on the north slope of a shallow valley. The valley falls in a direction slightly south of west at a shallow gradient of approximately 1:300 and, locally, the north slope falls to the south at a gradient of about 1:100. Crossfield Road runs North to South and has been raised slightly above the land to either side so that it was originally about 1.4m above ground level at the front (west) of the school site and 1.2m above the back playground area.*

EW Response: No comment.

2.2 Development history

19. *Initially, the school seems to have occupied a hall placed in the northern part of 23 Crossfield Road. The southern and eastern parts of the site were open playground areas surfaced with tarmacadam and having surface levels of about 55.8m OD and 55.6m OD at back and front of the site respectively. There was an access ramp rising to public footway level at the front.*

20. *Numerous minor planning consents were granted for the southern area after WW2 and eventually extensive redevelopment of the area followed consent to planning application TP8700144 in 1987.*

21. *Of relevance to this advice is the construction of the existing basement at that time. This extends in length from approximately 12m from the back of the public footway to a staggered line varying between 1m and 2.5m from the east boundary and, in width, from 1.5m from the southern boundary to the main school building. These are the visible limits shown by drawings; the unknown construction thicknesses of the walls would have increased the excavated area and decreased its distance from the boundaries.*

22. *The floor of the basement is 3.5m below the former playground level (now the level of a path beside the southern boundary) and I estimate that the necessary excavation would have been approximately 4m deep from the same level. Basement formation level was thus 51.6m OD.*

23. *No information concerning the method by which the existing basement was constructed in around 1987 is provided by the application. Considering the scope of the project and proximity of previously constructed property, however, my experience of that time suggests that the retaining walls were most likely to have been of cantilevered closely spaced contiguous piles designed to support the earth face without specific consideration of ground movement and faced with a reinforced concrete wall cantilevering from the basement floor.*

EW Response:

It is more likely that the temporary retaining wall was propped at the head in the temporary condition with intermediate props added where necessary. The permanent solution provides a robust concrete box with a stiff 375mm retaining wall.

2.3 Proposed development

2.3.1 General scope of subterranean construction

24. The intention shown by the current application is to create an enlarged basement. The area required for this, including wall construction thickness, is shown by the application drawings to extend from 5.5m from the back of the public footway to 0.5m from the eastern site boundary and, in width, from the main building to 1m from the southern site boundary.

25. The base of the excavation required would be 8.2m below the pathway beside the southern boundary or 47.4m OD. To achieve this, the depth of new excavation would be 8.2m at the front of the site and 4.2m where the current basement exists.

2.3.2 Construction Method Proposed

26. Drawings by engineering consultants Elliott Wood provide schematic information which illustrates pictorially the following intentions in principle.

27. Large parts of the existing school buildings are to be demolished to make way for the new construction proposed. Where no basement previously existed, a wall of closely spaced contiguous piles which extend below the proposed basement floor will support the lateral forces from surrounding ground and structures. Where there is already a basement, the existing perimeter retaining walls will stay and will be deepened by new concrete walls formed by underpinning.

28. The underpinning walls will be constructed in short lengths and each length will be made in two stages of depth: the existing wall will be underpinned and the first stage of underpinning will also be underpinned.

29. On completion of the walls and excavation, the basement floor, intermediate floor (where required) and ground level floors will be constructed in that order.

3 24 - 30 Crossfield Road & 50-52 Eton Avenue

3.1 Topography and history

30. *No. 24 is immediately to the south of and adjoins the land of Hall school. The house forms the end of an approximately 40m long terrace of seven broadly similar three storey houses, which were built in the 1960s. No.24 has an attached garage between the house and the school boundary.*

31. *Behind the garage and next to the boundary is an electricity substation, which is likely to be the property of UK Power Networks.*

32. *Until around 1960 the land had been the garden of 52 Eton Avenue. There is no planning record for the development or the substation but planning records for the school show the land vacant with No 52 demolished in 1964 and No.24 in place, apparently without garage or substation in 1971.*

33. *Relevant dimensions are:*

Back of pavement to front of house and garage	*6.0m*
Width of garage	*3.7m*
Width of house	*5.7m*
Length of garage	*6.0m*
Length of house	*10.7m*
Length of substation	*5.4m*

34. *According to Lidar DTM data, ground slopes down from a height of 56.75m OD at the pavement in front of No.24 to an approximate ground floor level of 56.00 at the house and a general level of about 55.25m OD in the rear garden. This places the ground floor of No.24 approximately 0.4m above the adjacent pathway in the school, rather than 1m below that level as suggested by the application*

EW Response:

The above statement is incorrect. The pathway to the side of the school is approximately at pavement level, which is above the ground floor level of the neighbouring buildings.

35. *There is nothing about the topography described or the ground conditions reported to suggest that foundations of a housing development of this type constructed in the 1960s would have been anything but shallow spread footings set 1m below ground level. That is to say founded at roughly 55m OD at the front of the house and 54m OD at the rear.*

EW Response:

Refer to comment to clause 34 regarding the levels. Founding level given above is incorrect in relation to the proposal.

The application assumes spread footings which is the worst case for the design. However, the First Site geological report suggests that there is anecdotal evidence that the houses directly to the south of the school site, No 24 Crossfield Road onwards, are founded on piles due to the effects of trees on the clay. If this is the case the application is conservative.

36. *All of these dimensions and levels for the school and No. 24 mean that:*

    (a) the front wall of the original school basement is level with the back wall of the substation;

    (b) the front wall of the new basement would be level with the front wall of the house and garage of No. 24, and

    (c) that the new excavation proposed would extend to 7.5m below and 1m away from the front footings of No.24.

37. *Figure 1 below is taken from a 1998 planning application for No.24 and shows the arrangement of the property at that time. The application was to remove the garage and extend to the boundary. It was refused and so the current arrangement is unlikely to differ very much from that shown. The construction of the front and back walls of the houses is of material significance for this case. Like many other housing terraces of the time, it followed the architectural fashion to have glazing that extended for the full width of the houses at all floor levels, with tiled or other probably non-brickwork apron walls below.*

38. *In this case it can be seen that most of the glazing and doors in the ground floor of No. 24 are full height on both elevations. On the front elevation there is at least one full height opening to the balcony and possibly a full height glazed panel. On the rear elevation there are full height glazed panels at both first and second floors.*

39. *Solid parts of walls between and below these openings were difficult to stabilise if made of brickwork and so were often timber framed, the frames being made on site and supported by being fixed to verticals between openings and to party and flank walls. Usually, as in this case, there were no continuous internal cross walls and it was only the structure between openings in the front and back walls that provided lateral stability to the terrace as a whole and stopped the "pack of cards " effect.*

FIGURE 1 Existing arrangement of 24 Crossfield Road 1998

40. *There are many such terraces which have performed and continue to perform satisfactorily but they are structurally less robust and more vulnerable to damage due to ground movement than other more traditional forms of construction. In my experience, damage has occurred in the form of distorted window and door openings and damp penetration rather than the more easily repaired crack damage referred to in the Camden CPG4.*

41. *Nos 50 and 52 are of similar age and construction as the terrace and adjoin its southern end, both properties facing upon Eton Avenue.*

4 Eton Court garages

42. *Eton Court residential flats and garages were built in the 1930s. The garages are single storey with brick walls and flat roofs. They are arranged in a "U" shaped block with a contained access pavement facing south towards the flats and Eton Avenue. The rear northern wall is built on approximately the eastern half of the boundary between the school and Eton Court, whilst the west wall is on the boundary with the Crossfield Road terraced houses.*

43. *As far as can be judged, the garage floor level is about the same as that of the pathway on the school side of the boundary beside the basement. According to the ground investigation records in the application, the garage foundation is approximately 0.95m below the path level.*

44. *A photograph relating to Trial Pit 4 in the basement impact assessment prepared for the application shows the rear wall of the garages. The later garden boundary wall for 24 Crossfield Road has been toothed into the garage corner and the junction shows clear signs of subsequent differential movement between the two.*

5 Hereward House classroom

45. *The classroom is a timber framed single storey structure, which planning drawings show was intended to rest on a concrete raft foundation. Walls are essentially of flexible timber stud construction lined with brittle plasterboard. The classroom is situated at the rear of 12 Strathay Gardens and 1.5m away from the boundary with Hall School. Planning consent for the original 11.5m by 4.5m structure, arranged with its length across the width of 12 Strathay Gardens, was granted in 1989. It has since been extended eastward.*

6 Observations concerning application response to the requirements of DP27(a)

6.1 Relevant parties and relationships

46. *Elliott Wood are the engineering consultants for the design and specification of the civil and structural engineering elements of the scheme.*

47. *Geotechnical and Environmental Associates (GEA) have undertaken research and physical investigation of ground conditions in the school, have reported their findings, and provided advice to Elliott Wood on a number of matters relevant to the engineering design. They have also prepared a basement impact assessment (BIA) in support of the application.*

6.2 Engineering information

48. *Elliott wood information within the application appears at first sight to be well-presented. But it actually provides no information whatsoever to justify the permanent safety of the proposed subterranean scheme or its ability to prevent damaging ground movement. DP27(a) requires both of these to be demonstrated.*

EW Response: Refer to comments to clause 6 and clause 15.

49. *The engineers' drawings provide no information either about how the works might be sequenced to provide continuity of support adequate to prevent unacceptable ground movement and damage beyond the excavation during the construction process.*

EW Response: Refer to comments to clause 6 and clause 15.

6.3 Basement impact assessment

50. *Basement impact assessments consider a variety of issues. Dr de Freitas has reported separately concerning ground conditions and I have confined my comments to geotechnical and structural engineering matters affecting policy DP27(a).*

EW Response:

GEA have provide comment on the following areas of the First Steps report; Basic Geology, Mechanical Properties, Ground Water, Made Ground and BIA.

GEA response to First Steps regarding the Basic Geology:

"The geological and topographical setting of the site is established in Part 1 of our report. However, the interpretation within the First Steps (FS) document that the site lies at the bottom of an east-west orientated valley between Primrose Hill and Hampstead seems somewhat overly simplistic and not truly reflective of the wider topographical setting shown on topographic maps, including that of Figure 10 of the ARUP report. It is true to say that the topography does elevate to form Primrose Hill, however it does not define the drainage paths of the two tributaries of the Tyburn River, which flow in a southerly direction, as shown on Figure 11 of the ARUP and referenced in our report. The position of the site between these tributaries, and the fact that the site is at a level of approximately 57 m OD, whilst the lower point between the base of Primrose Hill and Hampstead is at a level of approximately 47 m OD, 10 m below the level of the site, suggests it is not positioned on a 'valley floor'.

On the basis of the above, it does not seem possible for the sort of soft deposits derived from 'hill wash' sediments described in the FS document to have reached or to have been deposited on the site, as they would have been intercepted by and fed into the Tyburn tributaries before reaching the site. Additionally, such a

geological sequence is not presented on geological maps, discussed within the geological memoir for the area or acknowledged within the ARUP report. Further still, the British Geological Survey (BGS) borehole record referenced by FS (TQ28SE/1769) would seem to be somewhat unreliable as no strength or consistency of the material encountered is provided and the descriptions were carried out by the driller, rather than a qualified engineer. It would not be recommended that such borehole data be relied upon to provide evidence of the theory put forward by FS.

We are not of the opinion that our boreholes prove the theory put forward by FS or are reflective of the BGS borehole record, as no soft deposits were encountered below the made ground or over the London Clay."

GEA response to First Steps regarding Mechanical Properties of the Soil:

"The conclusion made by FS that the strength of the clay increases from 7.00 m seems at odds to what is shown by both undrained triaxial tests and insitu standard penetration test (SPT) results. The SPTs increase from an N value of 11 to 19 over that depth and from an undrained shear strength of 64 kN/m2 to 108 kN/m2, in what is seen to be a linear fashion, demonstrated on the plot of SPT N values and undrained shear strength against depth, included within the appendix of our report. It also seems somewhat of a leap to suggest that the top 7.00 m is disturbed due to freeze thaw action during periglacial conditions. Should this be the case, then we would have expected the clay to have had a greater disturbed fabric (open fissuring, mottled weathering); no evidence of such disturbance was noted within the clay.

It may be a fair interpretation to suggest that gradient of the linear increase in strength changes from around 7.50 m, although this is only shown through the results of undrained triaxial tests. Whilst the sample tested at 9.50 m still has an increased strength from the sample tested at 6.50 m, the increase is less than would have been expected. However, silty sand partings were noted in the clay around these depths and in the triaxial sample tested, which would have induced failure for the reasons outlined in the FS document. Whilst the SPT results show a similar linear increase in strength, a number of the other triaxial tests yielded lower than expected values of shear strength. As identified in our report, inspection of the failed samples indicated that failure occurred along pre-existing fissures, as can be expected, and therefore the results are not thought to be truly indicative of the insitu strength. Whilst greater onus was given to the results of SPTs, a conservative design line was also adopted to determine the average values of undrained shear strength for the example pile capacities and to determine the values of stiffness for the ground movement analysis. The predicted heave movements have therefore been calculated taking this into consideration.

In response to point 9, the bored pile retaining will be embedded through and beyond 9.50 m and will be embedded into the very stiff clay at a depth of approximately 10 m below basement formation level. The piles will

therefore provide a 'cutoff' to the sand partings observed between 9.00 m and 10.00 m, although it should be noted that no seepages or inflows were observed during the drilling of the borehole.

With regard to heave, it is true to say that changes in the strength of the clay will give rise to a change in heave experienced within any one layer of clay below the excavation. However as stated above, our design line has taking into account the changes in strength when calculating the stiffness and therefore the heave predicted by our ground movement analysis (GMA) are considered to provide good estimates"

GEA response to First Steps regarding Groundwater:

"We do not see the absence of groundwater within Borehole No 1 as unusual given the ground conditions encountered. The London Clay is not classified as an aquifer and as such does not support a groundwater table. Groundwater is present within the pores of the London Clay but due to extremely low permeability of the clay, groundwater will permeate extremely slowly. Higher permeabilities maybe encountered within the clay in the form of sand and silt partings and along fissure planes, however the permeability along these potential flow paths is still very low compared to coarser grained soils. The London Clay is widely considered to have, at best, a permeability of around 1x10-8 m/s horizontally and significantly less vertically. The standpipe installed in Borehole No 1 was constructed to determine any groundwater in the clay, i.e. the response zone was solely in the London Clay with the made ground sealed with plain standpipe and bentonite. Given a sufficient period of time, groundwater within the London Clay would be expected to permeate into the standpipe and rise to a level that is representative of the porewater pressure in the clay. However, taking into consideration the likely permeability of the London Clay, as our monitoring was carried out over a one-month period, it is not surprising that the standpipe was dry on each occasion. Whilst our report recommends carrying out further monitoring over a longer period of time, the findings are not considered to be unusual.

Within two of the shallow window sample boreholes, seepages of groundwater were encountered in the made ground, as indicated on the borehole records and discussed within our report. Standpipes were installed in these boreholes and a response constructed from 0.50 m below ground level, such to allow any inflows from the made ground to be monitored. Groundwater was inevitably measured in the standpipes during monitoring, although the variation in depths should be noted. Additionally, the hand dug trial pits also provide a good indication of groundwater conditions within the made ground, with groundwater not encountered in any of the positions, one of which was excavated to 1.80 m. The made ground predominantly comprises a clay, with variable inclusions of gravel, brick and other extraneous material. It is by its nature a variable material that is likely to have variable permeability throughout. It is of no surprise that groundwater is not encountered uniformly across the site within this material but rather in isolated pockets.

As discussed within our report, groundwater inflows from within the made ground may be encountered within the basement excavation, although these will be controlled by the contractor in order to maintain a dry excavation for construction purposes. However, it is not considered that a hydraulic pathway will be created between the made ground and London Clay. It is accepted that some settlement will occur within the made ground due to the deflection of the retaining walls, however some of this will also be offset due to the heave of the London Clay that will take place due to the unloading of the clay from the basement excavation. This however is not considered to significantly alter the already negligible permeability of the London Clay.

We have not stated that there is an absence of groundwater within our report, the presence of groundwater within the made ground has been fully acknowledged and we have given recommendations based on our findings. For example, a design groundwater level of 1.0 m below ground level has currently been adopted by the structural engineers for the preliminary design of the retaining walls, to allow for the building up of perched groundwater behind the retaining walls. As stated previously, the position of the site topographically is not considered to be indicative that groundwater must be present below the site, as it is questionable that the site sits on a valley floor."

GEA response to First Steps regarding Made Ground:

"We are aware of the variability of the made ground, as described previously above, although as also discussed in previous points, we do not agree that there is sufficient evidence to confirm that these deposits are derived from watery sediments deposited on a valley floor from hillside wash. It is true to say that made ground can typically comprise of re-worked natural soils present on site prior to the interaction of man. However, as detailed in the site history section of our report, the site has undergone several phases of redevelopment and it cannot be ruled out that the made ground on site has not been imported. The variability of the made ground is however accounted for in our report.

Whilst blocky fissuring can be indicative of desiccation of the clay, it can also purely describe the fissuring pattern. Borehole No 1 was advance in relatively close proximity to an established Oak tree and therefore it wouldn't be unusual for desiccation to be present. The results of laboratory moisture content and Atterberg limit tests do not suggest that the clay at the time of sampling was desiccated. In any case, the Oak tree in question would only have an impact on the buildings within the school's demise and the design of the proposed development will take into account the presence of the tree. An interesting point however is raised in the FS document, in that it suggests that there is anecdotal evidence that the houses directly to the south of the school site, No 24 Crossfield Road onwards, are founded on piles due to the effects of trees on the clay. This could certainly be the case, which would therefore have positive impact on the likely effects on those buildings from the proposed development, as discussed further in this letter.

The London Clay in Borehole No 3 was noted to be initially soft, due to the presence of the overlying perched groundwater in the made ground. It is our opinion that for the softening of the clay to occur, the water would need to remain perched in that location for a significant amount of time. This is therefore more of a commentary that water is stagnant rather than flowing."

GEA response to First Steps regarding BIA:

"It should be reminded that the screening questions are completed prior to an investigation being carried out on site. We therefore answered 'No' to Screening Question 1b as on the basis of the position of the site and the geology, it was not believed that the basement would extend below a water table. Following the investigation, it is our conclusion that a continuous piezometric surface is not present within the made ground and as such are satisfied with the answer to the question remaining as 'No', although we acknowledge that some form of groundwater may be encountered within the basement excavation in the form of perched inflows. The nearest spring line to the site is that of the nearby tributary to the Tyburn, which is located over 500 m of the site. At that distance, the site is not considered to have an impact on the spring or vice versa. In any case the answers to the screening questions have been validated by an audit review carried out by Campbell Reith.

The values of strength used to determine the stiffness of the clay have been based on those values of strength measured by insitu testing and the results of undrained triaxial testing. Taking conservative values is an engineering judgement.

No evidence of desiccation was noted by a site walkover carried out at the site and therefore the answer to the screening question 7 was considered to be 'No'. As discussed previously, these questions are answered prior to the results of the intrusive investigation. This has been validated by Campbell Reith. As also discussed further in this letter, that if the houses starting from No 24 Crossfield Road to the south are indeed piled, this is advantageous to the proposed development."

6.3.1 Ground movement

51. *In Part 3 (at pages 25 to 32) of their Desk Study and Basement Impact Assessment Report, GEA have presented their ground movement analysis. They commence by reporting the following general sequence of works provided by engineering consultants Elliott Wood.*

    (a) Demolition of existing superstructure.
    (b) Installation of contiguous bored piled wall in area where no existing basement is present.
    (c) Install capping beams.
    (d) Temporary props installed at high level.
    (e) Excavate down and install mid-level props and lower-level props as excavation progresses.
    (f) Install basement slab and liner walls from lowest point up, removing props after curing process.
    (g) Underpin existing basement to lower level.
    (h) Prop at higher level

(i) Excavate down and prop at lower level.
(j) Cast basement slabs and liner walls from lowest level up.

52. *This is followed by comment that underpins should be adequately laterally propped and a paragraph which specifically absolves GEA from any responsibility to consider the detail of these and other supports. A further comment passes the matter back to Elliott Wood as an issue to discuss with the contractor. As previously noted, Elliott Wood offer no relevant information.*

EW Response:

GEA have not absolved themselves of responsibility, however they are stating that the final propping and sequencing will be completed as part of the detailed design. Refer to comments to clause 15 for further information.

53. *The potential effect on the ground of making the new excavation has been modelled for the BIA using industry standard computer programs. Essentially, these model the interaction of two complex effects. Excavating soil removes weight from the ground below, which then expands and heaves upward. At the same time, pressure on walls supporting the surrounding ground makes the walls and the supported ground deflect into the excavated space. That in turn causes the ground near the excavation to subside.*

54. *The programs deal only with the ground: the walls themselves are not considered. That is to say the programs do not in any way compensate for the shortcomings of the Elliott Wood submission.*

EW Response:

The analysis by GEA is based on conservative empirical data.

55. *For analysis of ground movement due to movement of the sides of an excavation, it is first necessary to postulate the amount by which the walls and ground might move inward. To help, the program includes a database of displacements observed in a limited number of real walls [2]. Those recorded movements have varied considerably according to the type of wall and construction method used.*

56. *One of the most important variables cited by reference [2] is the particular sequence of propping and excavation used. This greatly affects the amount of wall displacement and falsl broadly into two types.*

57. *"Top down" causes the least movement. This applies when (1) piled walls are inserted around an area to be excavated, (2) the permanent ground level floor is cast, (3) working through a hole left in the floor, ground under the floor is excavated to the next floor level down and the floor there is cast, (4) the subsequent deeper floors and eventually the foundation are constructed in the same way.*

58. *"Bottom up" normally results in considerably more movement. In this case, the piled walls are constructed as before but, instead of permanent floors being constructed as the excavation proceeds, temporary struts are placed against the walls at each excavated level, so that the entire excavation remains open for its full depth. The foundation and each permanent floor are then constructed from the bottom up, with struts being adjusted or removed according to an agreed sequence.*

EW Response:

Bottom up construction has been used in the analysis.

59. *The construction method provided by the BIA describes a bottom up sequence but the BIA report analysis is based upon a stiff top down construction ground movement profile. Ground movement predicted around the excavated area is thus less that might be expected from an analysis that is compatible with the anticipated construction system.*

EW Response:

An engineering judgement has been made in determining the wall stiffness for modelling the displacements associated with the excavation following the installation of the contiguous bored pile wall. Having an excavation that is propped in the temporary condition as the excavation proceeds, in three to four levels, does not represent a low stiffness support. If the analysis was carried out on a low stiffness wall, whilst deflections will undoubtedly increase, this will not have an impact on the building damage category as this is based on the differential horizontal and vertical deflections occurring across a particular elevation. GEA have re-run the analysis using a low stiffness wall movement curve and the building damage categories remain the same.

It is known that the existing single level basement was constructed using temporary works and insitu RC retaining walls of 375 mm thickness. This is why underpinning is being proposed as the means of extending the existing retaining walls down to proposed new formation level, which is considered to be appropriate. The underpinning will be carried out in two stages while being propped. It is in EW's and GEA's opinion that this represents a 'high stiffness support'.

60. *Construction of the underpinning below the existing basement walls is another case of bottom up construction but there is no database for underpinning. Again, the profile for stiff top down construction has been used for analysis. In this case, the assumption that the existing retaining wall could be stiffly supported might be reasonable. But if, as seems most likely, that wall was constructed using contiguous bored piles in the same way as currently proposed for the western part of the new basement, the underpinning system proposed will not be possible.*

EW Response: Refer to comment to clause 59.

61. *Further, if a piled wall was used to support the excavation it might well have been designed for the more lightly loaded condition applicable to short term temporary support before some form of permanent cantilevered retaining wall was constructed. That could well mean that the currently embedded piles do not extend to the depth of the new basement excavation and that some additional change of construction method would be called for.*

EW Response: Refer to comment to clause 59.

62. *These possibilities are real but their potential effects on the permanent works design and upon the assumption of stiff excavation support throughout have not been considered by the application.*

EW Response: Refer to comment to clause 59.

63. *It has also to be considered that whatever the original method of construction, neither the temporary works nor the final permanent cantilever retaining wall that now exists could provide anything but low stiffness support to the retained ground on the southern school boundary. The cumulative effect of that and the further depth of excavation now intended has to be accounted for, but has been ignored by the application.*

EW Response: Refer to comment to clause 59.

64. *No information is provided about the groundwater level assumed for the analysis. As pointed out by Dr de Freitas, the GEA ground investigation report does not provide any conclusion arising from the varying water depths measured in some locations and absence of water in others. Groundwater conditions ought to be considered by the ground movement analysis and better information is required on that point.*

EW Response:

1m below ground level has been adopted for outline calculations and is considered conservative.

GEA have responded to Dr de Freitas concerns.

65. *In considering their estimates of ground movement, GEA comment that loads from the building will be greater than provided by Elliott Wood and will reduce the estimated amount of basement heave. They also state that site procedures (quality of control and workmanship) will reduce the calculated amounts of other ground movement.*

EW Response: Refer to comment to Clause 12.

66. *It is quite normal to use judgement to moderate calculated results but it is not acceptable to state that something (loads provided by another more qualified source) will increase to give a more favourable result without evidence. By the same token, it is not within the knowledge of a designer to say how and how well an as yet unknown contractor would control the works in practice.*

EW Response: Refer to comment to Clause 12.

6.3.2 Risk of damage to properties in Crossfield Road

67. *One of the computer programs GEA have used to model ground movement also extends to the modelling of its potential effects upon buildings. Analysis offered by this module is based upon what is generally termed the Burland method and, for situations to which that is suited, provides a rapid means of comparing effects upon different building configurations.*

68. *GEA conclude by his means that the maximum category of damage to be expected at No.24 Crossfield Road is very slight (category 1), which is acceptable according to CPG4.*

69. *It is appropriate to bear in mind the assumptions of the Burland method when considering this result. The Burland model building or wall is conceptualised as a weightless, continuous brick beam of constant rectangular cross section, which obeys the laws governing the behaviour of elastic materials and has a fixed ratio of constant bending and shear elastic moduli. It rests upon the ground and undergoes both a circular form of deflection due to both bending and shear deformation and uniform longitudinal tensile strain as the ground stretches. The method tolerates isolated openings for windows and doors as long as there is enough brickwork left to transfer the horizontal and vertical components of shear force sufficiently to justify the beam model but that is all.*

70. *Front and back walls of the 24 to 30 Crossfield road terrace do not comply or come anywhere near to complying with these assumptions. They are unlikely to be of brickwork, but in any event, they are not structurally continuous, either horizontally or vertically and they cannot be considered to be elastic beams.*

71. *They are more reasonably considered as cladding infill surrounded by vertical brick walls (the party walls) which are connected by some form of ties at each floor and roof level. As such they might be considered in terms of panel shear strain deformation [3].*

72. *As has been stated above, the assumption made by the application of high stiffness support for the new excavation beside No.24 is not appropriate.*

EW Response: Refer to comment to clause 59.

73. Calculation in accordance with [3] made using more appropriate data for bottom up construction in reference [2] (taken as midway between the two extreme cases provided there) suggests that, should the solid panels be of brickwork or other masonry, category 2 risk of damage should be expected in Nos.24, 25, 26 and 27 Crossfield Road. For the extensive glazing and in the event of the solid panels not being of masonry, the problem of evaluating the risk of damage in the composite construction and equating the severity of the result with crack damage categories for brick structures would remain.

74. The occurrence of this level of risk through 4 properties in the terrace is mainly due to horizontal straining of the ground consequent upon lateral displacement of the piled wall. Nothing is known about the continuity of the building foundations between party walls; it cannot be assumed that they would resist lateral ground movement and thereby reduce damage risk.

75. *In this respect it is important to realise that for the reasons described below in connection with the garages, excavation made in the late 1980s for the existing basement is likely to have caused at least some increased stress within the terraced buildings, even if damage was not evident. This means that the effect of the much deeper excavation now proposed would be to increase the already elevated levels of stress.*

EW Response: Refer to comment to clause 7.

76. A further point of note is that the BIA has not considered the risk of damage to the electricity substation sited in No.24, which is likely to be sensitive to ground disturbance.

EW Response: Refer to comment to clause 9.

6.3.3 Risk of damage to the garages of Eton Court

77. According to reference [2], the support afforded to the excavation walls during the initial construction of the basement next to the garages and the relatively flexible permanent support provided by the existing cantilevered retaining wall comprise low stiffness support. The Burland method predicts that this would have placed the risk of damage to the garages in Category 3, just above its lower limit.

EW Response: Refer to comments to clause 11 and clause 59.

78. *The actual effect of that construction upon the garages is not known. Above ground damage may have long since been repaired; damage below ground cannot be seen. What can be said, however, is that the best information currently available predicts that the ground and building have already been significantly strained by one excavation and that further excavation now proposed would add to that existing state of strain.*

EW Response: Refer to comment to clause 7.

79. *Using ground movement criteria that may prove to be overly optimistic, the BIA predicts Category 2 damage to the garages due only to the new excavation in the existing basement area. By itself that is unacceptable. If the effect of the first excavation is merged with that predicted by the BIA, the current risk of damage becomes Category 3, approaching Category 4. If the BIA assumption of stiff support proved to be unfounded the damage risk would increase.*

EW Response: Refer to comment to clause 8.

6.3.4 Risk of damage to Hereward House temporary classroom

80. *The classroom has not been considered by the application. Its date of construction is unknown but since it might have preceded that of the existing Hall School basement, its damage risk has to account for that possibility.*

EW Response: Refer to comments to clause 9.

81. *Half of the excavation for the existing 12.5m wide basement took place about 4.5m from the classroom, the other half being excavated closer, to a line about 2.5 from the building. The application proposes to create a new basement which is about 2.5m distant from the classroom over its full width. One half of the excavation width is to be supported by contiguous bored piles, while support for the other half is currently to be provided by underpinning the existing wall.*

EW Response: Refer to comments to clause 7.

82. *The damage risks for contiguous piled and underpin methods of construction have been previously assessed above as Category 2 and Category 3 respectively. Normally, the amount of ground movement and thus damage to be expected at this shorter side of the basement would be less than for the longer walls, but the hybrid system proposed, which requires two entirely different construction methods, makes that an uncertain source of risk amelioration.*

EW Response: Refer to comment to clause 11.

83. *It might also usually be supposed that if the shallow reinforced concrete raft foundation shown by the planning records was used, it would prevent the critical lateral ground movement being transferred to the brittle wall finishes above. But the drawing shows several trees close to the intended site of the building and it is not certain that a raft foundation was used.*

84. *Currently therefore, a damage risk prediction for the classroom of at least Category 2 is appropriate.*

EW Response: Refer to comment to clause 11.

7 Conclusions

85. *The application fails to demonstrate that the scheme complies with DP27(a) and CPG4 insofar as the risk of damage to Nos. 24 to 27 Crossfield Road, an electrical substation in No.24 Crossfield Road, Eton Court garages and a classroom in the garden of Hereward School are concerned.*

EW Response: Refer to comments to clause 5 and clause 17.

86. *Construction sequences have not evidently been thought through in practical terms in that the effect on proposed construction methods of temporary support elements that are likely to have remained following construction of the existing basement have not been considered.*

EW Response: Refer to comments to clause 6.

87. *The potential cumulative impact of the original and proposed basement excavations on structural damage risk for neighbouring property have not been accounted for.*

EW Response: Refer to comments to clause 7.

88. *Assessment of damage risk for neighbouring property has been made using overly optimistic computer in put values, which falsely reduce the apparent impact of the proposal.*

EW Response: Refer to comments to clause 4 and clause 8.

89. *Risk of damage to an electrical substation and a classroom in Hereward School have been ignored.*

EW Response: Refer to comments to clause 9.

90. *Camden planning guidance CPG4 permits schemes to evince damage risk for neighbouring property no greater than Category 1. I find that the following risks currently exist.*

(a) 24-27 Crossfield Road Category 2
(b) Eton Court garages Category 3
(c) Hereward House classroom Category 2
(d) Electrical substation Category 2 (building only, risk to power lines unknown)

EW Response: Refer to comments to clause 11.

91. *Comments in the BIA which seek to enhance the proposal are unjustified. The BIA states that building loads will differ from those provided by the structural engineers so as to reduce ground heave caused by the excavation. It also states that the contractor's workmanship will be so good as to improve the calculated risk assessment results in favour of the applicant. There is no evidence of the first and the design team have no way of knowing what an as yet unknown contractor will do.*

EW Response: Refer to comments to clause 12.

92. *DP27(a) also requires applications to demonstrate the stability of the proposed basement. The application provides no information to justify the permanent safety of the proposed subterranean scheme.*

EW Response: Refer to comments to clause 13.

93. *The engineers' drawings provide no information either about how the works might be sequenced to provide continuity of support adequate to prevent unacceptable ground movement and damage beyond the excavation during the construction process.*

EW Response: Refer to comments to clause 6.

94. *In effect, the application provides no information to justify either the permanent or temporary safety of the proposed subterranean scheme or its ability to prevent damaging ground movement.*

EW Response: Refer to comments to clause 15.

95. *Absence of such information is a fundamental failure of the application. It is not excused by the decision in the 2015 revision of CPG4 to allow final information about working sequence and temporary support to be delayed until a contractor has been appointed subject to a Section 106 agreement. Design engineers are required by legislation to ensure that their designs can be constructed safely and that includes consideration of practicable methods of temporary as well as permanent support.*

EW Response: Refer to comments to clause 15.

96. *My overall conclusion is that matters affecting compliance with DP27(a) and CPG4 need to be reconsidered by the applicant's advisers without use of criteria that falsely minimises the potential impact of the basement proposal.*

EW Response: Refer to comments to clause 17.

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[2] CIRIA Report C580 (2003) Embedded retaining walls – guidance for economic design.
[3] Cording, E., Long, J., Son, M., Laefer, D., and Ghahreman, B. (2010) Assessment of Excavation-Induced Building Damage. ASCE Earth Retention Conference 3: pp. 101-120

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