**APPENDIX D**
**Ground and Projects Consultants Limited Report dated September 2016**

# 28 Marefield Gardens, London, NW3 5SX
# Basement Impact Assessment  Land Stability
# September 2016


## Client:

**Ground and Water Ltd.,**
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**Alton**
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Contents

## Non-Technical Summary,

It is proposed to construct a 3.5m deep basement at 28 Maresfield Gardens, London, NW3 5SX. The basement will be built under the full footprint of the existing house.

The screening exercise identified a number of issues for further consideration as follows:

- The property is relatively close to an existing railway tunnel
- London Clay is the shallowest natural geological strata
- There is a tree close to the front of the house and there are bushes in the rear garden
- A 'lost river' runs relatively close to the site
- Groundwater may be encountered during construction works
- The basement will be deeper than neighbouring properties

The published geology suggests London Clay at site with the possibility of Head Deposits, which are softer and weaker.

A ground investigation was carried out by Ground & Water consisting of two boreholes to 5.0m and 10.45m bgl. These encountered a thin cover of Made Ground (i.e. ground placed by human activity) overlying London Clay as a grey silty clay and of high shrinkage potential. Groundwater was not encountered during the investigation.

The scoping and assessment of the BIA concluded that:

- Groundwater inflow, if encountered, should be properly managed and controlled such that there is no significant wash out of fine material.
- The retaining wall should be appropriately designed.
- The construction of the basement is carried out by competent and experienced contractors and precautions are taken to maintain the stability of the excavations.
- Care should be taken to minimise the disturbance and damage to bushes and their roots. Should bushes be removed then an assessment of the potential for swelling of the London Clay soils should be carried out.
- Concrete should be designed accounting for the sulphate conditions anticipated.
- Monitoring of the structures should be carried out before and during construction. The exact nature of this monitoring should be determined by the structural engineer.

## 1 Introduction

Ground and Project Consultants Ltd have been instructed by Ground and Water Ltd (G&W) to undertake the land stability element of a Basement Impact Assessment, for 28 Maresfield Gardens, London NW3 5SX. The property is located in the London Borough of Camden, London in the Frognal and Fitzjohns ward, its location is indicated on Figure 1.

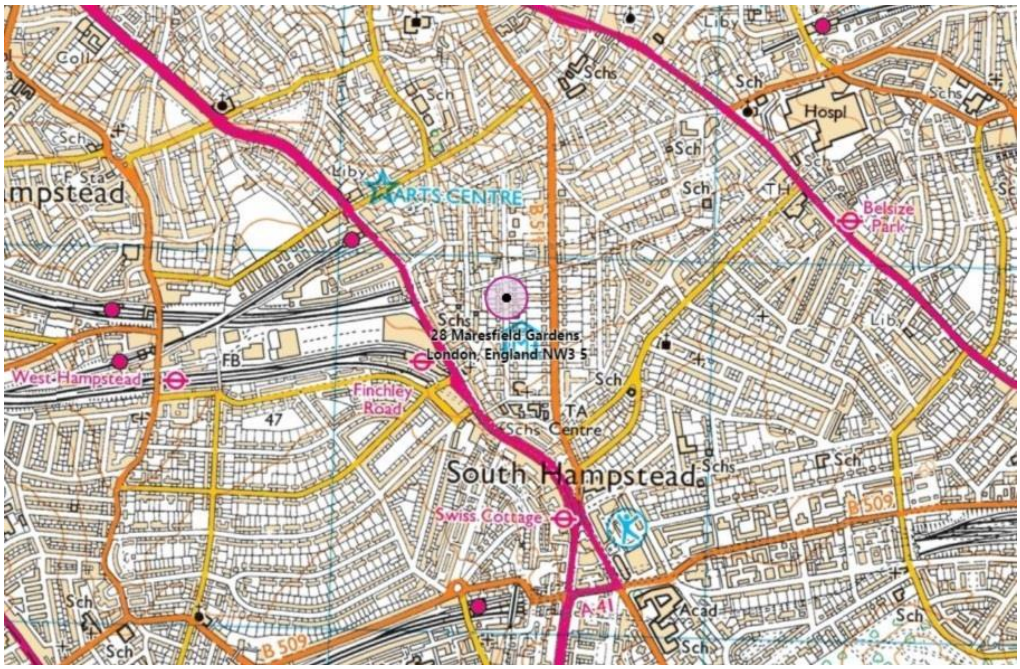


Figure 1: Site Location

## 2 Scope and Objective

The scope of this report and approach is as follows:

- A review of the existing data supplied by the client has been carried out, including the proposal drawings produced to date, Ground Investigation data, photos of the building and the background data available through London Borough of Camden's website and other freely available data such as BGS geological information and purchased environmental data.
- In line with the London Borough of Camden guidance, CPG4, latest revision:
- In line with the CPG4 guidance:
    - A detailed assessment of the published and encountered geology
    - Development of a ground model including an assessment of geotechnical properties
    - An engineering interpretation including an assessment of slope stability and commentary and assessment regarding ground movements.
- Recommendations for additional work/ monitoring and observation have been provided.

Assessment of Ground Movements due to the proposed basement construction have not been carried out at this stage.

The report has not considered contaminated land aspects of the site.

This report and the work to support it has been carried out by Jon Smithson who is a Director of Ground and Project Consultants Ltd and is a Chartered Geologist (CGeol) with over 30 years' experience.

## 3 BIA Screening for Slope/Land Stability

A screening exercise has been carried out as per the guidance in Camden's Guidance for Basements, CPG4 as follows:

| Question | Answer | Action/ Comment |
|---|---|---|
| **Question 1**: Does the existing site include slopes, natural or manmade, greater than 7 degrees? (approximately 1 in 8) | No. The front garden is approximately 1m higher than the rear. | None |
| **Question 2**: Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7deg? (approximately 1 in 8) | No. There are no significant changes in surface profile planned. | None |
| **Question 3**: Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7deg? (approximately 1 in 8) | No. There are no railway cuttings in the immediate vicinity. | None |
| **Question 4**: Is the site within a wider hillside setting in which the general slope is greater than 7degrees? (approximately 1 in 8) | The slope in the area is around 1 in 30 (<2$^{o}$) based on Ordnance Survey data. The site is relatively close to Hampstead Heath and steeper ground | None |
| **Question 5**: Is the London Clay the shallowest strata at the site? | Yes: London Clay is indicated as the shallowest strata on the BGS maps. Head deposits may also be expected | The presence of London Clay close to surface is further discussed in the Impact Assessment |
| **Question 6**: Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained? (Note that consent is required from LB Camden to undertake work to any tree/s protected by a Tree Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions). | It is understood that there will not be a need to fell trees. Trees (plane) are present close to site on the street in front of the property and in the rear garden. | Further discussed in the Impact Assessment. |
| **Question 7**: Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site? | None known. However London Clay/Head Deposits is close to surface. | Further discussed in the Impact Assessment |
| **Question 8**: Is the site within 100m of a watercourse or a potential spring line? | Figure 11 of the Arup report indicates a 'Lost River' around 200m distance to the west of the property. | None |
| **Question 9**: Is the site within an area of previously worked ground? | None known or suspected. | None |

| | | |
|---|---|---|
| **Question 10**: Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction? | No. The London Clay is classified by the Environment Agency as unproductive strata (rock layers with low permeability and negligible significance for water supply or river base flow). The site is not within a source protection zone of a public water supply.<br>However the basement may extend into the water table. | Groundwater management is discussed in the Impact Assessment. |
| **Question 11**: Is the site within 50m of the Hampstead Heath ponds? | No | None |
| **Question 12**: Is the site within 5m of a highway or pedestrian right of way? | No | None |
| **Question 13**: Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties? | It is understood that no basements are present in neighbouring properties, although they do appear to have lower ground floors. | This is further discussed in the Impact Assessment. |
| **Question 14**: Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines? | The Main Line Railway is understood about 20m to the north of the site beneath Nutley Terrace. | This is further discussed in the Impact Assessment. |

# 4 Site Information

## Existing Property and Basement Proposals

The property at 28 Maresfield Gardens is located on the east side of the road, about 20m from its junction with Nutley Terrace. The property is a brick built 5 storey terraced property (including lower ground floor and attic rooms, probably constructed around 1890.

The property is around 1.8km North Northwest of Regents Park and around 1.5km south west of Hampstead Heath. The Main Railway line passes in tunnel around 20m north of the site, beneath Nutley Terrace.

There are plane trees on the road side and smaller trees and bushes in the rear and adjacent rear gardens.

The basement proposals comprise a single storey beneath the footprint of the rear of the property and below part of the back garden. The basement depth will be around 4.7m. The basement footprint will be approximately 92m$^2$. The descriptions and dimensions above have been estimated from drawings provided by G&W.

The National Grid reference for the property is TQ 25228 84702. The location of the property is provided in Figure 1 above.

## Topography

The OS map indicates the property is around 72m AOD. The ground surface rises generally towards the North at around 1 in 30 (approx. 1.5$^o$). The slope becomes steeper to the north as the land rises towards Hampstead Heath. There is no significant change in elevation at the property although the front garden level is around 1m higher than the back. .

## Geology

The available geological mapping (Ref 1.) indicates that the site lies on London Clay which typically comprises a stiff grey fissured clay, weathering to brown near surface. Concretions of argillaceous limestone in nodular form (Claystones) occur throughout the formation. The geological map (North London 256) indicates that the property is within an area of 'propensity' for Head Deposits (stippled on the map), associated with the higher ground of Hampstead Heath. Typically these deposits are thin (<2m) and consist of soft, ocherous brown silty clay with blue-grey mottling in places and angular, frost-shattered fragments of flint occur sporadically throughout. The base of the London Clay is likely to occur significant depth below the property. The Claygate Member (darker brown on map), which immediately overlies the London Clay, and overlying Bagshot Formation (yellow on map) are indicated to the north. The boundary of the London Clay and Claygate Member is around 100-150m to the north. See figure 2 below.

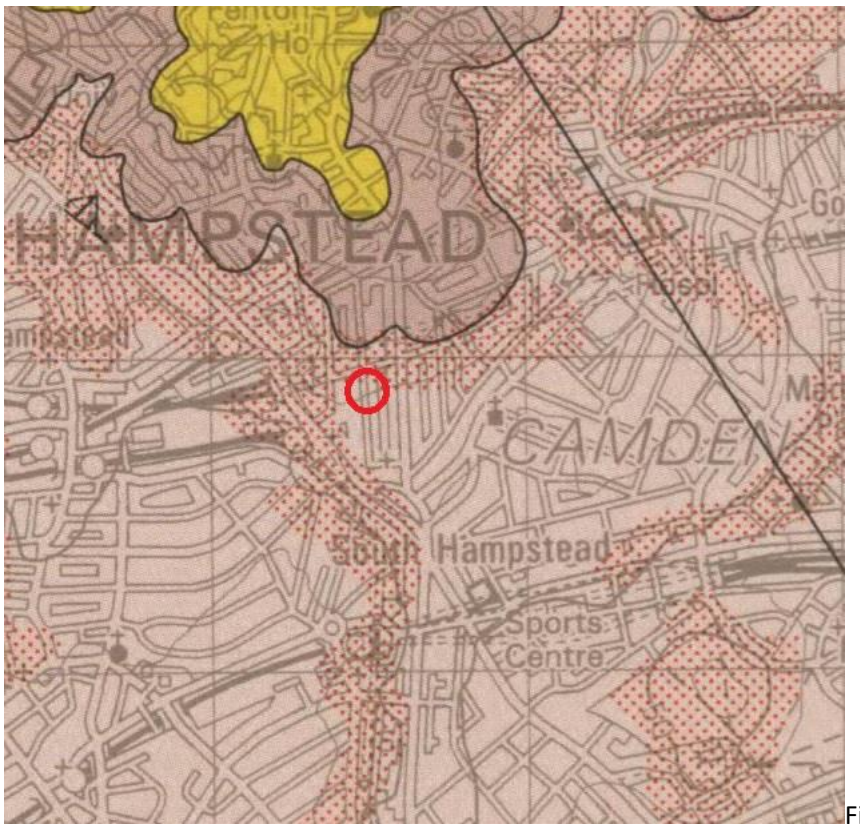


Figure 2: Geology



## Hydrology and Hydrogeology

The OS Map indicates that there are no surface water bodies in the vicinity of the site. The Hampstead Ponds are approximately 1.5km to the NE. There are no springs shown on OS mapping. There is a 'lost river' (a tributary of the Tyburn) indicated approximately 50-100m to the east.

The London Clay is classified by the Environment Agency as unproductive strata (rock layers with low permeability and negligible significance for water supply or river base flow). The site is not within a source protection zone of a public water supply. There are no groundwater abstraction licenses within 2 km of the site and no source protection zones within 500 m of the site. (Ref 5. Groundsure Report). Some springs and/or groundwater flow may be expected at or close to the boundary of the Claygate Member and the London Clay.

Other Environmental Data

A Groundsure report for a nearby property gives a wealth of background data on local environmental issues and hazards. (See Appendix A). The key issues are summarised in the table below:

| | |
|---|---|
| Drift Deposits | None are indicated on BGS mapping |
| Made Ground | None are indicated on BGS mapping |
| Groundwater Abstraction | 7 No. groundwater abstractions are recorded between 500m and 2000m of the site. |
| Shrink/ Swell | There is a moderate Hazard of shrink and swell from the Claygate Member/London Clay soils |
| Landslide | Very Low Risk: Slope instability problems are unlikely to be present. No special actions required to avoid problems due to landslides. No special ground investigation required, and increased construction costs or increased financial risks are unlikely due to potential problems with landslides. |
| Soluble Rocks | Negligible Risk |
| Compressible Ground | Negligible Risk |
| Collapsible Ground | Very Low Risk |
| Running Sand | Very Low Risk |
| Mining | None recorded |

## 5 Ground Investigation

A ground investigation (GI) has been carried out at the site by Ground and Water Ltd and results of these have been made available by G&W. The GI was carried out in August 2016.

The work comprised two boreholes, BH1 and WS2, drilled to 10.45m bgl and 5.0m bgl respectively. BH1 was drilled using a windowless sampler close to the southeast corner of the property. WS12 drilled using a handheld window sampler was located in the rear garden to the east of the house. Two hand dug trail pits were also excavated to expose existing foundations. A standpipe piezometer was installed in BH1 to allow longer term monitoring of groundwater.

Below is a summary derived from the Ground Investigation report. The boreholes encountered a cover of Made Ground 0.60 to 0.90m thick. This can be summarised as a dark brown slightly gravelly silty clay with brick, flint cement and carbonaceous fragments. Below this the boreholes encountered a clay deposit described as brown, becoming dark brown and grey with depth, silty clay with occasional silt pockets and rare fine selenite crystals throughout. The clay is likely to be London Clay.

Groundwater was not encountered during drilling, but was encountered in the standpipe piezometer at 2.70m bgl on 21 September 2016. Rootlets were noted above 1.5m and 1.0m depth respectively and decaying roots were noted at 3.50m bgl in both boreholes, presumably related to past trees.

TP1 was excavated to the rear and TP2 to the rear right in a corner. TP1 encountered made ground to 0.3m bgl overlying London Clay. Adjacent to this the pit revealed a stepped brick wall and underlying concrete foundation with a founding depth of 0.8mbgl (i.e. on London Clay). TP2 encountered a Made Ground to 0.80m bgl overlying London Clay. Again the wall overlies a stepped brick foundation with the concrete foundation base being at 1.20m below ground level, again onto London Clay.

Standard Penetration Tests (SPTs) were carried out in BH1. These gave results (N values) of between 4 and 8 from 1.0m to 3.0m bgl and from 14 increasing steadily to 32 from 4.0m bgl to 10.0m bgl. These indicate a soft to firm clay at the shallower depth range, and a firm to stiff becoming stiff clay at depth.

Laboratory tests were carried out on the samples collected from the boreholes. Testing consisted of the following:

4 No. Atterberg Limit test including moisture content determination
8 Moisture content determination
2 No. Soluble Sulphate, pH and related tests for Concrete Classification on soil samples

All of the Atterberg tests were conducted in the London Clay. These show general consistency with a slight reduction in water content with depth.

- Moisture content: 21 to 38%, generally in the range 31 to 38%
- Plastic Limit: 26 to 30%
- Liquid Limit: 75 to 86%
- Plasticity Index: 49 to 56%
- Liquidity Index 0.08 to 0.14

The low variation in liquid, plastic limits and plasticity index is consistent with undisturbed London Clay. There is limited correlation to the dynamic probe tests. The low liquidity index values are

suggestive of a firm and firm to stiff consistency. The London Clay here is of medium to high plasticity and has high volume change potential.

## 6 Conceptual Ground Model

From the above a conceptual Ground model has been developed and is presented in tabular form below:

| Strata | Typical Description | Depth at Property encountered in GI | Geotechnical Properties – Tentative Characteristic Values* | Other |
|---|---|---|---|---|
| Made Ground | Dark brown, very silty clay, with grave | Ground level to between 0.30 and 0.90m, deeper in foundation areas | N/A | Made Ground should not be relied upon as a bearing strata. Made Ground is likely to be encountered to greater depths at the front of the property. |
| London Clay | Brown and grey silty clay.<br>Probably firm to stiff becoming stiff with depth. | From between 0.30 and 0.90m (base not proven). | C' =0<br>$\phi' = 20^o$<br>Cu = 20 increasing to 70kN/$m^2$ at formation and to 160kN/$m^2$ at 10m. ** | The undrained shear strength of the London Clay should be confirmed prior to construction |
| Groundwater | 2.70m bgl | Dipped in sandpipe at 21/9/16. Not encountered during drilling | | May significantly vary seasonally or after prolonged wet or dry periods. |

Table 3: Summary of Strata Characteristics

*The determination of parameters is tentative due to the lack of test data.

**Strength should be verified by hand held shear vane/ inspection during ground excavation.

## 7 Impact Assessment

There are no apparent major issues which should seriously affect the viability of the construction of the new basement. However the assessment of the geological environment of 28 Maresfield Gardens and the screening exercise indicate some areas for further discussion in this report with suggested mitigation where appropriate.

### Nearby Railway Tunnel

The mainline is understood to be located in tunnel some 20m to the south of the property. The exact location, depth and details of the tunnel are not known and should be ascertained prior to construction. The tunnel appears to pass beneath Nutley Terrace. Network Rail will need to be consulted regarding the basement construction if appropriate. Network Rail make various stipulations in terms of activities and approvals and impose liabilities on the 'proposer'. These must be understood and adhered to as appropriate. It is understood that piling is not required or planned for the basement construction.

### London Clay/Shrink and Swell:

The basement will be founded in London Clay. These soils at this site are of high plasticity and high volume change potential. The basement will be founded at around 3.5m bgl, therefore below any seasonal shrink and swell. The London Clay soils are known for their high levels of soluble sulphate. The concrete mix design should take appropriate account of sulphate levels in accordance with BRE Special Digest 1. The basement structure should be designed to account for swelling pressures. It will be important to account for the shallow nature of the existing foundations at the property and its neighbours. Any change in drainage or significant interruption/change to groundwater levels and flow patterns will need to be assessed for its implication on soil water content and consequential effect on soil volume change.

### Trees and Bushes

No trees are located in the garden although there are some bushes and small trees in the rear garden and a plane tree outside on the pavement to the front. Roots have been noted in the ground investigation. Care should be taken to minimise root damage during construction works. Should bushes be removed there is potential for the soils to swell as a result which may affect this and neighbouring properties and this should be accounted for in design and further assessed as appropriate.

### Groundwater/Aquifer:

Groundwater was not encountered during the drilling but was found in the standpipe piezometer on 21 September at 2.7m bgl. It is recommended that a design level of ground surface is used, this accounts for seasonal variations and leaks from water supply, etc. Groundwater may be encountered during the works, particularly as seepages through sandy silty layers within London Clay or at the base of the Made Ground. These should be managed carefully to prevent ground loss particularly through loss of fines. Softening of

formation due to water ingress is a risk and softened soils should be excavated and replaced where practicable. Consideration should be given to limiting the size and time of face exposures during construction should significant flows be encountered during construction. Baseline and ongoing regular monitoring of the building and its immediate neighbours for settlement and movement/distress is highly recommended during building works and for a short period after completion. It is recommended that ongoing monitoring of groundwater levels is carried out during and up to the end of construction of the basement structure.

Basement Depth:

It is proposed to be construct the basement to a level of approximately 4.7m below the existing ground floor. The property adjoins neighbouring houses either side. The proposals to construct the basement is to be via underpinning at the party and rear and front walls. Underpinning proposals are understood to involve a 'hit and miss' approach in stages so each 'panel' is separated by 3-5 others from the next open one. It will be important that the building contractor is closely supervised and is experienced in this type of construction. It will be critical to prevent exposed faces from collapse or significant ground loss into the new excavation and temporary face support should be maintained where practicable. It is understood the there are no deep basements in adjoin/adjacent properties. Most ground movement should occur during wall installation, excavation of the basement and construction so the adequacy of temporary support will be critical in limiting ground movements. Heave movements will occur due to removal of soils. The presence of softer weathered London Clay may lead to slightly larger ground movements.

A number of factors will assist in limiting ground movements:

- The speed of propping and support
- Good workmanship
- Ensuring that adequate propping is in place at all times during construction
- Installation of the first (stiff) support quickly and early in the construction sequence.
- Avoidance of ground loss through the gaps between the piles.
- Avoid leaving ground unsupported.
- Minimise deterioration of the central soil mass by the use of blinding/ covering with a waterproof membrane.
- Avoid overbreak
- Control dewatering to minimise fines removal and drawdown.

# 8 Conclusions

The methodology and approach of CPG4 has been followed in developing this BIA with respect to Land stability. It is concluded that with the construction of the new basement at 28 Maresfield Gardens should not have significant impacts on land stability provided that:

- Groundwater inflow, if encountered, is reduced to a minimum and properly controlled such that there is no significant wash out of fine material. Groundwater levels should be monitored before and during construction.

- The presence and location of the railway beneath Nutley Terrace should be further assessed and where appropriate action and consultation undertaken.

- The retaining wall should be appropriately designed.

- The construction of the basement is carried out by competent and experienced contractors and precautions are taken to maintain the stability of the excavations.

- Care should be taken to minimise the disturbance and damage to bushes and their roots. Should bushes be removed then an assessment of the potential for swelling of the London Clay soils should be carried out.

- Concrete should be designed in accordance with BRE Special Digest 1 accounting for the sulphate conditions anticipated.

- Monitoring of the structures is carried out before and during construction. The exact nature of this monitoring should be determined by the structural engineer.

## 9 References

1. BGS Geological Map Sheet 256.
2. Ordnance Survey Map, Explorer 173, London North
3. Arup: Camden Geological, Hydrogeological and Hydrological Study.
4. Design Drawings supplied by G&W
5. G&W Ground Investigation Data available at 15/9/16

**APPENDIX E**
**Fieldwork Logs**

| Ground and Water Ltd | | | Borehole No **BH1** Sheet 1 of 2 |
|---|---|---|---|
| Project Name: 28 Marefield Gardens | Project No.: GWPR1761 | Co-ords: - | Hole Type: WLS |
| Location: South Hampstead, London NW3 5SX | | Level: - | Scale: 1:50 |
| Client: Mr and Mrs Freedman | | Dates: 05/08/2016 | Logged By: RF |

| Well | Water Strikes | Samples & In Situ Testing: Depth (m) | Type | Results | Depth (m) | Level (m AOD) | Legend | Stratum Description |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0.07 | | | MADE GROUND: Tarmac |
| | | 0.20 | D | | 0.20 | | | MADE GROUND: Brick and sand sub-base. |
| | | 0.50 | D | | 0.60 | | | MADE GROUND: Dark brown slightly gravelly silty clay. Gravel is occasional, fine to medium, sub-angular to sub-rounded flint and gravel and rare fine sub-angular to sub-rounded carbonaceous material (ash/clinker). |
| | | 0.80 | D | | | | | |
| | | 1.00 | SPT | N=4 | | | | LONDON CLAY FORMATION: Brown silty CLAY with rare fine selenite crystals. |
| | | 1.00 | D | (1,1/ 1,1,1,1) | | | | |
| | | 1.80 | D | | | | | |
| | | 2.00 | SPT | N=8 | | | | |
| | | 2.00 | D | (1,1/ 1,2,2,3) | | | | |
| | | 2.50 | D | | 2.60 | | | LONDON CLAY FORMATION: Brown silty CLAY with pockets of orange silt, veins of grey silt and rare fine selenite crystals. |
| | | 3.00 | SPT | N=7 | | | | |
| | | 3.00 | D | (2,3/ 2,1,2,2) | | | | |
| | | 3.50 | D | | | | | |
| | | 4.00 | SPT | N=14 | | | | |
| | | 4.00 | D | (2,2/ 3,3,4,4) | | | | |
| | | 4.50 | D | | | | | |
| | | 5.00 | SPT | N=15 | | | | |
| | | 5.00 | D | (3,4/ 4,4,3,4) | | | | |
| | | 5.50 | D | | | | | |
| | | 6.00 | SPT | N=17 | | | | |
| | | 6.00 | D | (4,4/ 3,4,5,5) | | | | |
| | | 6.50 | D | | | | | |
| | | 7.00 | SPT | N=21 | | | | |
| | | 7.00 | D | (4,5/ 5,5,6,5) | 7.20 | | | LONDON CLAY FORMATION: Dark grey brown silty CLAY with rare fine selenite crystals. |
| | | 7.50 | D | | | | | |
| | | 8.00 | SPT | N=21 | | | | |
| | | 8.00 | D | (5,5/ 5,6,5,5) | | | | |
| | | 8.50 | D | | | | | |
| | | 9.00 | SPT | N=25 | | | | |
| | | 9.00 | D | (5,5/ 6,6,6,7) | | | | |
| | | 9.50 | D | | | | | |
| | | | Type | Results | | | | Continued next sheet |

Remarks: No groundwater encountered.
Roots noted to 1.50m bgl.
Decaying roots noted at 3.50m bgl.

AGS

Ground and Water Ltd

Borehole No
**BH1**
Sheet 2 of 2

| | | | |
|---|---|---|---|
| Project Name: 28 Marefield Gardens | Project No.: GWPR1761 | Co-ords: - | Hole Type: WLS |
| Location: South Hampstead, London NW3 5SX | | Level: - | Scale: 1:50 |
| Client: Mr and Mrs Freedman | | Dates: 05/08/2016 | Logged By: RF |

| Well | Water Strikes | Samples & In Situ Testing: Depth (m) | Type | Results | Depth (m) | Level (m AOD) | Legend | Stratum Description |
|---|---|---|---|---|---|---|---|---|
| | | 10.00<br>10.00 | SPT<br>D | N=32<br>(7,8/<br>8,8,8,8) | 10.45 | | | LONDON CLAY FORMATION: Dark grey brown silty CLAY with rare fine selenite crystals.<br>End of Borehole at 10.45 m |

| Type | Results |
|---|---|

Remarks: No groundwater encountered.
Roots noted to 1.50m bgl.
Decaying roots noted at 3.50m bgl.

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Borehole No
**WS2**
Sheet 1 of 1

| | | | |
|---|---|---|---|
| Project Name<br>28 Marefield Gardens | Project No.<br>GWPR1761 | Co-ords: - | Hole Type<br>WS |
| Location: South Hampstead, London NW3 5SX | | Level: - | Scale<br>1:50 |
| Client: Mr and Mrs Freedman | | Dates: 05/08/2016 | Logged By<br>RF |

| Well | Water Strikes | Samples & In Situ Testing Depth (m) | Type | Results | Depth (m) | Level (m AOD) | Legend | Stratum Description |
|---|---|---|---|---|---|---|---|---|
| | | 0.20 | D | | | | | MADE GROUND: Dark brown slightly gravelly silty clay. Gravel is occasional, fine to medium, sub-angular to sub-rounded brick and rare to occasional fine sub-angular to sub-rounded carbonaceous material (ash/clinker). |
| | | 0.50 | D | | | | | |
| | | 0.80 | D | | | | | |
| | | 1.00 | D | | 0.90 | | | LONDON CLAY FORMATION: Brown silty CLAY with very rare fine selenite crystals. |
| | | 1.50 | D | | | | | |
| | | 2.00 | D | | 1.90 | | | LONDON CLAY FORMATION: Brown silty CLAY with fine selenite crystals and sub-rounded flint gravel |
| | | 2.50 | D | | 2.20 | | | LONDON CLAY FORMATION: Brown silty CLAY with veins of grey silt, pockets of orange silt and rare fine selenite crystals. |
| | | 3.00 | D | | | | | |
| | | 3.50 | D | | | | | |
| | | 4.00 | D | | | | | |
| | | 4.50 | D | | | | | |
| | | 5.00 | D | | 5.00 | | | End of Borehole at 5.00 m |
| | | | Type | Results | | | | |

Remarks: No groundwater encountered.
Fine roots to 1.00m bgl.
Decayed root noted at 3.50m bgl.

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**APPENDIX F**
**Geotechnical Laboratory Test Results**

# Summary of Natural Moisture Content, Liquid Limit and Plastic Limit Results

| Job No. | Project Name | Programme | |
|---|---|---|---|
| 21471 | 28 Maresfield Gardens, South Hampstead, London NW3 | Samples received | 24/08/2016 |
| | | Schedule received | 23/08/2016 |
| Project No. | Client | Project started | 24/08/2016 |
| GWPR1761 | Ground and Water Ltd | Testing Started | 09/09/2016 |

| Hole No. | Sample | | | | Soil Description | NMC | Passing 425µm | LL | PL | PI | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ref | Top | Base | Type | | % | % | % | % | % | |
| BH1 | S | 1.00 | - | D | Brown and occasional orangish brown silty CLAY with rare medium angular gravel | 34 | | | | | |
| BH1 | S | 1.50 | - | D | Brown silty CLAY with rare roots | 33 | 100 | 75 | 26 | 49 | |
| BH1 | S | 2.00 | - | D | Brown and rare grey silty CLAY with rare siltstone noduls and medium sub-rounded gravel | 30 | | | | | |
| BH1 | S | 2.50 | - | D | Brown slightly mottled grey silty CLAY with occasional orange fine sand pockets | 38 | | | | | |
| BH1 | S | 3.00 | - | D | Brown and occasional grey silty CLAY with rare fine selenite crystals | 38 | 100 | 86 | 30 | 56 | |
| BH1 | S | 3.50 | - | D | Brown slightly mottled grey silty CLAY with rare carbonaceous deposits and occasional selenite crystals | 36 | | | | | |
| WS2 | S | 1.00 | - | D | Brown and rare orangish brown silty CLAY with traces of carbonaceous deposits and rare fmc sub-angular gravel | 33 | 99 | 79 | 26 | 53 | |
| WS2 | S | 1.50 | - | D | Brown silty CLAY | 31 | | | | | |
| WS2 | S | 2.00 | - | D | Brown gravelly silty CLAY (gravel is fmc and sub-angular to sub-rounded) | 21 | | | | | |
| WS2 | S | 2.50 | - | D | Brown and rare orangish brown silty CLAY with rare fine mudstone fragments and rare fine gravel | 32 | 99 | 80 | 28 | 52 | |
| WS2 | S | 3.00 | - | D | Brown slightly mottled grey silty CLAY with rare orange fine sand pockets | 36 | | | | | |
| WS2 | S | 3.50 | - | D | Brown slightly mottled grey silty CLAY | 34 | | | | | |

**Test Methods: BS1377: Part 2: 1990:**
Natural Moisture Content : clause 3.2
Atterberg Limits: clause 4.3 and 5.0

**Test Report by K4 SOILS LABORATORY**
**Unit 8 Olds Close Olds Approach**
**Watford Herts WD18 9RU**

**Tel: 01923 711 288**
**Email: James@k4soils.com**

**Checked and Approved**

**Initials** **J.P**

**Date:** 13/09/2016

## Sulphate Content (Gravimetric Method) for 2:1 Soil: Water Extract and pH Value - Summary of Results

**Tested in accordance with BS1377 : Part 3 : 1990, clause 5.3 and clause 9**

| Job No. | Project Name | Programme | |
|---|---|---|---|
| 21471 | 28 Maresfield Gardens, South Hampstead, London NW3 | Samples received | 24/08/2016 |
| | | Schedule received | 23/08/2016 |
| Project No. | Client | Project started | 24/08/2016 |
| GWPR1761 | Ground and Water Ltd | Testing Started | 08/09/2016 |

| Hole No. | Sample | | | | Soil description | Dry Mass passing 2mm | SO3 Content | SO4 Content | pH | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ref | Top | Base | Type | | % | g/l | g/l | | |
| BH1 | S | 1.00 | - | D | Brown and occasional orangish brown silty CLAY with rare medium angular gravel | 98 | 0.23 | 0.28 | 8.26 | |
| WS2 | S | 2.00 | - | D | Brown gravelly silty CLAY (gravel is fmc and sub-angular to sub-rounded) | 56 | 0.25 | 0.30 | 8.32 | |
| | | | | | | | | | | |
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**Test Report by K4 SOILS LABORATORY**
**Unit 8 Olds Close Olds Approach**
**Watford Herts WD18 9RU**
**Tel: 01923 711 288**
**Email: James@k4soils.com**


**Checked and Approved**

**Initials J.P**

**Date: 13/09/2016**

Francis Williams
Ground & Water Ltd
2 The Long Barn
Norton Farm
Selborne Road
Alton
Hampshire
GU34 3NB

QTS Environmental Ltd
Unit 1
Rose Lane Industrial Estate
Rose Lane
Lenham Heath
Kent
ME17 2JN
t: 01622 850410
russell.jarvis@qtsenvironmental.com

# QTS Environmental Report No: 16-48409

| | |
|---|---|
| Site Reference: | 28 Maresfield Gardens, South Hampstead, London NW3 |
| Project / Job Ref: | GWPR1761 |
| Order No: | None Supplied |
| Sample Receipt Date: | 24/08/2016 |
| Sample Scheduled Date: | 24/08/2016 |
| Report Issue Number: | 1 |
| Reporting Date: | 31/08/2016 |

Authorised by:

Kevin Old
Associate Director of Laboratory

Authorised by:

Russell Jarvis
Associate Director of Client Services

QTS Environmental Ltd
Unit 1, Rose Lane Industrial Estate
Rose Lane
Lenham Heath
Maidstone
Kent ME17 2JN
Tel : 01622 850410

| Soil Analysis Certificate | | | | | | | |
|---|---|---|---|---|---|---|---|
| QTS Environmental Report No: 16-48409 | Date Sampled | 05/08/16 | 05/08/16 | | | | |
| Ground & Water Ltd | Time Sampled | None Supplied | None Supplied | | | | |
| Site Reference: 28 Maresfield Gardens, South Hampstead, London NW3 | TP / BH No | BH1 | WS2 | | | | |
| Project / Job Ref: GWPR1761 | Additional Refs | None Supplied | None Supplied | | | | |
| Order No: None Supplied | Depth (m) | 2.50 | 1.50 | | | | |
| Reporting Date: 31/08/2016 | QTSE Sample No | 224463 | 224464 | | | | |

| Determinand | Unit | RL | Accreditation | | | | | |
|---|---|---|---|---|---|---|---|---|
| pH | pH Units | N/a | MCERTS | 7.1 | 7.2 | | | |
| Total Sulphate as $SO_4$ | mg/kg | < 200 | NONE | 1449 | 359 | | | |
| Total Sulphate as $SO_4$ | % | < 0.02 | NONE | 0.14 | 0.04 | | | |
| W/S Sulphate as $SO_4$ (2:1) | mg/l | < 10 | MCERTS | 412 | 411 | | | |
| W/S Sulphate as $SO_4$ (2:1) | g/l | < 0.01 | MCERTS | 0.41 | 0.41 | | | |
| Total Sulphur | % | < 0.02 | NONE | 0.05 | < 0.02 | | | |
| Ammonium as $NH_4$ | mg/kg | < 0.5 | NONE | 4.9 | 5.5 | | | |
| Ammonium as $NH_4$ | mg/l | < 0.05 | NONE | 0.49 | 0.55 | | | |
| W/S Chloride (2:1) | mg/kg | < 1 | MCERTS | 15 | 16 | | | |
| W/S Chloride (2:1) | mg/l | < 0.5 | MCERTS | 7.5 | 7.9 | | | |
| Water Soluble Nitrate (2:1) as $NO_3$ | mg/kg | < 3 | MCERTS | < 3 | < 3 | | | |
| Water Soluble Nitrate (2:1) as $NO_3$ | mg/l | < 1.5 | MCERTS | < 1.5 | < 1.5 | | | |
| W/S Magnesium | mg/l | < 0.1 | NONE | 16 | 2.9 | | | |

Analytical results are expressed on a dry weight basis where samples are assisted-dried at less than 30$^{O}$C
Analysis carried out on the dried sample is corrected for the stone content
Subcontracted analysis $^{(S)}$

QTS Environmental Ltd
Unit 1, Rose Lane Industrial Estate
Rose Lane
Lenham Heath
Maidstone
Kent ME17 2JN
Tel : 01622 850410

4480

| Soil Analysis Certificate - Sample Descriptions | |
|---|---|
| QTS Environmental Report No: 16-48409 | |
| Ground & Water Ltd | |
| Site Reference: 28 Maresfield Gardens, South Hampstead, London NW3 | |
| Project / Job Ref: GWPR1761 | |
| Order No: None Supplied | |
| Reporting Date: 31/08/2016 | |

| QTSE Sample No | TP / BH No | Additional Refs | Depth (m) | Moisture Content (%) | Sample Matrix Description |
|---|---|---|---|---|---|
| $ 224463 | BH1 | None Supplied | 2.50 | 23.2 | Light brown clay |
| $ 224464 | WS2 | None Supplied | 1.50 | 19.4 | Light brown clay |

*Moisture content is part of procedure E003 & is not an accredited test*

Insufficient Sample I/S

Unsuitable Sample U/S

*$ samples exceeded recommended holding times*

QTS Environmental Ltd
Unit 1, Rose Lane Industrial Estate
Rose Lane
Lenham Heath
Maidstone
Kent ME17 2JN
Tel : 01622 850410

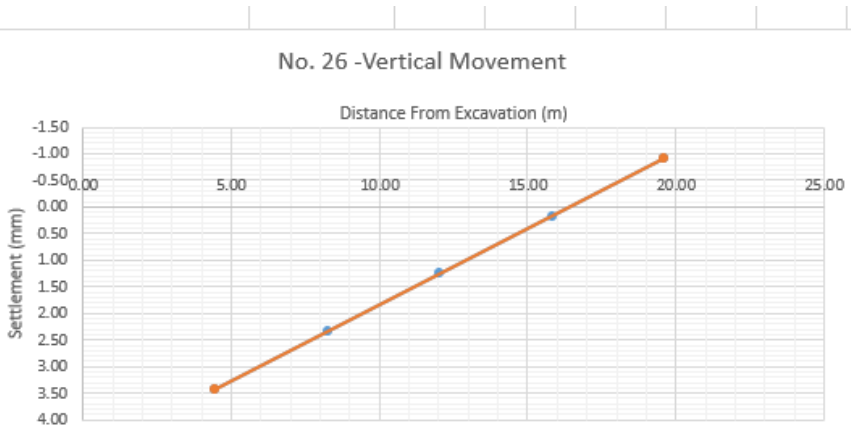
| Soil Analysis Certificate - Methodology & Miscellaneous Information |
|---|
| QTS Environmental Report No: 16-48409 |
| Ground & Water Ltd |
| Site Reference: 28 Maresfield Gardens, South Hampstead, London NW3 |
| Project / Job Ref: GWPR1761 |
| Order No: None Supplied |
| Reporting Date: 31/08/2016 |

| Matrix | Analysed On | Determinand | Brief Method Description | Method No |
|---|---|---|---|---|
| Soil | D | Boron - Water Soluble | Determination of water soluble boron in soil by 2:1 hot water extract followed by ICP-OES | E012 |
| Soil | AR | BTEX | Determination of BTEX by headspace GC-MS | E001 |
| Soil | D | Cations | Determination of cations in soil by aqua-regia digestion followed by ICP-OES | E002 |
| Soil | D | Chloride - Water Soluble (2:1) | Determination of chloride by extraction with water & analysed by ion chromatography | E009 |
| Soil | AR | Chromium - Hexavalent | Determination of hexavalent chromium in soil by extraction in water then by acidification, addition of 1,5 diphenylcarbazide followed by colorimetry | E016 |
| Soil | AR | Cyanide - Complex | Determination of complex cyanide by distillation followed by colorimetry | E015 |
| Soil | AR | Cyanide - Free | Determination of free cyanide by distillation followed by colorimetry | E015 |
| Soil | AR | Cyanide - Total | Determination of total cyanide by distillation followed by colorimetry | E015 |
| Soil | D | Cyclohexane Extractable Matter (CEM) | Gravimetrically determined through extraction with cyclohexane | E011 |
| Soil | AR | Diesel Range Organics (C10 - C24) | Determination of hexane/acetone extractable hydrocarbons by GC-FID | E004 |
| Soil | AR | Electrical Conductivity | Determination of electrical conductivity by addition of saturated calcium sulphate followed by electrometric measurement | E022 |
| Soil | AR | Electrical Conductivity | Determination of electrical conductivity by addition of water followed by electrometric measurement | E023 |
| Soil | D | Elemental Sulphur | Determination of elemental sulphur by solvent extraction followed by GC-MS | E020 |
| Soil | AR | EPH (C10 – C40) | Determination of acetone/hexane extractable hydrocarbons by GC-FID | E004 |
| Soil | AR | EPH Product ID | Determination of acetone/hexane extractable hydrocarbons by GC-FID | E004 |
| Soil | AR | EPH TEXAS (C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C40) | Determination of acetone/hexane extractable hydrocarbons by GC-FID for C8 to C40. C6 to C8 by headspace GC-MS | E004 |
| Soil | D | Fluoride - Water Soluble | Determination of Fluoride by extraction with water & analysed by ion chromatography | E009 |
| Soil | D | FOC (Fraction Organic Carbon) | Determination of fraction of organic carbon by oxidising with potassium dichromate followed by titration with iron (II) sulphate | E010 |
| Soil | D | Loss on Ignition @ 450oC | Determination of loss on ignition in soil by gravimetrically with the sample being ignited in a muffle furnace | E019 |
| Soil | D | Magnesium - Water Soluble | Determination of water soluble magnesium by extraction with water followed by ICP-OES | E025 |
| Soil | D | Metals | Determination of metals by aqua-regia digestion followed by ICP-OES | E002 |
| Soil | AR | Mineral Oil (C10 - C40) | Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge | E004 |
| Soil | AR | Moisture Content | Moisture content; determined gravimetrically | E003 |
| Soil | D | Nitrate - Water Soluble (2:1) | Determination of nitrate by extraction with water & analysed by ion chromatography | E009 |
| Soil | D | Organic Matter | Determination of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphate | E010 |
| Soil | AR | PAH - Speciated (EPA 16) | Determination of PAH compounds by extraction in acetone and hexane followed by GC-MS with the use of surrogate and internal standards | E005 |
| Soil | AR | PCB - 7 Congeners | Determination of PCB by extraction with acetone and hexane followed by GC-MS | E008 |
| Soil | D | Petroleum Ether Extract (PEE) | Gravimetrically determined through extraction with petroleum ether | E011 |
| Soil | AR | pH | Determination of pH by addition of water followed by electrometric measurement | E007 |
| Soil | AR | Phenols - Total (monohydric) | Determination of phenols by distillation followed by colorimetry | E021 |
| Soil | D | Phosphate - Water Soluble (2:1) | Determination of phosphate by extraction with water & analysed by ion chromatography | E009 |
| Soil | D | Sulphate (as SO4) - Total | Determination of total sulphate by extraction with 10% HCl followed by ICP-OES | E013 |
| Soil | D | Sulphate (as SO4) - Water Soluble (2:1) | Determination of sulphate by extraction with water & analysed by ion chromatography | E009 |
| Soil | D | Sulphate (as SO4) - Water Soluble (2:1) | Determination of water soluble sulphate by extraction with water followed by ICP-OES | E014 |
| Soil | AR | Sulphide | Determination of sulphide by distillation followed by colorimetry | E018 |
| Soil | D | Sulphur - Total | Determination of total sulphur by extraction with aqua-regia followed by ICP-OES | E024 |
| Soil | AR | SVOC | Determination of semi-volatile organic compounds by extraction in acetone and hexane followed by GC-MS | E006 |
| Soil | AR | Thiocyanate (as SCN) | Determination of thiocyanate by extraction in caustic soda followed by acidification followed by addition of ferric nitrate followed by colorimetry | E017 |
| Soil | D | Toluene Extractable Matter (TEM) | Gravimetrically determined through extraction with toluene | E011 |
| Soil | D | Total Organic Carbon (TOC) | Determination of organic matter by oxidising with potassium dichromate followed by titration with iron (II) sulphate | E010 |
| Soil | AR | TPH CWG (ali: C5- C6, C6-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C34, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35) | Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge for C8 to C35. C5 to C8 by headspace GC-MS | E004 |
| Soil | AR | TPH LQM (ali: C5-C6, C6-C8, C8-C10, C10 C12, C12-C16, C16-C35, C35-C44, aro: C5-C7, C7-C8, C8-C10, C10-C12, C12-C16, C16-C21, C21-C35, C35-C44) | Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge for C8 to C44. C5 to C8 by headspace GC-MS | E004 |
| Soil | AR | VOCs | Determination of volatile organic compounds by headspace GC-MS | E001 |
| Soil | AR | VPH (C6-C8 & C8-C10) | Determination of hydrocarbons C6-C8 by headspace GC-MS & C8-C10 by GC-FID | E001 |

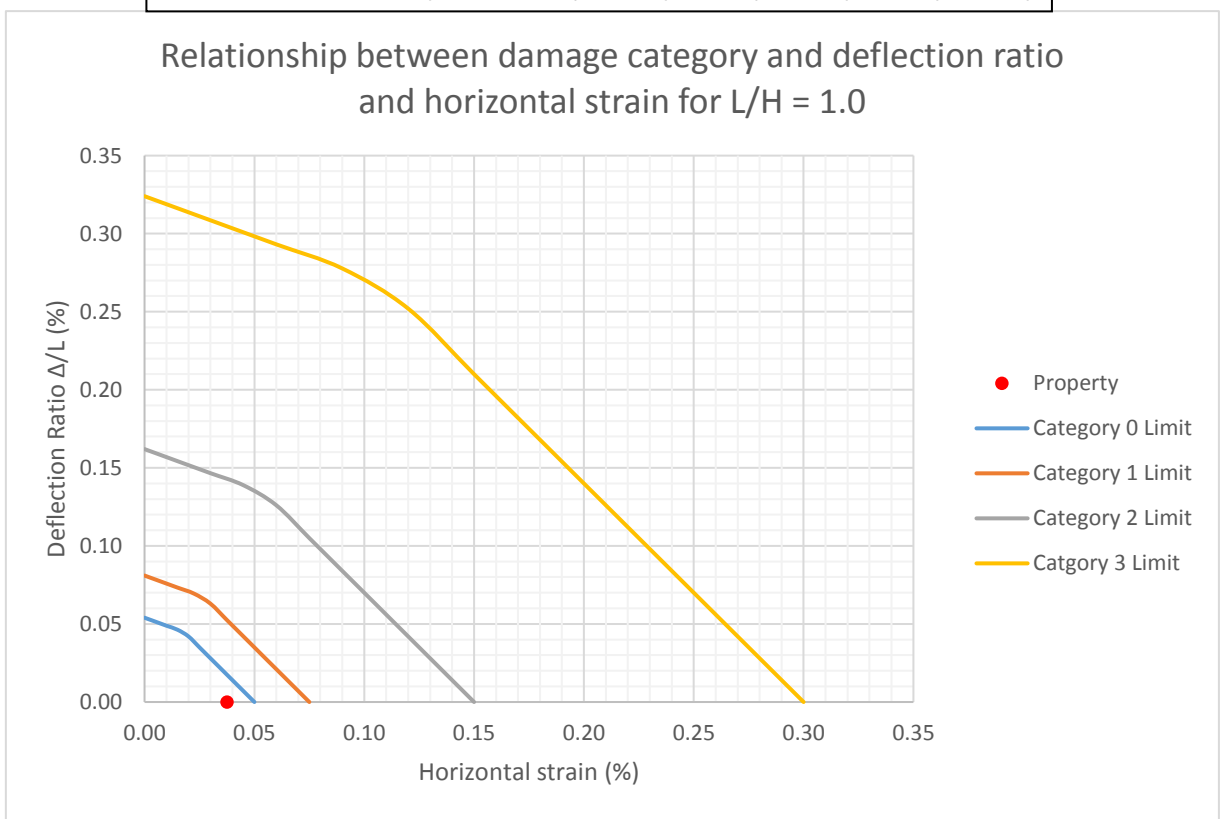
D Dried
AR As Received

**APPPENDIX G**
**Ground Movement Assessment Calculations**

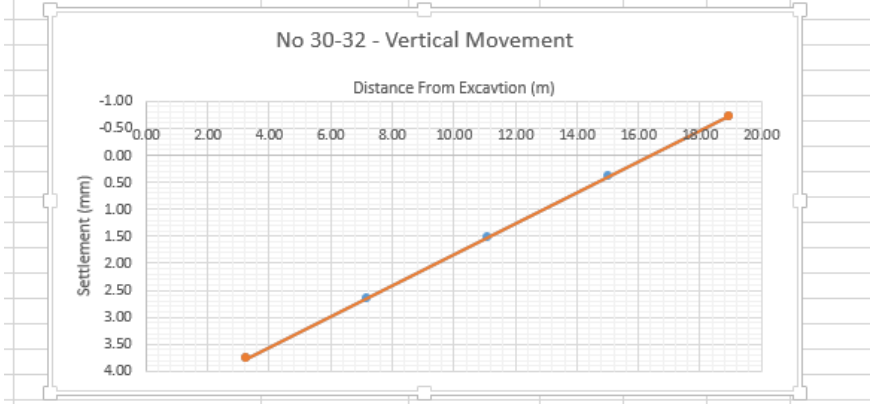
# No.26 Maresfield Gardens – Potential Damage Calculations in Stiff Clay



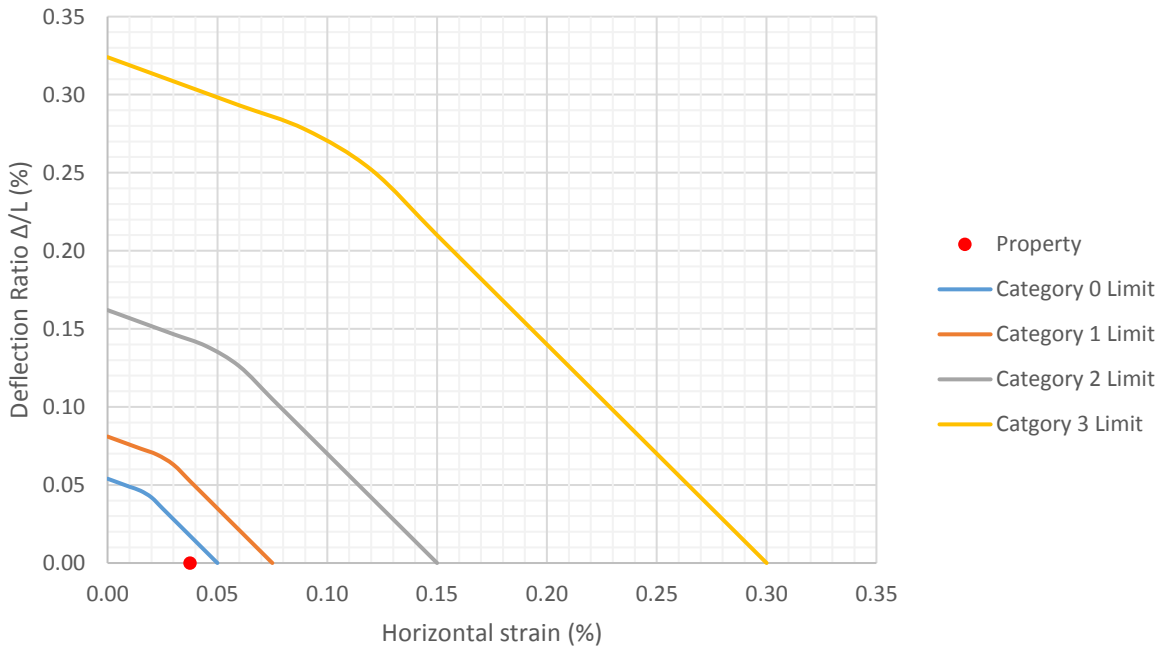

| | | | |
|---|---|---|---|
| **Neighbouring Property 1** | No. 28 | | |
| | m | mm | |
| **L** | 15.17 | 15170 | |
| **H** | 15.00 | 15000 | |
| **L/H** | 1.01 | | |
| Vertical Deflection (Δ) | 1.2 | mm | from graph (max difference between blue and orange line) |
| Defelction Ratio (Δ/L) | 0.007910 | % | |
| Horizontal Movement (δh) | 5.69 | mm | difference between horizontal movement at nearest and farthest walls |
| Horzontal Strain (εh) = δh/L | 0.03750 | % | |



# No.30-32 Maresfield Gardens – Potential Damage Calculations in Stiff Clay




| | | | |
|---|---|---|---|
| **Neighbouring Property 2** | No. 30 | | |
| | m | mm | |
| **L** | 15.70 | 15700 | |
| **H** | 15.00 | 15000 | |
| **L/H** | 1.05 | | |
| Vertical Deflection (Δ) | 1.2 | mm | from graph (max difference between blue and orange line) |
| Defelction Ratio (Δ/L) | 0.007643 | % | |
| Horizontal Movement (δh) | 5.89 | | difference between horizontal movement at nearest and farthest walls |
| Horzontal Strain (εh) = δh/L | 0.03750 | % | |



**Appendix H**
**Network Rail Enquiry**

Gmail by Google

**Francis Williams <francis.williams@groundandwater.co.uk>**

# Fwd: WB20941-EN13771 - London 28 Maresfield Gardens NW3 5SX - Excavation of basement near Belsize Tunnel

**Trevor Vincent** <trevor-vincent@sky.com> 30 January 2017 at 16:18
To: Francis Williams <francis.williams@groundandwater.co.uk>

Regards,

Trevor Vincent

Begin forwarded message:

**From:** Ako Jesse <Jesse.Ako@networkrail.co.uk>
**Date:** 27 January 2017 at 15:36:28 GMT
**To:** "trevor-vincent@sky.com" <trevor-vincent@sky.com>
**Cc:** Mohammad Jakeer <Jakeer.Mohammad@networkrail.co.uk>, Keegan Benedicta <Benedicta.Keegan@networkrail.co.uk>
**Subject: FW: WB20941-EN13771 - London 28 Maresfield Gardens NW3 5SX - Excavation of basement near Belsize Tunnel**

Trevor,

On review of the further detail given by yourself below, the structures team have no further objections to your proposals. I have attached a long section of the tunnel for your reference which you can use if needed, however please note that it is an approximate plan based upon archive information and may not be 100% accurate

Kind Regards

*Jesse Ako* | Project Management Assistant | Asset Protection Team | LNE - EM Route | Network Rail

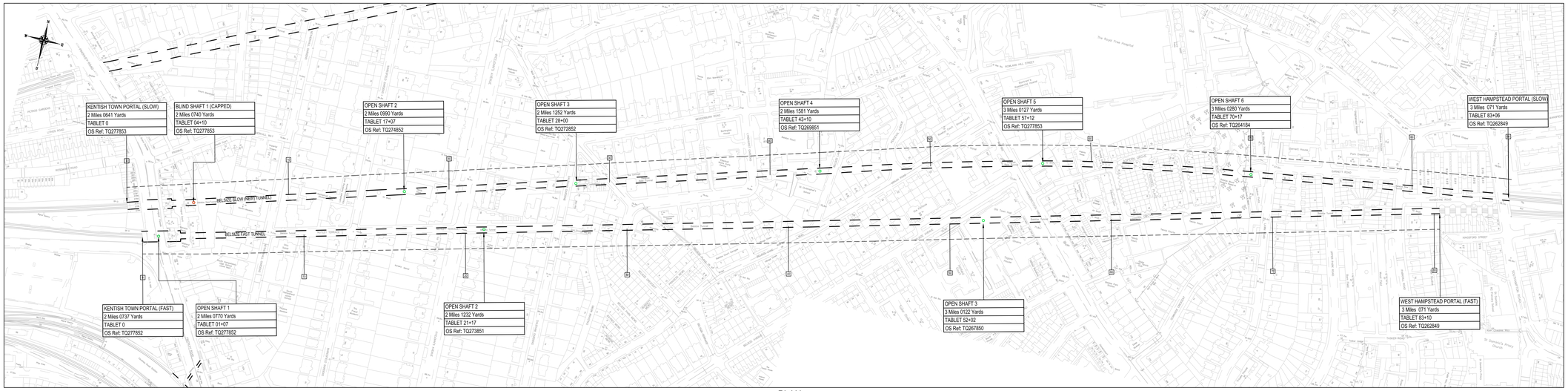
Desk 4 – 2nd Floor | Kings Cross Station | West Side Offices | Euston Road | London | N1C 4AP

☏ 0207 922 9065 | 002 9065

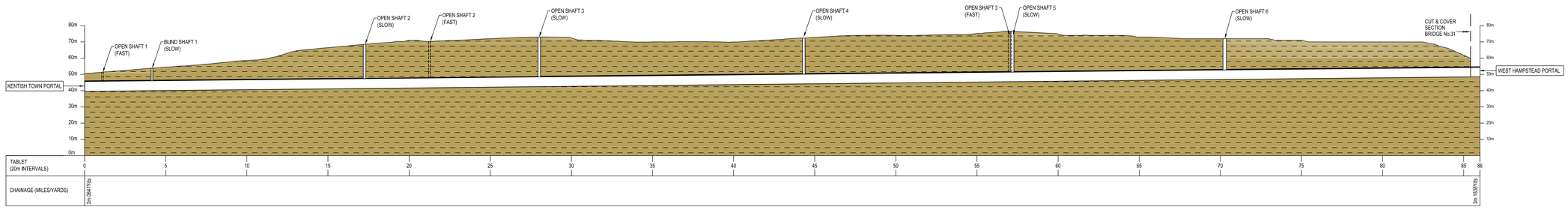
✉ jesse.ako@networkrail.co.uk | www.networkrail.co.uk

---

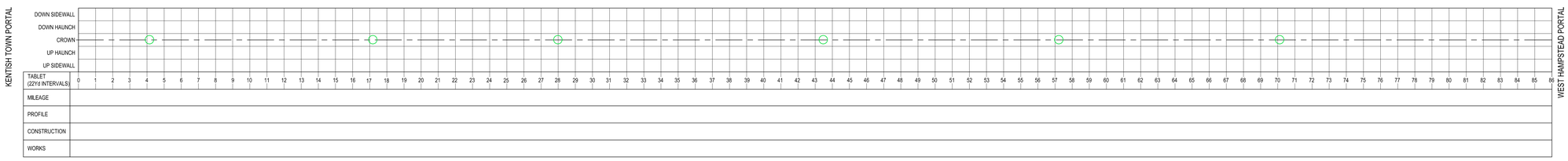
**From:** TREVOR VINCENT [mailto:trevor-vincent@sky.com]
**Sent:** 13 January 2017 16:43
**To:** Asset Protection LNE EM; Foster Barry (Structures)
**Cc:** Mohammad Jakeer; Keegan Benedicta
**Subject:** Re: WB20941-EN13771 - London 28 Maresfield Gardens NW3 5SX - Excavation of basement near Belsize Tunnel



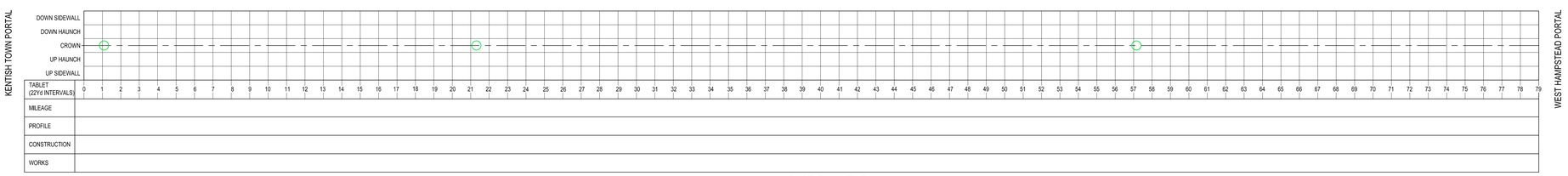

## PLAN
SCALE: 1:2000




## GEOLOGICAL SECTION
SCALES: HORIZ 1:2000 VERT 1:1000




## SLOW (NEW) TUNNEL PLAN
SCALES: HORIZ 1:2000




## FAST TUNNEL PLAN
SCALES: HORIZ 1:2000

### NOTES:

1. ALL MEASUREMENTS ARE IN MILES AND YARDS UNLESS OTHERWISE STATED
2. ALL LEVELS ARE IN METRES AND RELATE TO ORDNANCE DATUM UNLESS STATED OTHERWISE
3. ALL LEVELS, TOGETHER WITH THE GROUND PROFILE SHOWN ON THE LONGITUDINAL SECTION ARE APPROXIMATE AND ARE INTENDED FOR ILLUSTRATIVE PURPOSES ONLY
5. TABLETS ARE AT 22yd INTERVALS IN FAST TUNNEL & 20m IN SLOW TUNNEL.. TABLET 0 AT KENTISH TOWN PORTAL
6. ZONE OF INFLUENCE = 22m EITHER SIDE OF TUNNEL CENTRELINE
7. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE FOLLOWING DOCUMENTS:

   DESK STUDY REPORT J1377/DESK STUDY/BELSIZE TUNNELS

**SLOW (NEW) TUNNEL SHAFT LOCATIONS**

| SHAFT No. | SHAFT STATUS | LOCATION | OS REF. |
|---|---|---|---|
| 1 | BLIND (CAPPED) | T04+10 | TQ277853 |
| 2 | OPEN | T17+17 | TQ274852 |
| 3 | OPEN | T28+00 | TQ272852 |
| 4 | OPEN | T43+10 | TQ269851 |
| 5 | OPEN | T57+12 | TQ267850 |
| 6 | OPEN | T70+17 | TQ264184 |

**FAST TUNNEL SHAFT LOCATIONS**

| SHAFT No. | SHAFT STATUS | LOCATION | OS REF. |
|---|---|---|---|
| 1 | OPEN | T01+07 | TQ277852 |
| 2 | OPEN | T21+17 | TQ273851 |
| 3 | OPEN | T52+02 | TQ267850 |

**KEY**

- TABLET
- SHAFT OPEN
- SHAFT HIDDEN CONFIRMED
- SHAFT HIDDEN UNCONFIRMED

**GEOLOGICAL KEY**

- LONDON CLAY

THIS DRAWING WAS ISSUED BY DONALDSON ASSOCIATES LTD ON 03/08/2015.
DAL TAKE NO RESPONSIBILITY FOR ANY AMENDMENTS OR ALTERATIONS TO THE DRAWING FILE AFTER THE ISSUE DATE.

| Rev. | Revision Description | Drn | Chkd | Appd | Date |
|---|---|---|---|---|---|
| O | FIRST ISSUE | SOS | MAR | PH | 03/08/15 |

**Status:** FIRST ISSUE


DONALDSON ASSOCIATES
Peat House
Stuart Street
Derby, DE1 2EQ
Tel: 01332 343800
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E-Mail: derby@donaldsonassociates.com
Website: www.donaldsonassociates.com


**Client:** Network Rail

**Project:**
LONDON NORTH EASTERN TERRITORY
TUNNEL MANAGEMENT STRATEGY UPGRADE

| | | | |
|---|---|---|---|
| LINE: | ST PANCRAS TO CHESTERFIELD | | |
| E.L.R.: | SPC1 | STRUCTURE REF No: | 29 & 30 |
| MILEAGE: | 02 MILES 0641 YARDS TO 03 MILES 071 YARDS | | |
| AT: | KENTISH TOWN & WEST HAMPSTEAD | | |
| OS GRID REF: | TQ 277 853 TO TQ 262 849 | | |

**Title:**
NETWORK RAIL LAND OWNERSHIP PLAN,
GEOLOGICAL SECTION & TUNNEL PLAN
BELSIZE TUNNELS (SPC1/29 & 30)

| | | |
|---|---|---|
| **Drawn by:** SOS | **Designed by:** VH | **Checked:** MAR |
| **Date:** DEC 2014 | **Original Sheet Size** A0 | **Approved:** PH |
| **Scales:** AS SHOWN | | |

**Drawing No:** J1377/SPC1/29/30/001

**Revision** O