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April 2009

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1 ELM ROW, HAMPSTEAD

LONDON, NW3 1AA

REPORT ON A GROUND INVESTIGATION

Prepared for

Milk Architecture and Design Limited

Acting on behalf of

Stephen & Jackie Palmer

Reg Office: Units 14 + 15, River Road Business Park,
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Business Reg. No. 2255616

Ref: 09/15403
April 2009

Report on a Ground Investigation

At

1 Elm Row, Hampstead, London, NW3 1AA

For

Mr and Mrs S Palmer

1.0 INTRODUCTION

At the request of Milk Architecture and Design Limited, Consulting Engineers to the house owners, Mr and Mrs Stephen and Jackie Palmer, a ground investigation was carried out in connection with a proposed basement residential development at the above site.

The information was required for the design and construction of foundations and infrastructure for a proposed development and to assess whether any remediation was required for the protection of the end-user from the presence of potential contamination within the soils encountered.

Anticipated foundation loads for the proposed basement structure beneath the existing four-storey house are expected to be moderate and of the order of 200kN/m^2 and basement slab loadings are expected to be of the order of 10-15kN/m^2.

The recommendations and comments given in this report are based on the ground conditions encountered in the exploratory holes made during the investigation and the results of the tests made in the field and the laboratory. It must be noted that there may be special conditions prevailing at the site remote from the exploratory hole locations which have not been disclosed by the investigation and which have not been taken into account in the report. No liability can be accepted for any such conditions.

This report does not constitute a full environmental audit of either the site or its immediate environs.

2.0 THE SITE AND LOCAL GEOLOGY

(National Grid Reference: TQ 264 861)

2.1 General

The site of the proposed development is situated on the north side of Elm Row at its intersection with Heath Street just to the north of Hampstead centre in London, NW3 1AA. The site consists of a roughly rectangular shaped housing plot with a large Grade II Listed four-storey flat roof detached house with a small access driveway at the southern end and a garden area. Further details of the site layout are shown on the site sketch plan (Figure 1).

The existing house is set into a steep slope forming the southern flanks of Hampstead Heath with the garden being terraced to accommodate the slope. A number of trees are present around the garden and within the front driveway including a mature Willow together with a number of mature Lime trees along the western boundary with Heath Street and further trees in the adjacent gardens to the east.

2.2 Geology

The 1:50000 Geological Survey of Great Britain (England and Wales) covering the area indicates the site to be underlain by deposits of the Bagshot Formation underlain by the Claygate Member resting on London Clay although a surface cover of made ground may be expected in an established urban environment where some regrading may have taken place during construction of the house and garden.

3.0 SCOPE OF WORK

3.1 General

The scope of the investigation was generally specified by the Consulting Engineers and comprised:

- The drilling of two continuous flight auger boreholes to a depth of 7m below ground level.
- The placement of a gas and groundwater monitoring standpipe to a depth of 5m below ground level in each of the boreholes (Boreholes 1, 2 and 3).
- The excavation by hand of a single trial pit to a depth of 1.15m below ground level to expose the foundations of the front wall of the house, confirm the near surface soil conditions and obtain further samples for laboratory testing.
- The removal of a small panel of bricks and mortar for laboratory testing purposes.

- Sampling and in-situ testing as appropriate to the ground conditions encountered in the boreholes and trial pit.

- Interpretative reporting on foundation options for the proposed building works and infrastructure.

- A study into the possibility of the presence of toxic substances in the soil, together with limited comment upon any remediation required.

3.2 Ground Conditions

The locations of the boreholes, trial pit and brick samples are shown on the site sketch plan (Figure 1).

The exploratory holes revealed ground conditions that were generally consistent with the geological records and known history of the area and comprised between 0.80m and 0.90m thickness of made ground resting on deposits typical of the Bagshot Formation resting on materials typical of the Claygate Member.

For detailed information on the ground conditions encountered in the boreholes and trial pit, reference should be made to the exploratory hole records presented in Appendix A.

The made ground extended down to respective depths of 0.90m, 0.85m and 0.80m below ground level in Boreholes 1 and 2 and Trial Pit 1 and consisted of a surface layer of either stone paving slabs set on lean mix concrete, grassed topsoil or a flower bed underlain by a mixture of loose and locally loose to medium dense silty sand, fine to medium gravel, ashes, mortar and brick fragments.

Natural soils were encountered below the made ground and consisted initially of loose becoming medium dense and then dense mottled silty fine to medium sand with occasional fine gravel and some pockets of stiff sandy clay towards the base. These materials are typical of the Bagshot Formation and extended down to depths of 3.30m and 5.80m below ground level in Boreholes 1 and 2 respectively and to the full depth of investigation of 1.15m below ground level in Trial Pit 1.

The underlying material in Boreholes 1 and 2 comprised of stiff becoming stiff to very stiff mottled sandy silty clay with partings of silty fine sand representing deposits of the Claygate Member. These materials extended down to the full depths of investigation of 7.00m below ground level in both of the boreholes.

3.3 Groundwater

Groundwater was not encountered in Boreholes 1 and 2 during boring or in Trial Pit 1 during excavation and the material remained essentially dry throughout.

It must be noted that the speed of excavation is such that there may well be insufficient time for light seepages of groundwater to enter the boreholes and trial pit and hence be detected, particularly within more cohesive soils of low permeability.

Groundwater was subsequently found to have stabilised at depths in excess of 5.00m below ground level in the monitoring standpipes installed in Boreholes 1 and 2 after a period of approximately four weeks. It would appear from the borehole records and local experience that the groundwater table lies at a depth of more than 5m below existing ground level within the sandy clay deposits of the Claygate Member resting on top of the effectively impermeable saturated cohesive soils of the London Clay Formation indicated by the geological records to be present at depth below.

Isolated pockets of groundwater may be present perched within any less permeable material found at shallower depth on other parts of the site especially within any made ground.

It should be noted that the comments on groundwater conditions are based on observations made at the time of the investigation (March 2009) and that changes in the groundwater level could occur due to seasonal effects and also changes in drainage conditions.

3.4 Existing Foundations

Trial Pit 1 was made adjacent to the front south facing wall of the house at the site at the position shown on the site sketch plan (Figure 1) in order to expose the foundations supporting the structure. A sketch of the foundations exposed in the trial pit is presented as Figure 2..

4.0 IN-SITU AND LABORATORY TESTS

4.1 In-Situ Tests

In essentially cohesive natural soils, in-situ penetration vane tests were made at regular depth intervals in order to assess the undrained shear strength of the material and indicated that it was of a stiff becoming locally stiff to very stiff consistency with increasing depth below ground level.

In essentially granular soils, Mackintosh Probe tests were made in order to assess the relative density of the materials. The results indicate that the natural soils are generally in a loose becoming medium dense and then dense state of compaction with increasing depth below ground level based on the normally accepted correlation as follows:

Mackintosh N75 X 0.38 = SPT 'N' Value

or

Mackintosh N300 X 0.1 = SPT 'N' Value

The results of the in-situ tests are shown on the appropriate exploratory hole records contained in Appendix A.

4.2 Classification Tests

An Atterberg Limit test was conducted on a selected sample taken from the upper partly cohesive portion of the natural soils and showed the sample tested to fall into Class CH according to the British Soil Classification System.

These are fine grained sandy and silty clay soils of high plasticity and as such generally have moderate bearing and settlement characteristics, have a low permeability and a medium susceptibility to shrinkage and swelling movements with changes in moisture content, as defined by the NHBC Standards, Chapter 4.2. The results indicated a Plasticity Index value of 35% being below the 40% boundary between soils assessed as medium swelling and shrinkage potential and those assessed as high swelling and shrinkage potential.

The test results are given in Table 1, contained in Appendix B.

4.3 Sulphate and pH Analyses

The results of the sulphate and pH analyses made on three soil samples selected to be close to anticipated foundation level and to give a range of depth are presented on Table 2, whilst further results are contained within the contamination analyses, both contained in Appendix B. The results show the natural soil samples tested to have water soluble sulphate contents of up to 0.01g/litre associated with near neutral to slightly alkaline pH values and the samples of made ground tested to have water soluble sulphate contents of up to 0.11g/litre associated with slightly alkaline pH values.

4.4 Brick and Mortar Testing

4.4.1 Compression Tests

The compressive strength testing of the recovered four brick samples was carried out by Sandberg LLP, a UKAS accredited testing company and their report is presented in Appendix B.

4.4.2 Mortar Mix Proportions

The recovered sample of brick mortar was dried and prepared for analysis in accordance with B.S. 4551 : 2005. Clause 7.4.5 and analysed in accordance with Clause 7.5.3.

The analysis revealed a significant presence of excess calcium oxide. It is not possible from the chemical analysis to differentiate whether the additional calcium oxide is as a result of added hydrated lime or as a calcium impurity present within the aggregate or a combination of both. As the soluble silica content was quite low it is also possible that the sample comprised a lime mortar. As such the results have been calculated to include all scenarios.

The results obtained are presented on Table 3 (all excess calcium oxide calculated as calcium impurity, e.g. chalk), Table 3a (all excess calcium oxide calculated as added hydrated lime) and Table 3b (all calcium oxide calculated as hydrated lime - lime mortar option).

5.0 CONTAMINATION TESTING

5.1 General

Samples were obtained from 0.25m depth below ground level in Boreholes 1 and 2, from 0.50m depth in Borehole 2 and from 0.75m depth below ground level in Borehole 1 made at the positions shown on the site sketch plan (Figure 1). Samples were analysed from this depth range below ground level as it is felt that these soils will be representative of those of highest end-user exposure through the dermal contact, dust inhalation, soil ingestion and vegetable consumption pathways.

5.2 Interpretation of Findings

The hazard caused by the presence of a substance or element is not absolute but depends on the proposed end use of the site.

It is understood that the site is to be developed as part of a private residential house with associated gardens. As such the Health Criteria Values for residential use with plant up-take have been used in the following soil assessment.

Site data has been assessed against current generic assessment criteria (GAC) / guideline values in accordance with current industry practice and statutory guidance; both the DETR Circular 02/2002 and CLR7 and CLR11 (Environment Agency, 2002 and 2004, promote the use of GAC for the assessment of land contamination. Where available UK GAC has been used followed by European and American guidance.

However it must be remembered that GAC are not binding standards but can be useful in forming judgements regarding the level of risk i.e. unacceptable or acceptable. Exceedance of GAC does not automatically result in the requirement for remedial / risk management work but would warrant further assessment.

5.3 CLR Documents & Chartered Institute of Environmental Health Values

In March 2002 Soil Guidance Values for certain contaminants were issued in the Contaminated Land Reports (CLR) by the Department of the Environment, Food, Agriculture and Rural Affairs. These values and the CLEA methodology used to derive them have superseded those previously listed in the 59/83 ICRCL tables for soil contaminants.

In August 2008, the Environment Agency produced revised "CLR 10" guidance, which sets out a methodology for estimating human exposure to chemicals in soil. The Environment Agency has also produced revised "CLR 9" guidance on how to assess the toxicology of substances. The overall approach contained within the reports has been agreed by Defra, HPA and FSA.

The Environment Agency has also released a new version of the CLEA software and its handbook to help assessors estimate risks.

As such the site has been assessed using CLEA software version 1.04, the computer version of the CLEA model. This has replaced CLEA UK, the previous model. The Assessment settings and Health Criteria Values have been presented as Appendix C.

The CLR Documents are a series of contaminated land guidance documents developed by various past and present government agencies involved with protection of the environment. The most recent documents were developed by Environment Agency for the Department of the Environment, Food, Agriculture and Rural Affairs (DEFRA).

These documents aim to provide a set of generic Soil Guideline Values and a site specific modelling programme based upon tolerable predicted uptakes from experimental data for a variety of common industrial toxic contaminants. In instances of carcinogenic and mutanagenic substances the guideline values are set on the basis of "As Low As Reasonably Practicable" (ALARP), as theoretically mutation can occur on exposure to a single particle of the contaminant.

The Chartered Institute of Environmental Health Generic Assessment Criteria for Human Health Risk Assessment adopt the Environment Agency's CLEA UK (Beta) Model and as such have derived guideline values that are compatible with current English legislation, policy and technical guidance.

As no generic UK derived guidance is currently available for acceptable concentrations of Total Polycyclic Aromatic Hydrocarbons and Total Cyanide, screening values of 40mg/kg and 20mg/kg respectively (Thiocyanate) have been used as a preliminary screening tool to identify where potential risks may exist. Assessment criteria for selected individual Polycyclic Aromatic Hydrocarbons have been produced by Chartered Institute of Environmental Health; however no values have been attached to Total Polycyclic Aromatic Hydrocarbons. Individual Polycyclic Aromatic Hydrocarbons with attached screening values include Benzo(a)pyrene (1.08-1.12mg/kg), Dibenzo(a,h)anthracene (1.10-1.14mg/kg), Fluorene (38.4-184mg/kg) and Naphthalene (3.47-17.0mg/kg) for a residential scenario with plant uptake.

The concentrations of the phytotoxic substances Total Copper and Total Zinc have been assessed against the Chartered Institute of Environmental Health Generic Assessment Criteria for Human Health Risk Assessment of 111mg/kg and 330mg/kg respectively which assumes a residential scenario with plant uptake and a soil organic matter content of 1%. Whilst there are generally not anticipated to be significant human health risks associated with these concentrations there may be the potential for eco-toxicological effects at concentrations above these levels.

The concentrations of Total Petroleum Hydrocarbons have been assessed against assessment criteria for individual Aromatic and Aliphatic carbon band ranges produced by Chartered Institute of Environmental Health for a residential scenario with plant uptake.

5.4 Assessment of Soil Analyses

The samples selected for contamination assessment were sub-contracted to i2 Analytical Limited (a UKAS and MCERTS accredited laboratory) and their report is contained in Appendix B.

5.5 Discussion

The concentrations of zootoxic heavy metals encountered (Total Arsenic, Total Cadmium, Total Chromium, Total Mercury, Total Selenium and Total Nickel) did not exceed the Health Criteria Values produced for the site by the CLEA Model for residential use with plant uptake in any of the samples analysed. As such there is not considered to be any potentially significant level of end-user risk associated with the concentrations of these contaminants encountered.

An elevated concentration of the zootoxic heavy metal Total Lead was encountered in excess of the Soil Guideline Value for residential use with plant uptake of 450mg/kg in the sample obtained from 0.25m depth in Borehole 1. As such the potential risk to the end-users of the site cannot be discounted at this stage.

The concentrations of Total Cyanide are below the screening value of 20mg/kg and the concentrations of Total Phenol are below the Health Criteria Value for residential use with plant uptake and as such there are not considered to be any significant risks to end-users of the site from these contaminants.

The concentrations of Benzo(a)pyrene, Fluorene, Dibenzo(a,h)anthracene and Naphthalene did not exceed the CIEH Generic screening values for residential use with plant uptake.

Concentrations of Petroleum Hydrocarbons within individual Aromatic and Aliphatic carbon band ranges did not exceed the generic screening values produced by Chartered Institute of Environmental Health for a residential scenario with plant uptake and a 1% SOM content. There were no BTEX or MTBE substances detected within the samples analysed. As such there are not anticipated to be any significant risk to end-users of the site from the concentrations encountered.

The concentrations of the phytotoxic substances Total Copper and Total Zinc encountered in the samples obtained were below the CIEH Generic screening values and are not considered to be sufficient to impair the successful growth of plant species on site. The concentrations of Boron (water soluble) encountered were not considered to be sufficient to impair the successful growth of some sensitive plant species.

Concentrations of Total Sulphide did not exceed 1mg/kg in the samples obtained from the site. It is therefore not anticipated that sulphides will present any human health risk at the site and are not considered sufficient to affect construction or service materials.

Concentrations of Total Sulphate encountered did not exceed the BRE guidance concentration for aggressive ground with respect to construction materials of 2400mg/kg. From the water soluble sulphate concentrations BRE Special Digest 1 : 2005, Tables C1 and C2 would classify all samples as Class DS-1. As such reference should be made to the appropriate BRE Guidance documents when selecting construction materials on site.

5.6 Conclusions

Overall the contaminant of concern with respect to end-user protection which was encountered at the site was the concentration of Total Lead encountered in the sample obtained from 0.25m depth in Borehole 1 on site.

The concentrations of other contaminants analysed from the site were not present in sufficient quantities to pose significant risks to end-users of the site.

In the absence of further investigation it is anticipated that the protection of the end-user may be achieved by effective management of the pathway between the hazard (Total Lead) and the receptor (end-users) on site. This could be achieved by undertaking one of the following options:

a) Removal of the made ground in garden areas and soft landscaped areas to the depth of the underlying natural material or to at least 0.60m below ground level and replacement with clean imported fill.

b) Developing the site exclusive of areas of soft landscaping thereby removing the potential pathways of direct soil contact between the end-users of the site and the soil bound contamination.

c) The use of a 1.00m clay capping to isolate the end-users of the site from potential soil bound contaminants.

It is recommended that precautions for construction workers should be adopted. These should include keeping to a good standard of hygiene with the wearing of boots and gloves. Washing facilities should be made available for all ground workers.

The above conclusions have been drawn on the results of the tests carried out on the soils encountered within the exploratory holes and address remediation issues for the protection of the end-user only. The comments made in this report do not address any third party liability.

5.7 Gas and Groundwater Monitoring Results

The standpipes installed in Boreholes 1 and 2 were monitored for gas and groundwater levels on 19th and 31st March 2009 and the results are presented on Tables 4 and 4a contained in Appendix B.

The groundwater level measurements indicate that the groundwater level has stabilised after a period of about four weeks at depths in excess of 5.00m below ground level in the monitoring standpipes installed in Boreholes 1 and 2.

No significant putrifiable material that could give rise to on-site generation of methane gas was encountered in the boreholes.

Methane is a flammable asphyxiating gas, the flammable range being 5 to 15% by volume in air. If such a methane-air mixture is confined in some way and ignited it will explode. The 5% by volume concentration is termed the lower explosive limit (LEL). Methane is a buoyant gas having a density about two-thirds that of air. Carbon Dioxide is a non-flammable toxic gas, which is about 1.5 times as heavy as air.

Various guidelines have been published to help determine mitigation measures for landfill gas. 'Landfill Gas' includes gas which may be generated in natural soils such as organic alluvium peat. The DETR Waste Management Paper No. 27 – "Landfill Gas is a technical memorandum", which provides guidance on the monitoring and control of landfill gas. This document quotes 1.0% v/v methane (i.e. 1.0% methane by volume) and 1.5% v/v Carbon Dioxide as being concentrations above which buildings should be evacuated. Methane presents an explosion and asphyxiant hazard and Carbon Dioxide an asphyxiant hazard.

Building Research Establishment Report BR212 'Construction of New Buildings on Gas-Contaminated Land', states that if Methane concentrations in the ground are unlikely to exceed 1% by volume and a house or small building is constructed in accordance with its recommendations, then no further protection is required. The recommendations include installing granular under slab venting and sealing floor slabs.

Building Research Establishment Report BR212 'Construction of New Buildings on Gas-Contaminated Land', 1991 states that if carbon dioxide concentrations are above 1.5% by volume then protection should be considered to prevent gas ingress. If concentrations exceed 5% by volume, such protective measures are required.

CIRIA Report C665 (2007) "Assessing risks posed by hazardous ground gases to buildings" suggest a classification system which is summarised in Table 8.5 in the document and employs a method which uses both gas concentrations and borehole flow rates to define a characteristic situation for a site based on the Gas Screening Value (also named the limiting borehole gas volume flow) for methane and carbon dioxide.

The Gas Screening Value is calculated as follows:

The Gas Screening Value (litres of gas per hour) = maximum borehole flow rate (l/h) x maximum gas concentration (%)

Monitoring of the gas wells on site has shown emissions of methane in air of 0.00% and carbon dioxide in air of up to 0.9% recorded during the monitoring visits. The maximum borehole flow rate was 0.2 l/h.

As such the Gas Screening Value for methane at site is 0.0 l/h and the Gas Screening Value for carbon dioxide at site is less than 0.002 l/h. As such the worst case value for the site would be less than 0.002 litres of gas per hour.

This equates to a Characteristic Situation 1, which requires no special precautions at site.

Employing the NHBC 'traffic light' characterisation system, the site would be classified as Green in accordance with CIRIA Report C665. Table 8.7 using the Gas Screening Value for methane and carbon dioxide and as such gas prevention measures would not be considered necessary for the site.

For further information on design and construction details, discussions should be sought with a specialist contractor. Guidance may also be obtained from the BRE Report BR212 'Construction of New Buildings on Gas-Contaminated Land' and CIRIA Report C665 (2007). It may also be prudent to contact the local Environmental Health Officer in order to comply with the Local Authority requirements.

6.0 FOUNDATION DESIGN

6.1 General

It is proposed to install a new basement under the full footprint of the existing house supported on reinforced concrete beams supported on either conventional spread foundations or piled foundations. Exact details of the structure, layout and loadings were not available at the time of preparation of this report although anticipated foundation loads are expected to be moderate and of the order of 200kN/m^2 and basement slab loadings may be of the order of 10-15kN/m^2.

6.2 Conventional Spread Foundations

A result of the inherent variability of uncontrolled fill, (Made Ground) is that it is usually unpredictable in terms of bearing capacity and settlement characteristics. Foundations should therefore, be taken through any made ground and either into, or onto suitable underlying natural strata of adequate bearing characteristics.

Based on the ground and groundwater conditions encountered in the boreholes, it should be possible to support the development on conventional spread foundations. Such foundations should be taken below any made ground and placed in the natural deposits at a minimum depth of 0.90m below final ground level in order to avoid the zone affected by seasonal moisture content changes.

Care should be taken to ensure that softening of the formation does not occur by the immediate placement of a blinding layer of lean mix concrete or the foundation itself. Any soft or loose pockets encountered in otherwise competent formations should be removed and replaced with well-compacted granular fill.

Such foundations placed within natural soils may be designed to allowable net bearing pressures of approximately 100kN/m^2 at a depth of about 2.00m below existing ground level, approximately 200kN/m^2 at a depth of about 3.00m below existing ground level and approximately 150kN/m^2 at a depth of about 4.00m below existing ground level. These values allow for a factor of safety of about three against general shear failure. Total and differential settlement is expected to be within tolerable limits, should not exceed approximately 10-15mm under the loadings given above and be generally substantially complete by the end of the construction period.

The actual allowable bearing pressure applicable will depend of the form of foundation, its geometry and depth in accordance with classical analytical methods, details of which can be obtained from "Foundation Design and Construction", Seventh Edition, 2001 by M J Tomlinson (see references) or similar texts.

The clayey soils present below 3.30m depth at the front of the house are of medium swelling and shrinkage potential and consequently, foundations could possibly need to be taken deeper should they become within the zone of influence of the root systems of the existing nearby trees or any planned trees. NHBC Standards, Chapter 4.2, April 2003 provides recommendations for the foundation depths of houses, within the zone of influence of trees and it is considered that this document is relevant in this case.

6.3 Piled Foundations

In the event that the use of conventional spread foundations proves either impracticable or uneconomical due to the size and depth of foundation required, then a piled foundation would be needed. In these ground conditions, it is considered that some form of auger bored and in-situ cast concrete piled foundation with reinforced concrete ground beams should prove satisfactory.

The construction of a piled foundation is a specialist activity and the advice of a reputable contractor, familiar with the type of soil and groundwater conditions encountered at this site, should be sought prior to finalising the foundation design. The actual pile working load will depend on the particular type of pile chosen and method of installation adopted.

To achieve the full bearing value a pile should penetrate the bearing stratum by at least five times the pile diameter.

Where piles are to be constructed in groups the bearing value of each individual pile should be reduced by a factor of about 0.8 and a calculation made to check the factor of safety against block failure.

Driven piles could also be used and would develop much higher working loads approximately 2.5 to 3 times higher than bored piles of a similar diameter at the same depth. However, the close proximity of adjacent buildings will in all probability preclude their use due to noise and vibration.

6.4 Basement Floor Slabs

The basement floor slab may be cast directly on the natural silty sand deposits or the underlying stiff clay deposits provided that the exposed formation is adequately compacted and protected from the elements.

6.5 Retaining Walls

The results of the investigation indicated that made ground occurs to depths of about 0.9m below existing ground level and is followed by silty sand deposits down to depths of between 3.30m and 5.80m below existing ground level. The general groundwater level beneath the site lies at a depth of more than 5m below existing ground level

Retaining walls should generally be designed as self-supporting cantilevered retaining walls. The excavations for a basement must not affect the integrity of adjacent structures and therefore will need to be supported. Two forms of support could be considered, these being temporary works i.e. sheet piling which could be removed after the earth retaining walls have been constructed or as permanent works incorporated into the final design.

To facilitate support of the excavation, consideration could be given to a contiguous, secant or a sheet piled wall. Generally, cantilevered piled walls have an open face to embedded ratio of about one to two, i.e. a supported face three metres in height would require a penetration into the ground of about six metres below the base of the excavation. Should the piled retaining wall be purely an unsupported cantilever, then it is likely that quite deep section sheet piles or large diameter bored piles would be required.

The section of the sheet or the diameter of the piles could be reduced by installing a braced waling to the wall. Piles placed as part of the permanent works would be propped by the roof to the basement and would not be acting purely as a cantilevered support in the long term.

To reduce the likelihood of loss of ground if a sheet piled wall was adopted when removing the sheets, it is considered that the sheet piles should be incorporated into the final wall design. Assuming that the earth retaining wall will be propped, i.e. have its base slab and first floor slab cast in place soon after excavation, it is unlikely that full if any earth pressures will act on the wall while it is not propped. The greatest force acting on the wall, in the short term, is likely to be from the hydrostatic head should water percolate and be retained to the rear of the earth retaining structure.

It is recommended that the made ground deposits present above 1.0m depth will have an average SPT 'N' Value of N=7 with an angle of shearing resistance of about 29 degrees equating to a coefficient of active pressure of 0.3 and a coefficient of passive resistance of 3.5 and the natural silty sand deposits will have an average SPT 'N' Value of N=10 with an angle of shearing resistance of about 30 degrees equating to a coefficient of active pressure of 0.3 and a coefficient of passive resistance of 4.0 and these values may be adopted in the calculation of both active and passive earth pressures behind the retaining structures. The design parameters for the underlying cohesive deposits throughout the zone of the proposed basement may be assessed as having an average undrained shear strength of about 100kPa with a peak angle of shearing resistance of about 23 degrees equating to a coefficient of active pressure of 0.4 and a coefficient of passive resistance of 3.0. It is further recommended that a soil dry density of 1.85mg/m^3 be adopted in the calculation of both passive and active earth pressures behind the retaining structures.

It is further considered that should a basement raft foundation be adopted, then there is a potential for some total and differential settlement and consequently the foundation should be designed to a maximum loading of $100kN/m^2$, be constructed on a 300mm thick proof rolled layer of gap graded granular fill and be of a sufficient stiffness to be capable of allowing for a minimum of two linear metres loss of support. Any service entry and exit points should be designed to accommodate settlement by the use of sealed flexible joints.

It is considered that such a foundation would generate total settlements of the order of 10 to 15mm of which approximately 80% (10mm) would be due to immediate elastic settlement during the construction period and remainder over a ten year period. Heave of the base of the excavation is likely to be minimal due to the relatively low groundwater level.

6.6 Excavations

Shallow excavations for foundations and services are likely to require nominal side support in the short term and groundwater is unlikely to be encountered in significant quantities once any accumulated surface water has been removed. Deeper and longer excavations below approximately 1.0m to 1.5m below existing ground level will require close side support and some light seepages of groundwater could be encountered within the silty sand deposits.

No particular difficulties are envisaged in removing such water by conventional internal pumping methods from open sumps.

Normal safety precautions should be taken if excavations are to be entered.

6.7 Chemical Attack on Buried Concrete

The results of the chemical analyses show the natural soil samples tested to have water soluble sulphate contents of up to 0.01g/litre associated with near neutral to slightly alkaline pH values and the samples of made ground tested to have water soluble sulphate contents of up to 0.11g/litre associated with slightly alkaline to alkaline pH values.

In these conditions, it is considered that deterioration of buried concrete due to sulphate or acid attack is unlikely to occur. The final design of buried concrete according to Tables C1 and C2 of BRE Special Digest 1:2005 should be in accordance with Class DS-1 conditions.

p.p. SITE ANALYTICAL SERVICES LIMITED

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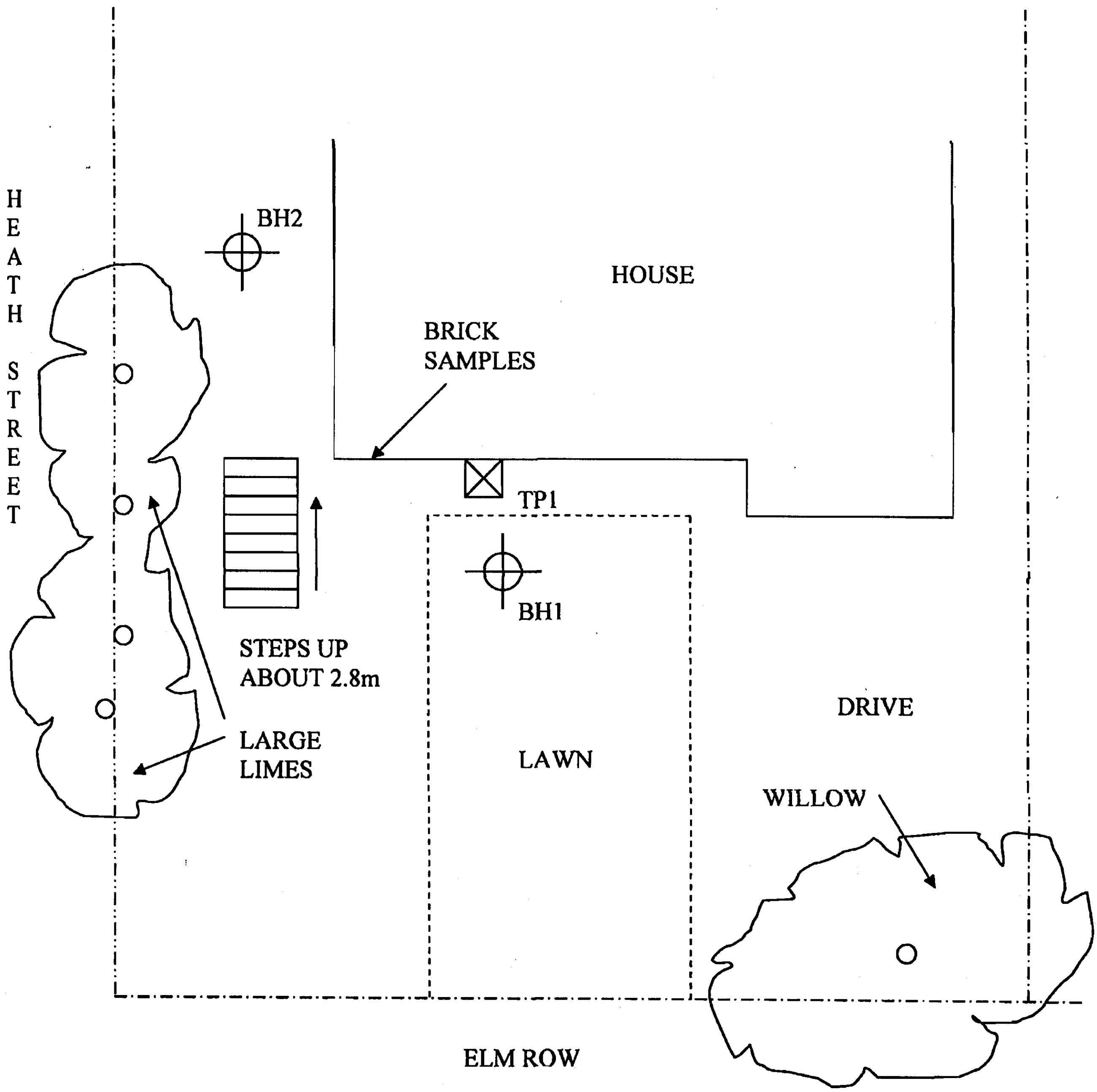
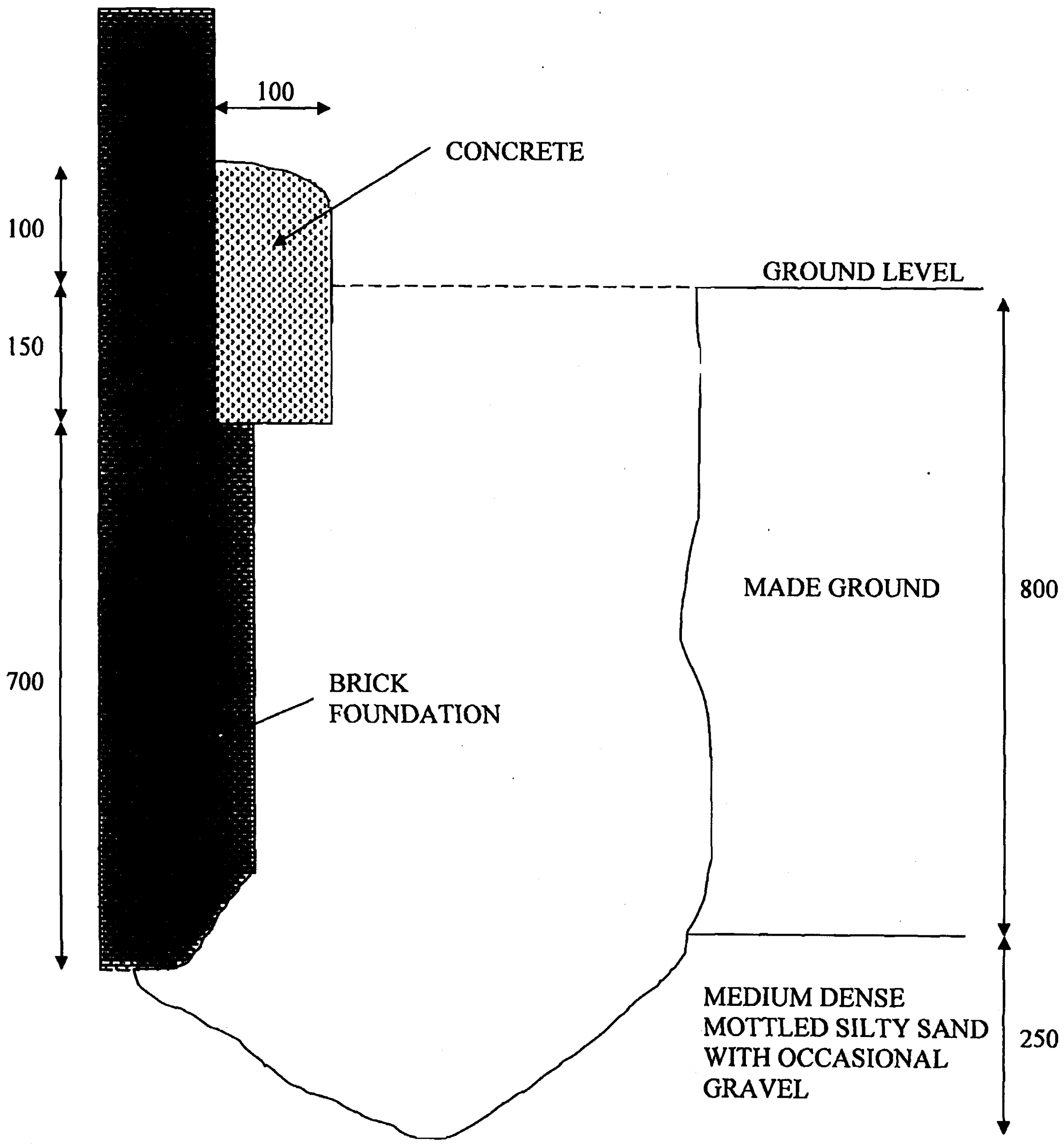
SAS	**Site Analytical Services Ltd.**	REF: 09/15403
	LOCATION: 1 Elm Row, Hampstead, London, NW3 1AA	FIG: 1
	TITLE: Site Sketch Plan DATE: March 2009	SCALE: NTS



Site Analytical Services Ltd.		REF: 09/15403
LOCATION: 1 Elm Row, Hampstead, London, NW3 1AA		FIG: 2
TITLE: Trial Pit 1	DATE: Mar 2009	SCALE: NTS



END OF TRIAL PIT 1 AT 1150mm DEPTH

DIMENSIONS IN mm

APPENDIX `A'

Borehole / Trial Pit Logs

Site Analytical Services Ltd.

Site	1 ELM ROW, HAMPSTEAD, LONDON, NW3 1AA
Borehole Number	BH1
Boring Method	CONTINUOUS FLIGHT AUGER
Casing Diameter	100mm cased to 0.00m
Ground Level (mOD)	
Client	STEPHEN AND JACKIE PALMER
Job Number	0915403
Location	TQ 264 861
Dates	04/03/2009
Engineer	MILK ARCHITECTURE AND DESIGN LIMITED
Sheet	1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
0.25	D1					(0.30) 0.30	MADE GROUND - grass over dark brown sandy topsoil with gravel, ashes and brick fragments		
0.50	D2					(0.60)	MADE GROUND - loose grey brown silty sand, ashes and brick fragments		
0.75	D3					0.90			
1.00 1.00-1.30	D4 M1 53/300						Loose becoming medium dense mottled light brown, orange brown and light grey silty fine to medium SAND with occasional fine gravel		
1.50 1.50-1.80	D5 M2 70/300					(1.80)			
2.00 2.00-2.30	D6 M3 135/300								
2.50 2.50-2.63	D7 M4 81/125					2.70			
3.00 3.00-3.05	D8 M5 50/50					(0.60) 3.30	Medium dense to dense mottled beige, light brown and light grey silty fine to medium SAND with some pockets of stiff sandy silty clay		
3.50 3.50-3.80	D9 M6 120/300						Stiff becoming stiff to very stiff mottled brown and grey sandy silty CLAY with partings of orange brown silty fine sand		
4.00 4.00	D10 V1 101								
4.50 4.50	D11 V2 97								
5.00 5.00	D12 V3 115					(3.70)			
6.00 6.00	D13 V4 131								
7.00 7.00	D14 V5 140+			04/03/2009:DRY		7.00			
							Complete at 7.00m		

Remarks
Groundwater was not encountered during boring although the soil was moist at 2.60m depth
V = Vane Test - Result in kPa
M = Mackintosh Probe - Blows/Penetration (mm)
D = Disturbed Sample

Scale (approx)	Logged By
1:50	SL

Figure No. 0915403.BH1

Site Analytical Services Ltd.

Site	1 ELM ROW, HAMPSTEAD, LONDON, NW3 1AA	**Borehole Number**	BH1
Installation Type MONITORING STANDPIPE	**Dimensions** Internal Diameter of Tube [A] = 50 mm; Diameter of Filter Zone = 100 mm	**Client** STEPHEN AND JACKIE PALMER	**Job Number** 0915403
Location TQ 264 861	**Ground Level (mOD)**	**Engineer** MILK ARCHITECTURE AND DESIGN LIMITED	**Sheet** 1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
					Bentonite Seal
				1.00	Slotted Standpipe
				5.00	General Backfill
				7.00	

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)

Groundwater Observations During Drilling

Date	Start of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	End of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
04/03/09				DRY			7.00		DRY	

Instrument Groundwater Observations

Inst. [A] Type : SINGLE STANDPIPE

Date	Instrument [A] Time	Depth (m)	Level (mOD)	Remarks
19/03/09		DRY		Gas readings taken
31/03/09		DRY		Gas readings taken

Remarks
Lockable cover set in concrete
Gas valve fitted

Site Analytical Services Ltd.

Site	Borehole Number
1 ELM ROW, HAMPSTEAD, LONDON, NW3 1AA	BH2

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
CONTINUOUS FLIGHT AUGER	100mm cased to 0.00m		STEPHEN AND JACKIE PALMER	0915403
	Location TQ 284 861	**Dates** 04/03/2009	**Engineer** MILK ARCHITECTURE AND DESIGN LIMITED	**Sheet** 1/1

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
						(0.15) 0.15	MADE GROUND - stone paving set on lean mix concrete		
0.25	D1						MADE GROUND - loose grey brown silty sand, fine to medium gravel and brick fragments		
0.50	D2					(0.70)			
0.75	D3					0.85			
1.00 1.00-1.30	D4 M1 132/300						Medium dense and locally loose mottled light brown, orange brown and light grey silty fine to medium SAND with occasional fine gravel		
1.50 1.50-1.80	D5 M2 86/300					(2.05)			
2.00 2.00-2.30	D6 M3 102/300								
2.50 2.50-2.80	D7 M4 133/300					2.90			
3.00 3.00-3.11	D8 M5 100/110						Medium dense to dense becoming dense mottled beige, light brown and light grey silty fine to medium SAND with some pockets of stiff sandy silty clay		
3.50 3.50-3.57	D9 M6 100/110								
4.00 4.00-4.04	D10 M7 50/40					(2.90)			
4.50 4.50-4.54	D11 M8 50/40								
5.00 5.00-5.03	D12 M9 50/30					5.80			
6.00 6.00	D13 V1 81					(1.20)	Stiff mottled brown and grey sandy silty CLAY with partings of orange brown silty fine sand		
7.00 7.00	V2 93 D14			04/03/2009:DRY		7.00			
							Complete at 7.00m		

Remarks
D = Disturbed Sample
M = Mackintosh Probe - Blows/Penetration (mm)
V = Vane Test - Result in kPa
Groundwater was not encountered during boring

Scale (approx)	Logged By
1:50	SL

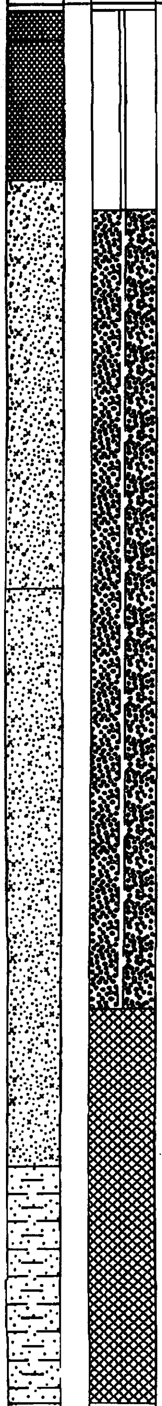
Figure No. 0915403.BH2

Site Analytical Services Ltd.

Site	Borehole Number
1 ELM ROW, HAMPSTEAD, LONDON, NW3 1AA	BH2

Installation Type	Dimensions	Client	Job Number
MONITORING STANDPIPE	Internal Diameter of Tube [A] = 50 mm Diameter of Filter Zone = 100 mm	STEPHEN AND JACKIE PALMER	0915403

Location	Ground Level (mOD)	Engineer	Sheet
TQ 264 861		MILK ARCHITECTURE AND DESIGN LIMITED	1/1



Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				1.00	Bentonite Seal
				5.00	Slotted Standpipe
				7.00	General Backfill

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)

Groundwater Observations During Drilling

Date	Start of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	End of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)
04/03/09				DRY			7.00		DRY	

Instrument Groundwater Observations

Inst. [A] Type : SINGLE STANDPIPE

Date	Instrument [A] Time	Depth (m)	Level (mOD)	Remarks
19/03/09		DRY		Gas readings taken
31/03/09		DRY		Gas readings taken

Remarks
Lockable cover set in concrete
Gas valve fitted

Site Analytical Services Ltd.

Site	1 ELM ROW, HAMPSTEAD, LONDON, NW3 1AA		**Trial Pit Number**	TP1
Excavation Method HAND EXCAVATION	**Dimensions** 800 X 800	**Ground Level (mOD)**	**Client** STEPHEN AND JACKIE PALMER	**Job Number** 0915403
	Location TQ 264 861	**Dates** 04/03/2009	**Engineer** MILK ARCHITECTURE AND DESIGN LIMITED	**Sheet** 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					(0.30)	MADE GROUND - flower bed over dark brown sandy topsoil with gravel, ashes and brick fragments		
0.25	D1				0.30			
0.50	D2				(0.50)	MADE GROUND - loose to medium dense grey brown silty sand, fine to medium gravel, mortar and brick fragments		
					0.80			
0.85 0.85-1.15	D3 M1 110/300				(0.35)	Medium dense mottled light brown, orange brown and light grey silty fine to medium SAND with occasional fine gravel		
			04/03/2009:DRY		1.15			
						Complete at 1.15m		

Plan

Remarks

M = Mackintosh Probe - Blows/Penetration (mm)
D = Disturbed Sample
For details of foundations exposed see sketch
Groundwater was not encountered during excavation

Scale (approx)	Logged By	Figure No.
1:25	SL	0915403.TP1