



Mr. O. Froment,
10 Pilgrim's Lane,
Hampstead,
London NW3 1SL

28th November 2012

Dear Mr. Froment,

**Planning Application 2012/5825/P
8 Pilgrim's Lane NW3 1SL**

Summary

The application as submitted contains no evidence showing that the nature of the ground on site has been understood. Drilling boreholes, commissioning tests and measuring a few water levels is by itself not enough; the data so revealed by these activities needs to be analysed and interpreted to generate a model of the ground and how it works; for example how quickly water can flow through it, what strength it has, and how it responds to rainfall. This is not a matter of "detailed design" as is often presented but of getting the basic geology right so that the "outline design" can be granted with confidence in its outcomes because it is based on fact. In this case, where particularly difficult structural arrangements of a flying Freehold exist, there is no wriggle-room for mistakes; it is absolutely essential to be sure of the ground conditions and how they can change within the wetting cycles of nature.

The present application leaves basic questions of water flow unanswered because these facts are not known; further, modelling of groundwater fails to include the basement in No.6. The proposal also raises the prospect of generating ground water of unwanted quality by the operation of an under drainage blanket to avoid the basement causing changes in water level around neighbouring properties.

The strength and stiffness of the ground have not been assessed despite a considerable number of tests being done, a great variation in strength being revealed and the site being more sensitive than usual to ground movement.

The basic geology of the site is therefore poorly defined and no outline design, no matter how good, can be based on it with confidence until values for hydraulic conductivity for 3D flow are established based on fact, until the quality of water issuing from the under drainage blanket at the start of the wet period is considered and until the values for strength and stiffness of the ground are justified.

It is easy to describe the site as simply "Claygate beds over London Clay" but that belies the complexity of the material in which this proposal has to be designed.

1. Introduction

1.1 This Report is written on behalf of the neighbours to No.8; Mr Oliver Froment (No.10) and Mr Timothy Owens (No.6), by Dr Michael de Freitas, a Chartered Geologist and UK Registered Ground Engineering Adviser.

1.2. The application for the development of No.8 has been produced with the aid of three ground investigations; two by Geotechnical Engineering Associates, the first in 2010 and the next in 2011, followed by that of Listers Geotechnical Consultants, as reported in 2012. These have been assessed collectively by Arup to support their Basement Impact Assessment of June 2012.

1.3 In that Basement Impact Assessment are two issues of relevance to the design of the works at No.8; viz.

- i) the control of ground water, and
- ii) the control of ground movement.

The effects of both have been considered separately whereas they will operate in conjunction, and quantified with the aid of numerical models. In assessing the confidence that can be placed on the conclusions from both of these exercises it is necessary to consider the extent to which those models represent the ground on site. That is the purpose of this Report.

1.4 Interestingly there appears to be no vertical cross section of the geology of the site in the reports submitted, the nearest to this being in the section dealing with groundwater modelling. Fig.1 illustrates the geology across the site from the front of the property in Pilgrim's Lane to its rear; Fig.1A shows the location of the holes.

1.5 The vertical profile on site is Made Ground of between 1m to 2m thickness, overlying between 4m to 5m of the Claygate beds (called the Claygate Member of the London Clay Formation) which itself overlays the London Clay. Water when encountered in boreholes tends to be found near the junction between the Made Ground and the Claygate beds. Evidence from spring lines shown on the topographic and geologic maps confirms that groundwater penetrates the Made Ground and resides in the Claygate beds from where it discharges laterally throughout the year at their junction with the London Clay below.

2. Groundwater

2.1 In reviewing groundwater in the Hampstead area it is common to overlook the presence just below the top soil of a mantle of transported material that sludged down hill as mudflows during the Ice ages, when conditions in Hampstead resembled those of the Tundra. This has now stabilised by drying out but provides a near surface zone of material that acts as an aquifer.

2.2 The water bearing properties of this shallow zone come largely from the fact that uphill from this site there are Claygate beds that increase in coarseness and are capped by the sands and gravels of the Bagshot beds, which form the upper part of Highgate Hill. These coarse materials have sludged down the hill becoming increasingly mixed with the finer fractions in the lower parts of the Claygate beds and the London Clay where they cross it, as seen down slope from Pilgrim's Lane in Downshire Hill.

2.3 It is into this mantle of transported material that foundations and other earthworks have traditionally been placed, and such work leaves behind a trace of itself usually in the form of anthropogenic material; bricks, cinders, wood etc. On finding these the ground tends to be described as "Made Ground"; i.e. generally formed by man. That is usually not the case and is not the case here; it would be better to think of this layer as naturally transported and a water bearing deposit containing anthropogenic material.

2.4 The Made Ground should therefore be considered as a potential aquifer capable of absorbing infiltrated rain and transmitting it just below ground level. It is also the zone into which water from soak-aways is usually discharged and into which water bearing utilities will leak. It therefore has a life of its own which can be quite different in its hydrological activity from that of the strata below. It is quite common for older dwellings in this area of Hampstead to have hand-dug shallow wells on their property, and one such well is believed to exist at No.10, even when on London Clay; these were almost certainly fed from "Made Ground".

2.5 Most reports consider the strata below, i.e. the Claygate beds, to be the near surface aquifer; it has a permeability greater than that of the London Clay beneath it and is classified as an aquifer by the Environment Agency, albeit a "secondary" aquifer. It tends to be the horizon attributed for filling standpipes and other devices for monitoring ground water but as explained in 2.2 – 2.4, this may not be entirely so.

2.6 Not much in the way of groundwater level monitoring has been made available to describe the natural circumstances of the site. If the standpipes are recharged mainly from near surface water travelling through "Made Ground" then it is likely that the fluctuations in water level observed in them are short lived, as pulses of water make their way downhill. Under these circumstances water levels can be expected to rise from a fairly static "base" level to a short-lived peak (perhaps over 2 or 3 days) and then fall back again to their base level.

2.7 The base level will be governed by the volume of the aquifer; large aquifers and can slowly drain their water at their spring lines, causing an almost imperceptible change in water level in wells and observation holes measured over the short term (e.g. over a week). The occasional measurement of water level, as has happened with this application, is not sufficient to describe how this ground works in a hydrological sense; further, the period over which observations of water level were made coincides with a

particularly dry period in British hydrology. Given that and the fact the only day on which detailed measurements were made (5th March 2012) was a day without rain in Hampstead, it is evident that the factual basis for designing ground water management measures for the site is not adequate. How inadequate is often underappreciated; a simple comparison can here be made – would the planning authorities accept the use of man-made building materials if they were highly variable but used in design on the basis of a few tests? The answer is “No” because it would be unacceptable. Ignorance of groundwater for the purpose of designing groundwater management is no different.

2.8 Thus the basis for assessing the groundwater heads and their implications at this site is weak. Under ideal circumstances the fluctuations measured at intervals appropriate for the response time of the ground should be extended until a typical hydrological year has been experienced. When this is not done then the effect of water levels higher than those measured here should be included in the assessment of their consequences.

2.9 The direction of flow has been reviewed in the Arup report where it is concluded that the relevant levels are recorded by a linear set of observation points so preventing the assessment of flow direction to be made. It is unclear why this was felt to be so as the data from BH's A1, A3 and A4 provide a 3-point solution for the 5th March 2012, suggesting flow is in the direction N105°; nevertheless this is virtually “downhill” as the Arup report concludes, Fig.2.

2.10 However this simple construction does show that the hydraulic gradient is closer to 1 in 11 rather than 1 in 20 as mentioned in the Arup report. In other words the gradient is almost double that which has been assumed. This will have gone into the groundwater model and generated a lower flow than the data warrants.

2.11 Values for hydraulic conductivity (also called permeability) have been derived from field tests conducted in boreholes. The flow in these tests would have been essentially horizontal, meaning that the value of conductivity generated would be that for horizontal flow. Arup make the point that flow also has to have a vertical component, to get under the basement, and so a value for vertical conductivity is required. At this point assumptions have to be made and the test value is reduced by an order of magnitude. This would be reasonable if supported by some evidence but it has not been and there is evidence to question whether that was the correct assumption to make.

2.12 The reason for raising this is because the ground was frozen during the Ice age and frozen ground can be disturbed by the formation of ice within it. The overall effect of that can be to destroy the lateral continuity original sedimentation imparted to the deposit so reducing the difference between vertical and horizontal values.

2.13 Fig.3 is a plot of ground resistance measured in-situ at the base of a borehole; the value 0 is low and 50 is high. Tests in different boreholes but at

the same elevation relative to Datum gave different results, and thus it is not obvious that the Claygate beds are horizontally continuous. It would therefore be prudent to run a suite of parametric tests to assess the effect of hydraulic anisotropy on predicted groundwater flow and its associated heads.

2.14 The groundwater flow model itself is based on steady flow and whilst that may be a reasonable approximation of the case for periods without rain as shown by the measurements for the 5th March 2012 when no rain fell (and see 2.7 above), it is probably not sufficient to mimic the response of the ground during periods of rain, especially if the Made Ground is playing an active part in the short term response of the ground. It is a common experience in Hampstead for complaints of flooding in cellars and basements to follow periods of rainfall.

2.15 It also appears that the model for groundwater does not incorporate the existence of a basement under the neighbouring property, No.6. Arup state that little is known about the basements under Nos. 10 and 6 and this is another “unknown” within the material supporting the application.

2.16 The assessment of groundwater and its change, for the purposes of supporting this application, is therefore questionable and that has implications for the management of groundwater which is accepted by the applicant as being necessary. The designs for this need to be revised to show they accommodate greater background flows and can cope with short term bouts of infiltration.

2.17 A drainage by-pass is considered in the form of a permeable drainage blanket beneath the property; however some consideration needs to be given to the shape and function of that installation. The aquifer properties of the ground are likely to be stratified with Made Ground being an infrequently used route of high transmission and the Claygate beds being a route of continuous slow flow. Being stratified one rate can flow in parallel with another at the same time and without discord. This will now be interrupted by a U-tube like drainage blanket so that occasional high flows will be routed through the same pathway as slower continuous flows.

2.18 It is therefore necessary to demonstrate how this will work in practice before accepting the idea as being the solution to the groundwater flow interrupted by basements, as it generates its own physical problems and may just replace one problem with another. Once in place it cannot be altered so its functionality has to be resolved.

2.19 The drainage blanket could also generate chemical problems in terms of water quality. A basic U-tube profile will mean the drainage blanket has within it slow moving Claygate beds water which can be flushed through at times of high flow from Made Ground water. The water that has been residing in the drainage blanket will have a certain quality depending on its period of residence and the rate of dissolution of soluble components in the Claygate beds. This water could be flushed out as a concentrated discharge of

dissolved solids and head off down slope for Downshire Hill – where there are basements some of which are pumped whenever it rains.

2.20 It is therefore necessary for some thought to be given to this so as to demonstrate the environmental impact of the development does not contain a component of unwanted water quality.

3. Ground movement

3.1 The site is sandwiched between two other properties with the portion flying associated with the flying freehold of No.10 relying on there being no perceptible ground movement. There is no wriggle-room on this site and that imposes considerable constraints on what is acceptable at planning stage.

3.2 Some measure of the strength of the ground is provided by simple tests done in-situ at the base of a borehole at various stages during its sinking. These provide what is called an “N” value and those obtained by the investigations at No.10 are plotted against depth (shown as height above Datum or sea level) in Fig.3. Also shown in Fig.3 is the Formation levels for the excavations at No.10 and the depth to which piling has been considered.

3.3 Given that the analyses of ground movement will assume homogeneous and isotropic conditions for the Claygate beds and the London Clay the considerable scatter of values revealed by the plot deserves some explanation to justify the idealisation the analyses have used. No such explanation is provided.

3.4 It is customary to consider a relationship that ensures all the data found are stronger than the values used in the analyses and although this provides a solution in theory, by ignoring the natural variations which exist in practice, a price has to be paid for this. The problem of doing so at this site is that one cannot be sure the result predicted will appear in practice. Further if theory is not reflected in practice and the ground has not been understood, it is almost impossible to know what action to take to remedy movements that were not expected other than to provide more support.

3.5 A considerable amount of laboratory testing has been undertaken and the location of samples whose mechanical strength was tested is shown on the right side of Fig.3. Given the natural variations in ground resistance revealed by the “N” values it is easy to appreciate the difficulties the analyst has in assessing whether a sample tested was representative of the ground from which it came. Again no comment on this is made.

3.6 It should also be noted that the performance of geological materials such as sand, silt and clay is very sensitive to their moisture content. The ground at this site is desiccated, probably by the roots from vegetation and the heat from the house. Suctions ranging from 55kN/m² to 105kN/m² have been measured which can be thought of as forces pressing the particles of soil

together – as happens in sand castles. If recharge from the drainage blanket or SUDS reduces these suctions then the strength of the ground will also change, and like the sand castle the ground becomes weaker.

3.7 Most of the samples tested had moisture contents around 30% and if these were to change through easier access to water (as may occur via the under drainage blanket and use of SUDS to compensate for increases in impermeable cover) and/or the relaxation of ground as excavation commences, their strength and stiffness would change also. Thus the ground is not a simple material with which to engineer and that is why planning permission should be satisfied that a proposal which is feasible is in fact achievable.

3.8 Considerable attention in design has to be given to the stiffness of the ground. This is not an easy parameter to either measure or to assess, and in many respects still remains a subject for research. It is common for stiffness to be gauged from strength and in this case RKD have mentioned a relationship in the form of $750C_u$, where C_u is the undrained shear strength of the material.

3.9 There is a range of values for C_u provided by the ground investigations and they can be expected to vary with depth, usually increasing, although those measured by GEA seem not to do so. That is an interesting point in itself because the insitu tests (those giving “N” values) show a consistent increase with depth. The data for the site is conflicting and no account of this seems to be taken in the analyses.

3.10 The values for C_u obtained by GEA range from 50kN/m^2 to 100kN/m^2 which if multiplied by 750 gives a stiffness of 37500kN/m^2 to 75000kN/m^2 . Values obtained from the testing of samples collected by Listers range from 57kN/m^2 to 150kN/m^2 which multiplied by 750 give a stiffness of 42750kN/m^2 to 112500kN/m^2 . So the range to choose from is 37500kN/m^2 to 112500kN/m^2 .

3.11 Undrained small strain stiffness recorded by the triaxial undrained shear strength tests reported by Listers appears to range from 8000kN/m^2 to 17500kN/m^2 . These values are considerably different from those achieved from relationships of the sort described in 3.8 and given in 3.10.

3.12 It is therefore important that designs submitted for planning give a reasoned account of how the mechanical properties of the ground have been selected and used in the analyses of stability and ground movement. A considerable amount of test data exists for this site and almost none of it appears to have been used; nor has it been compared (i.e. the profile with depth of “N” with C_u); to do so is not “detailed design” which applicants often claim it to be but simply understanding the ground in which an outline design is to be accomplished. Planning permission granted on the basis of mechanical properties that are not as great in practice as assumed in theory leads to an unachievable design, which in this case could result in ground movements greater than predicted.

4. Conclusions

4.1 There are a number of important aspects of this proposal that need to be resolved before planning permission can be given in the confidence that the what is proposed can be achieved without causing damage to neighbouring properties. These are listed below.

4.2 The hydrogeology of the site needs to be more carefully described so that the management of ground water can be correctly designed. This requires better monitoring than has been done so far, particularly to see how water in the Made Ground responds to rainfall in the short term.

4.3 The difficulties of assessing the hydraulic anisotropy of the ground suggests that the sensitivity of the design to this parameter needs to be completed and the design adjusted accordingly if necessary.

4.4 It would also be necessary to include in the modelling the basement for No.6, as this removes ground which the model believes is there and through which it directs flow; the basement appears not to have been considered.

4.5 The effects on ground water quality the operation of the drainage blanket could have, especially when rain follows a period of dryness, should also be reviewed especially in view of the density of development in the immediate area.

4.6 The data for the strength of the ground seems not to have been analysed in ways that are helpful for design of retaining structures particularly when these will have to resist movements of the ground that could cause damage to neighbouring properties. The ground does not appear to have been understood. There is ample evidence that the ground on site is not simple; just describing it as "Claygate beds over London Clay" belies the complexity of its fabric, moisture content and stratification. These need to be understood better than they are for the design at planning stage to be founded on reasonable evidence.

4.7 With respect to ground strength the following questions need to be answered;

- What stiffness profile is being taken as representative of the ground?
- What evidence is considered to support that profile?
- How might that profile change with a change in moisture content arising from the removal of vegetation and the insertion of a drainage blanket?

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References

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Fig 1. Vertical cross section of site geology

Fig 1A Location of bore holes on site

Fig 2 Map of water table across site

Fig 3 Profile of strengths beneath site.