Eldred Geotechnics
11A Woodside Chelsfield
Orpington Kent BR6 6JR
Telephone 01689 869406
Email mail@eldreds-geo.co.uk

TECHNICAL ADVICE G1701-TA-01-E1

Project	**The Hall School, 23 Crossfield Road NW3 4NU**	**Project Ref**	**G1701**
Subject	**Planning Application 2016/6319/P**	**Date**	**08/02/17**

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, Geoenvironmental, 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.

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.

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.

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

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

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.

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

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

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)

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

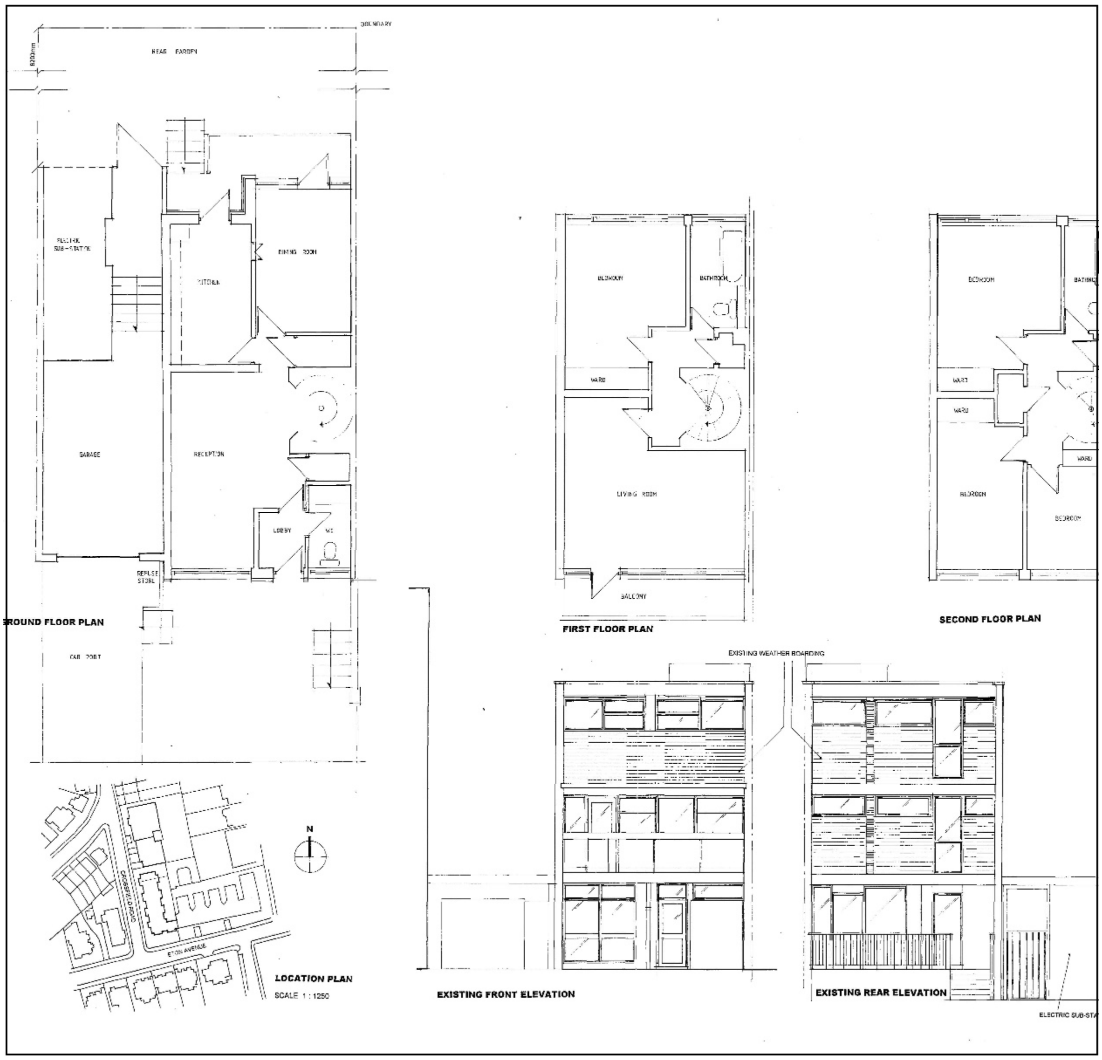

FIGURE 1 Existing arrangement of 24 Crossfield Road 1998

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.

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.

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).

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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

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

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.

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

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)

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.

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.

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.

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.

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.

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.

MICHAEL ELDRED MSc CEng FIStructE MICE
ELDRED GEOTECHNICS Ltd

References:

[1] de Freitas MH (2017). Technical review of ground conditions at Hall School, 23 Crossfield Road London NW3 4NT.

[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