28 HOLLYCROFT AVENUE, NW3 7QL

APPENDIX C

SITE INVESTIGATION REPORT

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EXECUTIVE SUMMARY

This executive summary contains an overview of the key findings and conclusions. No reliance should be placed on any part of the executive summary until the whole of the report has been read. Other sections of the report may contain information that puts into context the findings that are summarised in the executive summary.

BRIEF

This report describes the findings of a ground investigation carried out by Geotechnical and Environmental Associates Limited (GEA) on the instructions of Sinclair Johnston and Partners Limited, on behalf of Mr Andrew Millward, with respect to the construction of a basement beneath the existing house, extending to a maximum depth of 3.5 m. The plans are still in the early stages and the extent of the basement is not known. The results of the contamination testing are currently outstanding and the results will be reported as an addendum to this report. A desk study did not form part of the project brief at this stage. Additional investigation is required to finalise the geotechnical advice and local planning requirements.

GROUND CONDITIONS

The investigation has generally confirmed the expected ground conditions in that, below a variable thickness of made ground / topsoil, the Claygate Member was encountered to the maximum depth investigated of 7.00 m. In Borehole Nos 1 and 2, the made ground / topsoil extended to a depth of 0.50 m (8.89 m TBM) and 1.70 m (8.88 m TBM) and generally comprised brown silty sandy gravelly clay with occasional fragments of brick, ash, concrete and charcoal. In Borehole No 1, fine rootlets were noted to a depth of 1.7 m (7.69 m TBM). In Trial Pit No 1 the made ground extended to a depth of 1.15 m (9.43 m TBM) and in Trial Pit Nos 3 and 4 it was proved to the maximum depth investigated of 0.30 m (9.52 m TBM) and 1.30 m (8.96 m TBM). The underlying Claygate Member initially comprised soft becoming firm light brown mottled grey silty clay with abundant partings of orange-brown fine sand and occasional selenite crystals was proved to a depth of 3.00 m (10.55 m TBM) in Borehole No 2, the maximum depth of the borehole and the silty clay was encountered to a depth of 6.70 m (2.69 m TBM) in Borehole No 1, although a layer of light orange-brown mottled grey clayey silty fine sand was encountered between 4.0 m (5.39 m TBM) and 5.5 m (3.89 m TBM). Beneath a depth of 6.7 m (2.69 m TBM), dark grey clayey silty fine sand was encountered and proved to the maximum depth investigated of 7.0 m (2.39 m TBM). The base of this stratum was not reached.

The original part of the existing house is founded on two brick corbels, apparently bearing on made ground at a depth of 1.29 m. The extension along the northern elevation of the house is founded on concrete footings and in Trial Pit No 1, the foundations were bearing within firm silty clay of the Claygate Member at a depth of 1.15 m. In Trial Pit No 2, the base of the footing was not encountered as a service drain restricted the working space available, however the top of this foundation was encountered at a depth of 1.2 m and extended 200 mm from the wall. The garden wall is founded on a concrete footing at a depth of 0.25 m bearing within the made ground / topsoil.

Groundwater was encountered during drilling, at a depth of approximately 4.80 m from within sand partings of the Claygate Member and in Trial Pit Nos 1, 2 and 4 perched water was noted around the footings. A standpipe was installed to a depth of 6.0 m (3.39 m TBM) and groundwater has been measured at depths of 4.52 m (4.87 m TBM), and 4.53 m (4,86 m TBM), six days and two weeks respectively after installation.

Three samples of the made ground have been sent for chemical analyses as a precautionary measure, although the results are currently outstanding.

RECOMMENDATIONS

The excavation of the 3.5 m deep basement will result in a formation level in the firm silty clay of the Claygate Member and based on the groundwater observations to date, groundwater inflows are not anticipated in the basement excavation. It should therefore be possible to adopt moderate width pad or strip foundations in the firm silty clay, designed to apply a net allowable bearing pressure of 100 kN/m^2 below the level of the proposed basement floor. Excavations for the proposed basement structure will require temporary support to maintain stability and prevent any excessive ground movement. Care must be taken not to undermine the existing foundations, which may need to be underpinned prior to construction of the proposed basement or supported by new retaining walls. If proposed loads are high such that spread foundations become unfeasible, piled foundations extending into the London Clay would provide a suitable solution, although additional investigations in the form of deep boreholes would be required in this respect.

Part 1: INVESTIGATION REPORT

This section of the report details the objectives of the investigation, the work that has been carried out to meet these objectives and the results of the investigation. Interpretation of the findings is presented in Part 2.

1.0 INTRODUCTION

Geotechnical and Environmental Associates Limited (GEA) have been commissioned by Sinclair Johnston and Partners Limited, on behalf of Mr Andrew Millward, to carry out a ground investigation at 28 Hollycroft Avenue, London, NW3 7QL. A desk study did not form part of the project brief at this stage.

1.1 Proposed Development

It is understood that the current proposal is to construct a basement beneath the existing house, extending to a maximum depth of 3.5 m. The plans are still in the early stages and the extent of the basement is not known.

This report is specific to the proposed development and the advice herein should be reviewed once the development proposals have been finalised.

1.2 Purpose of Work

The principal technical objectives of the work carried out were as follows:

- to determine the ground conditions and their engineering properties;
- to investigate the existing foundations;
- to provide advice with respect to the design of suitable foundations and basement construction;
- to provide an indication of the degree of soil contamination present; and
- to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.

1.3 Scope of Work

In order to meet the above objectives, the ground investigation comprised, in summary, the following activities:

- four hand-dug trial pits, excavated to a maximum depth of 1.3 m to expose the existing foundations;
- two window sampler boreholes advanced to a maximum depth of 7.0 m;
- a single groundwater monitoring standpipe installed to a depth of 6.0 m below garden level;
- laboratory testing of selected soil samples for geotechnical purposes and for the

presence of contamination; and

- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

The plans for the development are currently in the early stages and the scope of the investigation was therefore limited to a preliminary assessment of the ground conditions. A desk study will be required, in addition to further investigation and assessment, to finalise the geotechnical advice and additional work will also probably be required to comply with the Local Authority's requirements with respect to assessment of the effects of basement excavations on groundwater and land stability.

1.4 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, gas or groundwater samples tested; no liability can be accepted for information in other data sources or conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate; no independent validation of such information has been made by GEA.

2.0 THE SITE

2.1 Site Description

The site is located in a residential area approximately 1.3 km to the northwest of Hampstead London Underground Station. It is rectangular in shape, measuring approximately 40 m by 8 m, fronts onto Hollycroft Avenue to the southwest and is adjoined to the neighbouring property to the northwest. The site is bordered to the southeast by a three-storey semi-detached house and to the north by the rear gardens of houses fronting onto Rosecroft Avenue to the northeast.

The local topography slopes down towards the southeast but the rear garden slopes gently down towards the northeast. The site is currently occupied by a three-storey semi-detached house, with a driveway at the front of the house and a single storey flat roof extension at the rear of the property. The rear garden comprises a terraced patio with steps leading down to a central lawn, approximately 1 m lower than ground floor level. There are shrub borders and a mixture of semi-mature to mature trees along the boundary of the site with the neighbouring gardens.

2.2 Other Information

The British Geological Survey (BGS) map of the area (Sheet 256) indicates that the site is underlain by the Claygate Member overlying the London Clay.

3.0 EXPLORATORY WORK

The scope of the works was specified by the consulting engineers. Access was severely limited by the presence of the existing property and services. Therefore, in order to meet the objectives described in Section 1.2, as far as possible within the constraints presented by the limited access to the rear of the site a single window sampler borehole was carried out in the rear garden and extended to a depth of 7.0 m. In addition, four hand-dug trial pits were excavated to depths of between 0.3 m and 1.3 m to expose the foundations of the existing house and a small garden wall. To supplement the investigation, an additional window sampler borehole was advanced through the base of Trial Pit No 2 to a depth of 3.0 m, to confirm the ground conditions at depth as the presence of a service drain running parallel with the southern elevation of the existing house, limited the working area available to extend this pit to expose the extent of this footing.

It was agreed with the consulting engineers on site to install a standpipe in Borehole No 1, in order to facilitate groundwater monitoring. The standpipe was installed to a depth of 6.0 m and has been monitored on two occasions, six days and two weeks after installation.

All of the above work was carried out under the supervision of a geotechnical engineer from GEA.

A selection of the disturbed samples recovered from the boreholes was submitted to a soil mechanics laboratory for a programme of geotechnical testing and an analytical laboratory for a programme of contamination testing.

The borehole and trial pit records and results of the geotechnical laboratory testing are enclosed, together with a site plan indicating the exploratory positions. The ground levels shown on the borehole and trial pit records have been interpolated from spot heights shown on Drawing Ref 001, dated August 2011, by Sacks Maguire Architects, which was provided by the consulting engineers. These spot heights were measured relative to a temporary bench mark (TBM) shown on the aforementioned drawing as Station 1, located on the southwest side of Hollycroft Avenue, which was assigned an arbitrary value of +10.00 m.

3.1 Sampling Strategy

The trial pit and borehole locations were specified by the consulting engineers and positioned on site by GEA and the consulting engineers to provide optimum coverage of the site with due regard to the proposed development whilst avoiding the areas of known services, including drains.

Three samples of the made ground have been sent for chemical analyses as a precautionary measure. For this investigation the analytical suite for the soil included a range of metals, speciation of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols. The soil samples were selected to provide a general view of the chemical conditions of the soils that are likely to be involved in a human exposure or groundwater pathway and to provide advice in respect of re-use or for waste disposal classification. The results of the chemical analyses are currently outstanding and the results will be reported as an addendum to this report.

4.0 GROUND CONDITIONS

The investigation has generally confirmed the expected ground conditions in that, below a variable thickness of made ground / topsoil, the Claygate Member was encountered to the maximum depth investigated of 7.0 m.

4.1 Made Ground / Topsoil

In Borehole Nos 1 and 2, the made ground / topsoil extended to a depth of 0.50 m (8.89 m TBM) and 1.70 m (8.88 m TBM) and generally comprised brown silty sandy gravelly clay with occasional fragments of brick, ash, concrete and charcoal. In Borehole No 1, fine rootlets were noted to a depth of 1.70 m (7.69 m TBM).

In Trial Pit No 1 the made ground extended to a depth of 1.15 m (9.43 m TBM) and in Trial Pit Nos 3 and 4 it was proved to the maximum depth investigated of 0.3 m (9.52 m TBM) and 1.3 m (8.96 m TBM).

No evidence of significant contamination was noted during the investigation, however three samples of the made ground have been sent for chemical analyses as a precautionary measure. The results of the chemical analyses are currently outstanding and the results will be reported as an addendum to this report.

4.2 Claygate Member

The underlying Claygate Member initially comprised soft becoming firm light brown mottled grey silty clay with abundant partings of orange-brown fine sand and occasional selenite crystals and was proved to a depth of 3.00 m (10.55 m TBM) in Borehole No 2, the maximum depth of the borehole and to a depth of 6.70 m (2.69 m TBM) in Borehole No 1, although a layer of light orange-brown mottled grey clayey silty fine sand was encountered between 4.0 m (5.39 m TBM) and 5.5 m (3.89 m TBM). Beneath a depth of 6.7 m (2.69 m TBM), dark grey clayey silty fine sand was encountered and proved to the maximum depth investigated of 7.0 m (2.39 m TBM). The base of this stratum was not reached.

Plasticity index tests have indicated the clay to be of medium and high volume change potential.

These soils were observed to be free of any evidence of soil contamination.

4.3 Groundwater

Groundwater was encountered during drilling, at a depth of approximately 4.80 m from within sand partings of the Claygate Member and in Trial Pit Nos 1, 2 and 4, perched water was noted to be present around the foundations.

A standpipe was installed to a depth of 6.0 m (3.39 m TBM) and groundwater has been measured at depths of 4.52 m (4.87 m TBM), and 4.53 m (4,86 m TBM), six days and two weeks respectively after installation.

4.4 Existing Foundations

Trial Pit No 1, excavated against the extension along the northern elevation of the existing house, encountered a concrete footing bearing within firm silty clay of the Claygate Member at a depth of 1.15 m.

Trial Pit No 2, also excavated against the extension along the northern elevation encountered the top of the foundation at a depth of 1.20 m, but the base of the footing was not proved as a service drain was encountered 250 mm from the wall at a depth of approximately 0.80 m and restricted the working space available. A borehole was advanced through the base of this trial pit and found that the natural soils are present at a depth of 1.70 m.

Trial Pit No 3, excavated against the garden wall, indicated that the wall is founded on a concrete footing at a depth of 0.25 m, bearing within the made ground.

Trial Pit No 4, excavated against the eastern elevation of the existing house, indicated that the existing house is founded on two brick corbels, apparently bearing within the made ground at a depth of 1.29 m. A service drain was encountered 230 mm from the wall at a depth of 0.93 m.

The trial pit records are included in the appendix.

Part 2: DESIGN BASIS REPORT

This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to the basement excavation and the design of suitable foundations and retaining walls.

5.0 INTRODUCTION

It is understood that the current proposal is to construct a basement beneath the existing house, extending to a maximum depth of 3.5 m (7.00 m TBM). The plans are still in the early stages and the extent of the basement is not known.

6.0 GROUND MODEL

A desk study did not form part of the project brief at this stage. However the site is not expected to have had a potentially contaminative history, having been occupied by the existing house since the early 1900s and in a residential area. On the basis of the ground conditions at this site can be characterised as follows:

- the investigation has generally confirmed the expected ground conditions in that, below a variable thickness of made ground / topsoil, the Claygate Member was encountered to the maximum depth investigated of 7.0 m;

- in Borehole Nos 1 and 2, the made ground / topsoil extended to depth of 0.50 m (8.89 m TBM) and 1.70 m (8.88 m TBM) and generally comprised brown silty sandy gravelly clay with occasional fragments of brick, ash, concrete and charcoal. In Borehole No 1, fine rootlets were noted to a depth of 1.7 m (7.69 m TBM);

- in Trial Pit No 1 the made ground extended to a depth of 1.15 m (9.43 m TBM). The made ground in Trial Pit Nos 3 and 4 was proved to the maximum depth investigated of 0.3 m (9.52 m TBM) and 1.3 m (8.96 m TBM);

- the underlying Claygate Member initially comprised soft becoming firm light brown mottled grey silty clay with abundant partings of orange-brown fine sand and occasional selenite crystals and was proved to a depth of 3.00 m (10.55 m TBM) in Borehole No 2, the maximum depth of the borehole and to a depth of 6.70 m (2.69 m TBM) in Borehole No 1, although a layer of light orange-brown mottled grey clayey silty fine sand was encountered between 4.0 m (5.39 m TBM) and 5.5 m (3.89 m TBM). Beneath a depth of 6.7 m (2.69 m TBM), dark grey clayey silty fine sand was encountered and proved to the maximum depth investigated of 7.0 m (2.39 m TBM). The base of this stratum was not reached;

- plasticity index tests have indicated the Claygate Member to be of medium and high volume change potential;

- groundwater was encountered during drilling, at a depth of approximately 4.80 m from within sand partings of the Claygate Member and in Trial Pit Nos 1, 2 and 4 perched water was noted to be present around the foundations;

- a standpipe was installed to a depth of 6.0 m (3.39 m TBM) and groundwater has

been measured at depths of 4.52 m (4.87 m TBM), and 4.53 m (4,86 m TBM), six days and two weeks respectively after installation; and

- three samples of the made ground have been sent for chemical analyses as a precautionary measure. The results of the chemical analyses are currently outstanding and the results will be reported as an addendum to this report.

7.0 ADVICE AND RECOMMENDATIONS

The excavation of the 3.5 m deep basement will result in a formation level in the firm silty clay of the Claygate Member at a level of approximately 7.0 m TBM. It should apparently be possible to adopt spread foundations constructed from basement level, subject to findings of additional groundwater monitoring.

If proposed loads are high or groundwater is encountered close to the base of the foundations such that spread foundations become unfeasible, piled foundations extending into the London Clay would provide a suitable solution, although additional investigations in the form of deep boreholes would be required in this respect.

Excavations for the proposed basement structure will require temporary support to maintain stability and prevent any excessive ground movements. The existing foundations will need to be underpinned prior to construction of the proposed basement or will need to be supported by new retaining walls.

7.1 Basement Excavation

The proposed 3.5 m deep basement excavation will extend into the firm silty clay of the Claygate Member. The monitoring carried out to date suggests that groundwater will not be encountered within the excavation, although further monitoring should however be carried out to establish equilibrium levels and the extent of any seasonal fluctuations. Additional monitoring standpipes may be required as part of the planning requirements, to determine groundwater flow direction.

Inflows could in any case conceivably occur from perched water tables, particularly in the vicinity of existing foundations and should be adequately dealt with through sump pumping.

It would be prudent to carry out a number of trial excavations, to depths as close to the full basement depth as possible, to confirm this view. It is important to bear in mind that inflows may result from the presence of inter-connected pockets of water within the sand and silt pockets of the Claygate Member, which were not encountered during the investigation.

The design of basement support in the temporary and permanent conditions needs to take account of the need to maintain the stability of the excavation and of the neighbouring structure to the east and to protect against any groundwater inflows. The choice of wall may be governed to a large extent by the access restrictions.

The most suitable method of support will probably therefore be to form the retaining walls by mass concrete underpinning of the existing foundations, using a traditional ‘hit and miss’ approach. Careful workmanship will be required to ensure that movement of the surrounding structures does not arise, but this method will have the benefit of minimising the plant required and maximising usable space in the new basement.

If it is not possible to carry out trial excavations, the contractor should have a contingency in place to deal with any groundwater inflows.

Alternatively, consideration could be given to the use of a bored pile wall, which could have the advantage of being incorporated into the permanent works and will be able to provide support for structural loads. The monitoring carried out to date would suggest that groundwater will not be encountered within the excavation and therefore it should be possible to adopt a contiguous bored pile wall with the use of localised grouting and sump pumping if necessary in order to deal with any groundwater inflows. A contiguous bored piled wall would, however, have the disadvantage of reducing usable space in the basement.

If trial excavations indicate significant inflows of groundwater into the basement excavation a secant wall may be required to provide the necessary watertightness.

The ground movements associated with the basement excavation will depend on the method of excavation and support and the overall stiffness of the basement structure in the temporary condition. Thus, a suitable amount of propping will be required to provide the necessary rigidity. In this respect the timing of the provision of support to the wall will have an important effect on movements. The stability of the foundations of the neighbouring buildings and structures will need to be ensured at all times and the retaining walls will need to be designed to accommodate the loads from these foundations unless they are underpinned.

7.1.1 Basement Retaining Walls

The following parameters are suggested for the design of the permanent basement retaining walls.

Stratum	Bulk Density (kg/m^3)	Effective Cohesion (c' – kN/m^2)	Effective Friction Angle (□' – degrees)
Made ground	1700	Zero	27
Claygate Member	1850	Zero	25

The investigation has indicated that groundwater is unlikely to be present within the approximately 3.5 m deep excavation. However, further monitoring should however be carried out to establish equilibrium levels and the extent of any seasonal fluctuations and trial excavations should be carried out to confirm this view.

Reference should be made to BS8102:2009[1] with regard to requirements for waterproofing and design with respect to groundwater pressures.

7.1.2 Basement Heave

The excavation of the proposed basement is likely to result in heave of the underlying Claygate Member, which will comprise an "immediate" elastic component that may be expected to occur within the construction period, together with long term swelling movement that would theoretically occur over a period of many years. The effects are likely to be mitigated to some extent by the loads applied by the existing and proposed structures. However, a a more detailed analysis of the possible heave should be carried out once the basement design has been finalised.

1 BS8102 (2009) *Code of practice for protection of below ground structures against water from the ground*

7.1.3 Basement Floor Slab

Following the excavation of the basement, it is possible that the floor slab for the proposed basement will need to be suspended over a void or layer of compressible material to accommodate the anticipated heave unless the slab can be suitably reinforced to cope with these movements. This should be reviewed once the levels and loads are known.

Following a proof rolling exercise and infilling any soft spots with suitably compacted granular fill, a ground bearing floor slab may be adopted on the clay. Consideration will need to be given to designing the slab to accommodate heave movements. This should be considered in more detail once the proposed loads and levels are known. If it proves to be uneconomical to attempt to resist the heave the floor slab should be suspended over a void.

7.2 Spread Foundations

The excavation of the approximately 3.5 m deep basement will result in a formation level in the firm silty clay of the Claygate Member at a level of roughly 7.0 m TBM and it should be possible to adopt moderate width pad or strip foundations in the firm silty clay, designed to apply a net allowable bearing pressure of 100 kN/m^2 below the level of the proposed basement floor. This value incorporates an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits.

Desiccation was not noted at the limited number of locations investigated. However, due to the close proximity of semi-mature and mature trees along the boundary of the site with the neighbouring gardens desiccation may be present. Once the final levels are known, the depth of founding should be checked to ensure that it provides sufficient protection against tree root growth and it is recommended that the basement excavation is inspected by a qualified and experienced geotechnical engineer.

If proposed loads are high or groundwater is encountered close to the base of the foundations such that spread foundations become unfeasible, piled foundations extending into the London Clay would provide a suitable solution, although additional investigations in the form of deep boreholes would be required in this respect.

7.3 Excavations

On the basis of the borehole and trial pit findings it is considered likely that it will be generally feasible to form relatively shallow excavations terminating within the made ground or firm silty clay of the Claygate Member without the requirement for lateral support, although localised instabilities may occur. Inflows of groundwater are unlikely to be encountered in shallow excavations although perched water may be present within the made ground, particularly in the vicinity of existing foundations and any such inflows should be controllable with sump pumping.

However, should deeper excavations be considered or if excavations are to remain open for prolonged periods it is recommended that provision be made for battered side slopes or lateral support. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

7.4 Effect of Sulphates

Chemical analyses on samples of the Claygate Member have revealed low concentrations of soluble sulphate and slightly acidic pH's of 5.2 and 6.3, corresponding to Class DS-1 and AC-1 of Table 2 of BRE Special Digest 1 Part C (2005). The guidelines contained in the above digest should be followed in the design of foundation concrete.

8.0 UNCERTAINITIES

The ground is a heterogeneous natural material and variations will inevitably arise between the locations at which it is investigated. This report provides an assessment of the ground conditions based on the discrete points at which the ground was sampled, but the ground conditions should be subject to review as the work proceeds to ensure that any variations from the Ground Model are properly assessed by a suitably qualified person.

Access for any form of ground investigation was severely limited by the presence of the existing property and the scope of the investigation was limited to a preliminary appraisal of the ground conditions.

Once the proposals for the basement are finalised, additional investigation and assessment will be required to finalise the geotechnical advice and will also probably be required to comply with the local planning requirements for basements.

Further groundwater monitoring should be carried out to establish equilibrium levels and the extent of any seasonal fluctuations. It would be prudent to carry out a number of trial excavations, to depths as close to the full basement depth as possible. Additional monitoring standpipes may be required to determine direction of groundwater flow.

Additional investigations in the form of deep boreholes will be required, if piled foundations are to be considered.