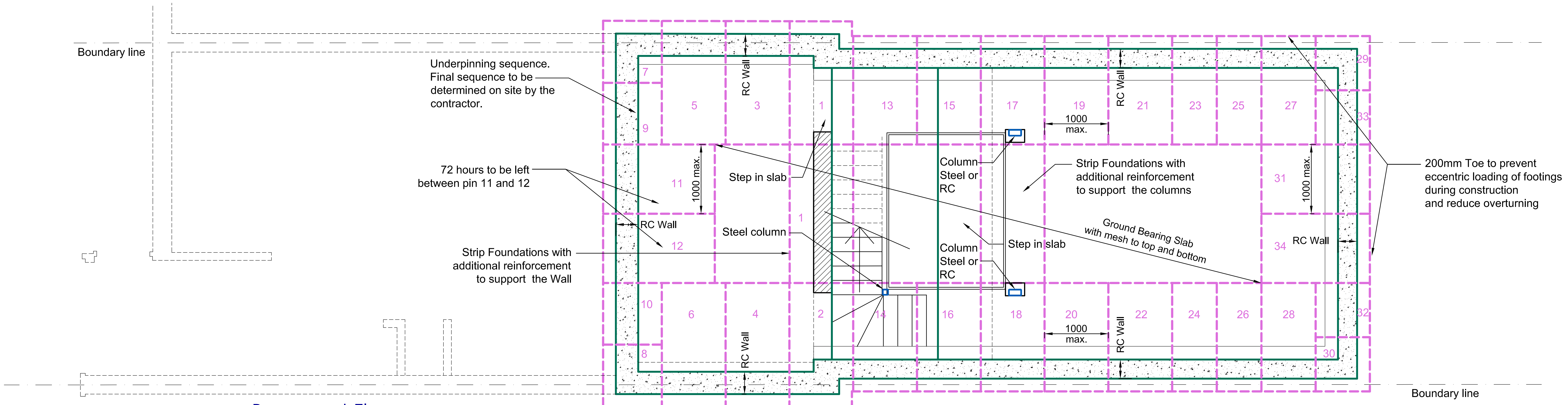
Appendix D

Method Statement



Basement Floor

scale 1:50

Rev	Date	Amendments
	11.14	ISSUE FOR BIA

Client: Mr Khalid Zaky

Project: 14F Avenue Road

Title : Basement layout

Job nos 141005	date 10.14
Dwg Nos SL-10	Rev -
drawn EJ	Ch'kd CT
Scale 1:50 @ A2	

Job Number: 13.10.2014
Date: 10 November 2014

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Basement Method Statement

14F Avenue Road NW8 6BP

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Revision	Date	Comment
	10/11/14	First Issue

Contents

14 Avenue Road

1. Basement Formation Suggested Method Statement.

1.1. This method statement provides an approach which will allow the basement design to be correctly considered during construction, and the temporary support to be provided during the works. The Contractor is responsible for the works on site and the final temporary works methodology and design on this site and any adjacent sites.

1.2. This method statement 14 F Avenue Road has been written by a Chartered Engineer. The sequencing has been developed considering guidance from ASUC.

1.3. This method has been produced to allow for improved costings and for inclusion in the party wall Award. Should the contractor provide alternative methodology the changes shall be at their own costs, and an Addendum to the Party Wall Award will be required.

1.4. Contact party wall surveyors to inform them of any changes to this method statement.

1.5. The approach followed in this design is; to remove load from above and place loads onto supporting steelwork, then to cast cantilever retaining walls in underpin sections at the new basement level.

1.6. The cantilever pins are designed to be inherently stable during the construction stage without temporary propping to the head. The base benefits from propping, this is provided in the final condition by the ground slab. In the temporary condition the edge of the slab is buttressed against the soil in the middle of the property, also the skin friction between the concrete base and the soil provides further resistance. The central slab is to be poured in a maximum of a 1/3 of the floor area.

1.7. A soil investigation has been undertaken. The soil conditions are London clays.

1.8. The bearing pressures have been limited to 125kN/m^2 as specified by the Soil Investigation Report.

1.9. The SI states the Current water Table. No water encountered in the trial holes and borehole.

2. Enabling Works

2.1. The site is to be hoarded with ply sheet to 2.2m to prevent unauthorised public access.

2.2. Licenses for Skips and conveyors to be posted on hoarding

2.3. Provide protection to public where conveyor extends over footpath. Depending on the requirements of the local authority, construct a plywood bulkhead onto the pavement. Hoarding to have a plywood roof covering, night-lights and safety notices.

1.10. The water table is known. The soil investigation has been carried out on this site. Groundwater was not found during the construction of the trial holes and borehole-6.0mbgl. It has been specified and this has determined the water table height.

Dewater will be localized if required.

1.10.1. Place a bore hole to the front of the property down to a depth of 6m
1.10.2. Pump water away from site.

2.4. On commencement of construction the contractor will determine the foundation type, width and depth. Any discrepancies will be reported to the structural engineer in order that the detailed design may be modified as necessary.

3. Basement Sequencing

3.1. Begin by placing cantilevered walls 1and 2 noted on plans (max 1.0m span. Cantilevered walls to be placed in accordance with section 4.). Erect the conveyor.

3.2. Needle & prop the existing ground floor and wall over.

3.3. Insert steel over and sit on cantilevered walls 1 and 2.

3.3.1. Beams over 6m to be jacked on site to reduce deflections of floors.

3.3.2. Dry pack to steelwork. Ensure a minimum of 24 hours from casting cantilevered walls to dry packing.

3.4. Continue excavating section pins to form front of the basement. (Follow methodology in section 4)

3.5. When pins: 7, 9, 8 and 10 ready, the steel frame to be placed.

3.6. Needle & prop the existing first floor and wall over.

3.7. Insert steel frame sit on cantilevered walls 7 and 8.

3.7.1. Beams over 6m to be jacked on site to reduce deflections of floors.

3.7.2. Dry pack to steelwork. Ensure a minimum of 24 hours from casting cantilevered walls to dry packing. Grout column bases

3.8. Remove the existing ground floor wall,

3.9. Place cantilevered retaining wall 11 and 12- 72 hours to be left between pin 11 and 12.

3.10. Continue cantilevered wall formation around perimeter of basement following the numbering sequence on the drawings.

3.10.1. Excavation for the next numbered sequential sections of underpinning shall not commence until at least 8 hours after dry packing of previous works. Excavation of adjacent pin to not commence until 48 hours after dry packing. (24hours possible due to inclusion of Conbextra 100 cement accelerator to dry pack mix). No more than

3.10.2. Floor over to be propped as excavations progress. Steelwork to support Floor to be inserted as works progress.

3.11. Excavate a maximum of a 1/3 of the middle section of basement floor. Place reinforcement to central section of ground bearing slab and pour concrete. Excavate next third and cast slab. Excavate and cast final third and cast.

3.12. Provide structure to ground floor and water proofing to retaining walls as required.

4. Underpinning and Cantilevered Walls

4.1. Prior to installation of new structural beams in the superstructure, the contractor may undertake the local exploration of specific areas in the superstructure. This will confirm the exact form and location of the temporary works that are required. The permanent structural work can then be undertaken whilst ensuring that the full integrity of the structure above is maintained.

4.2. Provide propping to floor where necessary.

4.3. Excavate first section of retaining wall (no more than 1000mm wide). Where excavation is greater than 1.0m deep provide temporary propping to sides of excavation to prevent earth collapse (Health and Safety). A 1000mm width wall has a lower risk of collapse to the heel face.

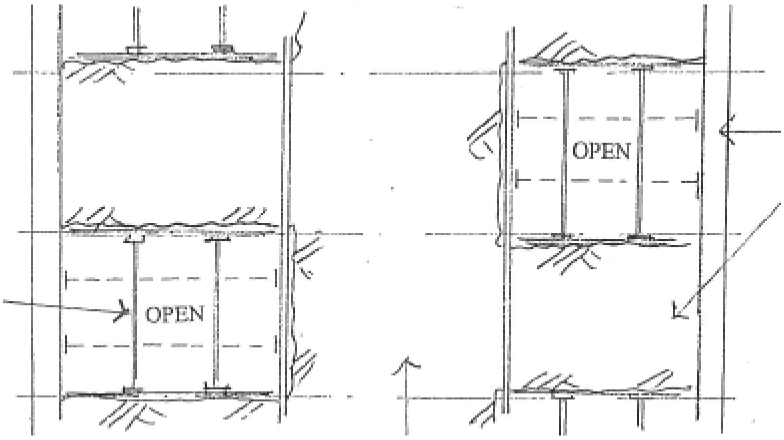


Figure 1 – Schematic Plan view of Soil Propping

Figure 2 Propping

4.4. Back propping of rear face. Rear face to be propped in the temporary conditions with a minimum of 2 Trench sheets. Trench sheets are to extend over entire height of excavation. Trench sheets can be placed in short sections are the excavation progresses.

4.4.1. If the ground is stable, trench sheets can be removed as the wall reinforcement is placed and the shuttering is constructed.

4.4.2. Where soft spots are encountered leave in trench sheets or alternatively back prop with precast lintels or trench sheeting. (If the soil support to the ends of the lintels is insufficient then brace the ends of the PC lintels with 150x150 C24 Timbers and prop with Acrows diagonally back to the floor.)

4.4.3. Where voids are present behind the lintels or trench sheeting. Grout voids behind sacrificial propping; Grout to be 3:1 sand cement packed into voids.

4.4.4. Prior to casting place layer of DPM between trench sheeting (or PC lintels) and new concrete. The lintels are to be cut into the soil by 150mm either side of the pin. A site stock of a minimum of 10 lintels to be present for to prevent delays due to ordering.

4.5. If cut face is not straight, or sacrificial boards noted have been used, place a 15mm cement particle board between sacrificial sheets and or soil prior to casting. Cement particle board is to line up with the adjacent owners face of wall. The method adopted to prevent localised collapse of the soil is to install these progressively one at a time. Cement particle board must be used to in any condition where overspill onto the adjacent owners land is possible.

4.6. Excavate base. Mass concrete heels to be excavated. If soil over unstable prop top with PC lintel and sacrificial prop.

4.7. Visually inspect the footings and provide propping to local brickwork, if necessary sacrificial acrow, or pit props, to be sacrificial and cast into the retaining wall.

4.8. Clear underside of existing footing.

4.9. Local authority inspection to be carried for approval of excavation base.

4.10. Place reinforcement for retaining wall base & toe. Site supervisor to inspect and sign off works for proceeding to next stage.

4.11. Cast base. (on short stems it is possible to cast base and wall at same time)

4.12. Take 2 cubes of concrete and store for testing. Test one at 28 days if result is low test second cube. Provide results to client and design team on request or if values are below those required

4.13. Horizontal temporary prop to base of wall to be inserted. Alternatively cast base against soil.

4.14. Place reinforcement for retaining wall stem. Site supervisor to inspect and sign off works for proceeding to next stage.

4.15. Drive H16 Bars U-Bars into soil along centre line of stem to act as shear ties to adjacent wall.

4.16. Place shuttering & pour concrete for retaining wall. Stop a minimum of 75mm from the underside of existing footing.

4.17. 24 hours after pouring the concrete pin the gap shall be filled using a dry pack mortar. Ram in dry pack between retaining wall and existing masonry.

4.18. After 24 hours the temporary wall shutters are removed.

4.19. Trim back existing masonry corbel and concrete on internal face.

4.20. Site supervisor to inspect and sign off for proceeding to the next stage. A record will be kept of the sequence of construction, which will be in strict accordance with recognised industry procedures.

5. Floor Support

Concrete Ground bearing slabs

5.1. The support of the existing concrete floor will be undertaken in conjunction with the underpinning process. Two opposite pins are constructed and allowed to cure as described elsewhere.

5.2. Locally prop concrete floors with Acros at 2m centres with timbers between. If the underside is found be in poor condition then temporary boarding and props are to be introduced.

5.3. Insert Steelwork and dry pack to underside of floor

5.4. Between steelwork place 215wide x 65dp PC lintels at a maximum spacing of 600mm

5.5. If necessary Brick up to the 50mm below underside of floor

5.6. Dry pack between lintel/brickwork to underside of slab.

5.7. Remove props

5.8. This process is to continue one pin width at a time.

6. Supporting existing walls above basement excavation

6.1. Where steel beams need to be installed directly under load bearing walls, temporary works will be required to enable this work. Support comprises the installation of steel needle beams at high level, supported on vertical props, to enable safe removal of brickwork below, and installation of the new beams and columns.

6.1.1. The condition of the brickworks must be inspected by the foreman to determine its condition and to assess the centres of needles. The foreman must inspect upstairs to consider where loads are greatest. Point loads and between windows should be given greater consideration.

6.1.2. Needles are to be spaced to prevent the brickwork above “saw toothing”. Where brickwork is good needles must be placed at a maximum of 1100mm centers. Lighter needles or strong boys should be placed at tighter centres under door thresholds

6.2. Props are to be placed on Sleepers of firm ground or if necessary temporary footings will be cast.

6.3. Once the props are fully tightened, the brickwork will be broken out carefully by hand. All necessary platforms and crash decks will be provided during this operation.

6.4. Decking and support platforms to enable handling of steel beams and columns will be provided as required.

6.5. Once full structural bearing is provided via beams and columns down to the new basement floor level. The temporary works will be redundant and can be safely removed.

6.6. Any voids between the top of the permanent steel beams and the underside of the existing walls will be packed out as necessary. Voids will be dry packed with a 1:3 (cement: sharp sand) dry pack layer, between the top of the steel and underside of brickwork above.

6.7. Any voids in the brickwork left after removal of needle beams can at this point be repaired by bricking up and/or dry packing, to ensure continuity of the structural fabric.

7. Approval

7.1. Building control officer/approved inspector to inspect pin bases and reinforcement prior to casting concrete.

7.2. Contractor to keep list of dates pins inspected & cast

7.3. One month after work completed the contractor is to contact adjacent party wall surveyor to attend site and complete final condition survey and to sign off works.

8. Trench sheet design and temporary prop Calculations

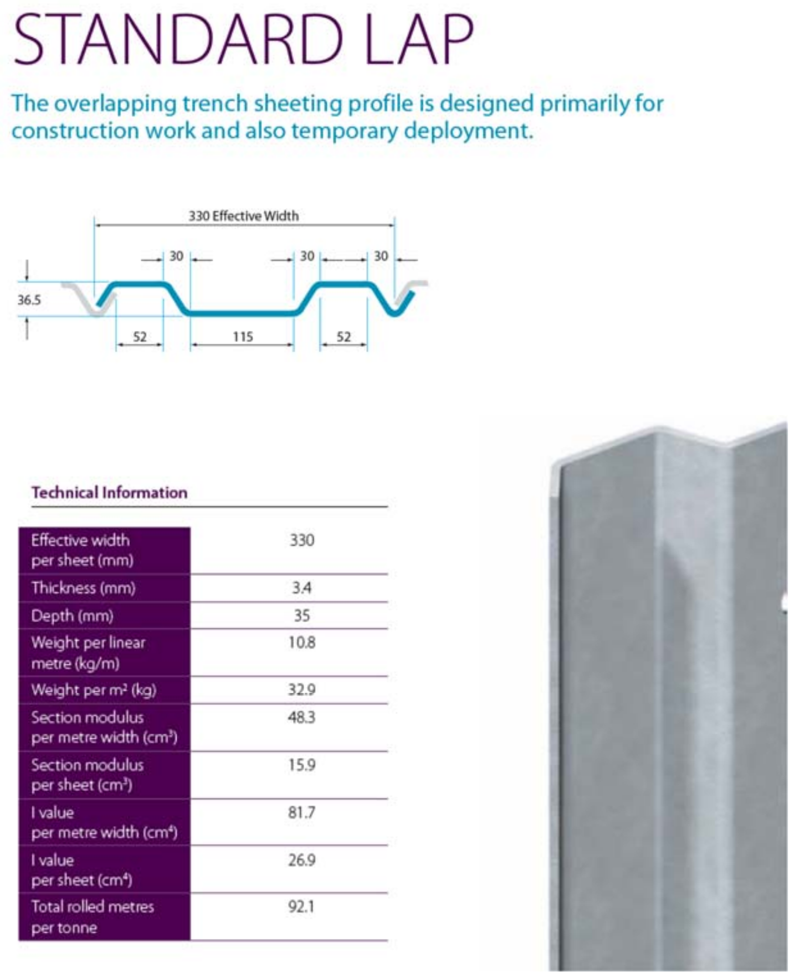
This calculation has been provided for the trench sheet and prop design of standard underpins in the temporary condition. There are gaps left between the sheeting and as such no water pressure will occur. Any water present will flow through the gaps between the sheeting and will be required to pump out.

Trench sheets should be placed at centres to deal with the ground. It is expected that the soil between the trench sheeting will arch. Looser soil will required tighter centres. It is typical for underpins to be placed at 1000c/c, in this condition the highest load on a trench sheet is when 2 no trench sheets are used. It is for this design that these calculations have been provided.

Soil and ground conditions are variable. Typically one finds that in the temporary condition clays are more stable and the C_u (cohesive) values in clay reduce the risk of collapse. It is this cohesive nature that allows clays to be cut into a vertical slope. For these calculations weak sand and gravels have been assumed. The soil properties are:

Surcharge	sur = **10.** kN/m^2	
Soil density	δ = **20** kN/m^3	
Angle of friction	ϕ = **25** °	
Soil depth	Dsoil = **3000.000** mm	
	$k_a = (1 - \sin(\phi)) / (1 + \sin(\phi))$	= **0.406**
	$k_p = 1 / k_a$	= **2.464**
Soil Pressure bottom	soil = $k_a * \delta *$ Dsoil	= **21.916**kN/m^2
Surcharge pressure	surcharge = sur * k_a	= **4.059** kN/m^2

STANDARD LAP TRENCH SHEETING



STANDARD LAP

The overlapping trench sheeting profile is designed primarily for construction work and also temporary deployment.

Technical Information

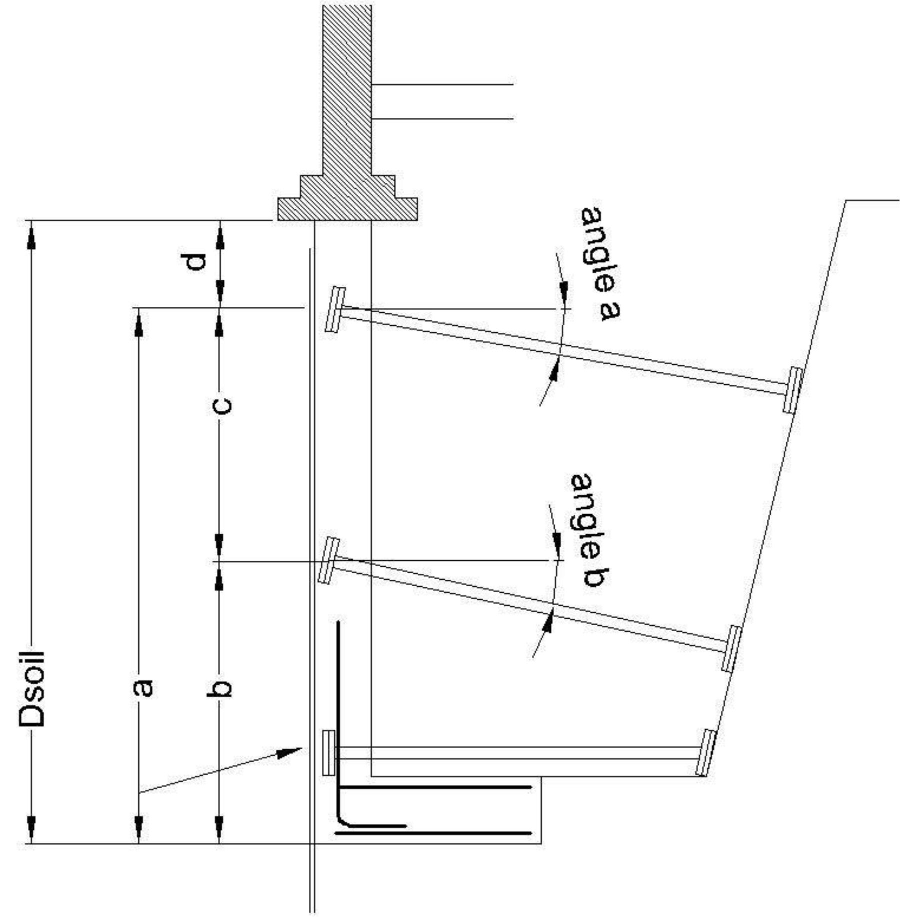
Effective width per sheet (mm)	330
Thickness (mm)	3.4
Depth (mm)	35
Weight per linear metre (kg/m)	10.8
Weight per m^2 (kg)	32.9
Section modulus per metre width (cm^3)	48.3
Section modulus per sheet (cm^3)	15.9
I value per metre width (cm^4)	81.7
I value per sheet (cm^4)	26.9
Total rolled metres per tonne	92.1

Sxx = 15.9 cm^3

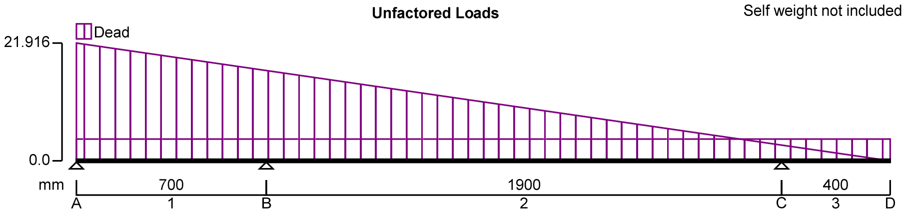
py = 275N/mm^2

Ixx = 26.9cm^4

A = ($1m^2$ * 32.9kg/m^2) / (330mm * 7750kg/m^3) = **12864.125**mm^2



Length a	a = **2.600** m
Length b bottom	b = **0.700** m
Length c Middle	c = a – b = **1.900**m
Length d top	d = Dsoil – a = **0.400**m



CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = **3**

Material Properties:

Modulus of elasticity = **205** kN/mm^2

Material density = **7860** kg/m^3

Support Conditions:

Support A	Vertically **"Restrained"**	Rotationally **"Free"**
Support B	Vertically **"Restrained"**	Rotationally **"Free"**
Support C	Vertically **"Restrained"**	Rotationally **"Free"**

Support D Vertically **"Free"** Rotationally **"Free"**

Span Definitions:

Span 1	Length = **700** mm	Cross-sectional area = **12864** mm^2	Moment of inertia = **$269.\times10^3$** mm^4
Span 2	Length = **1900** mm	Cross-sectional area = **12864** mm^2	Moment of inertia = **$269.\times10^3$** mm^4
Span 3	Length = **400** mm	Cross-sectional area = **12864** mm^2	Moment of inertia = **$269.\times10^3$** mm^4

LOADING DETAILS

Beam Loads:

Load 1	UDL Dead load **4.1** kN/m
Load 2	VDL Dead load **21.9** kN/m to **0.0** kN/m

LOAD COMBINATIONS

Load combination 1

Span 1	1×Dead
Span 2	1×Dead
Span 3	1×Dead

CONTINUOUS BEAM ANALYSIS - RESULTS

Unfactored support reactions

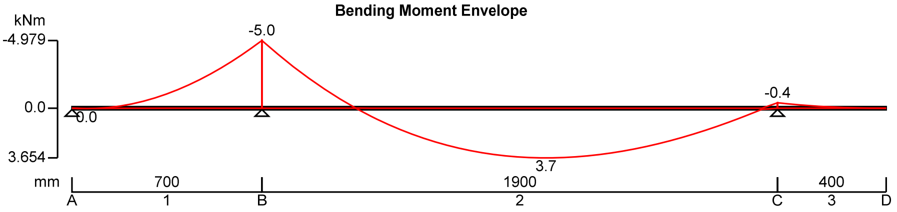
	Dead (kN)							
Support A	**-1.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Support B	**-32.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Support C	**-10.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Support D	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

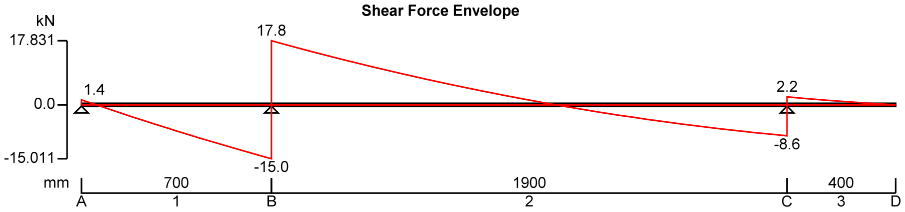
Support Reactions - Combination Summary

Support A	Max react = **-1.4** kN	Min react = **-1.4** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support B	Max react = **-32.8** kN	Min react = **-32.8** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support C	Max react = **-10.8** kN	Min react = **-10.8** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support D	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm

Beam Max/Min results - Combination Summary

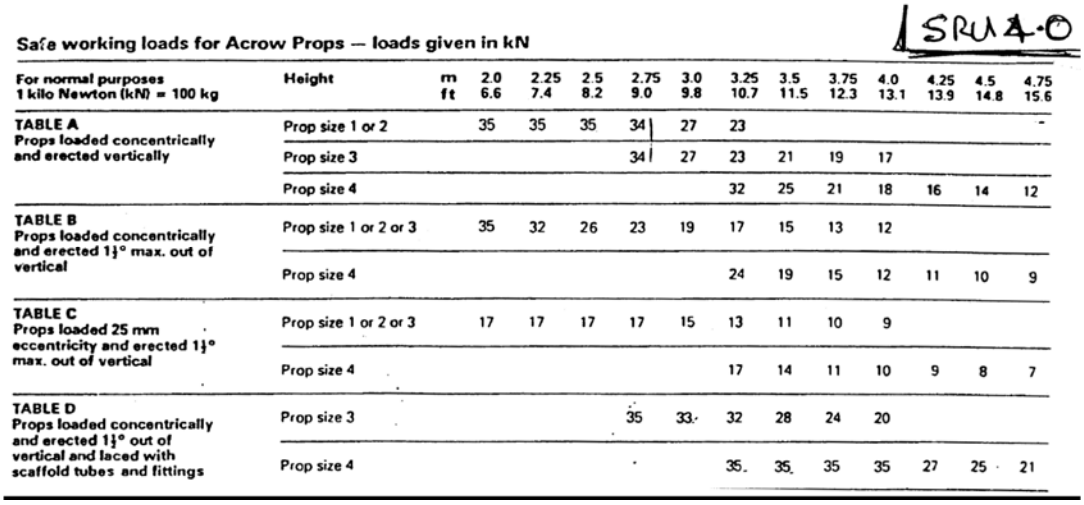
Maximum shear = **17.8** kN	Minimum shearF_{min} = **-15.0** kN
Maximum moment = **3.7** kNm	Minimum moment = **-5.0** kNm
Maximum deflection = **21.0** mm	Minimum deflection = **-14.3** mm





Number of sheets Nos = 2

Mallowable = Sxx * py * Nos = **8.745**kNm



SRU4·0

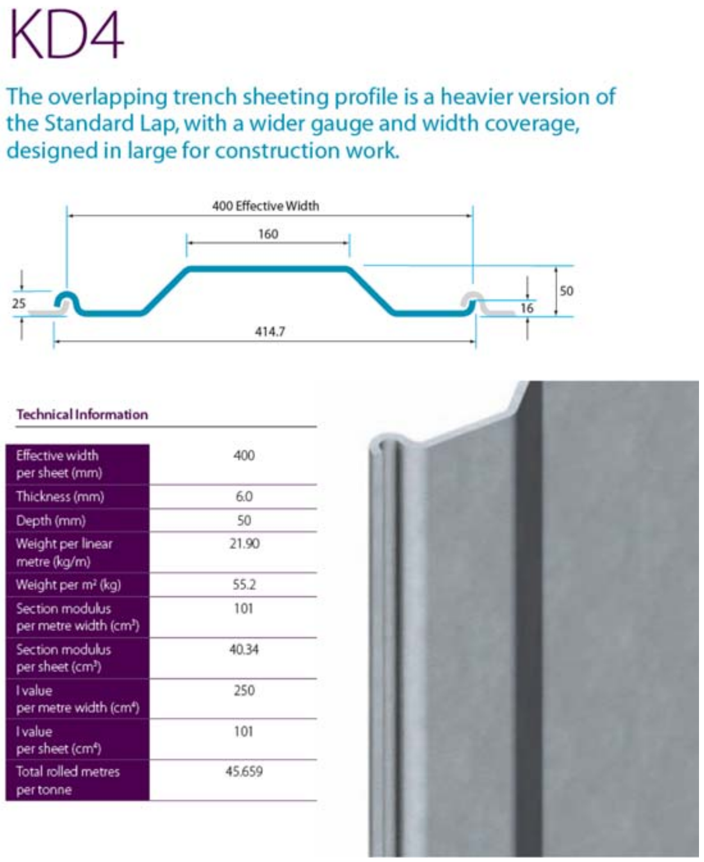
Safe working loads for Acrow Props — loads given in kN

For normal purposes 1 kilo Newton (kN) = 100 kg	Height	m ft	2.0 6.6	2.25 7.4	2.5 8.2	2.75 9.0	3.0 9.8	3.25 10.7	3.5 11.5	3.75 12.3	4.0 13.1	4.25 13.9	4.5 14.8	4.75 15.6
TABLE A Props loaded concentrically and erected vertically	Prop size 1 or 2		35	35	35	34	27	23						-
	Prop size 3					34	27	23	21	19	17			
	Prop size 4							32	25	21	18	16	14	12
TABLE B Props loaded concentrically and erected 1½° max. out of vertical	Prop size 1 or 2 or 3		35	32	26	23	19	17	15	13	12			
	Prop size 4							24	19	15	12	11	10	9
TABLE C Props loaded 25 mm eccentricity and erected 1½° max. out of vertical	Prop size 1 or 2 or 3		17	17	17	17	15	13	11	10	9			
	Prop size 4							17	14	11	10	9	8	7
TABLE D Props loaded concentrically and erected 1½° out of vertical and laced with scaffold tubes and fittings	Prop size 3					35	33	32	28	24	20			
	Prop size 4							35	35	35	35	27	25	21

Shear V = (14.6kN + 13.4kN) /2 = 14.000kN

Any Acro Prop is accetpable

KD4 SHEETS



KD4

The overlapping trench sheeting profile is a heavier version of the Standard Lap, with a wider gauge and width coverage, designed in large for construction work.

Technical Information

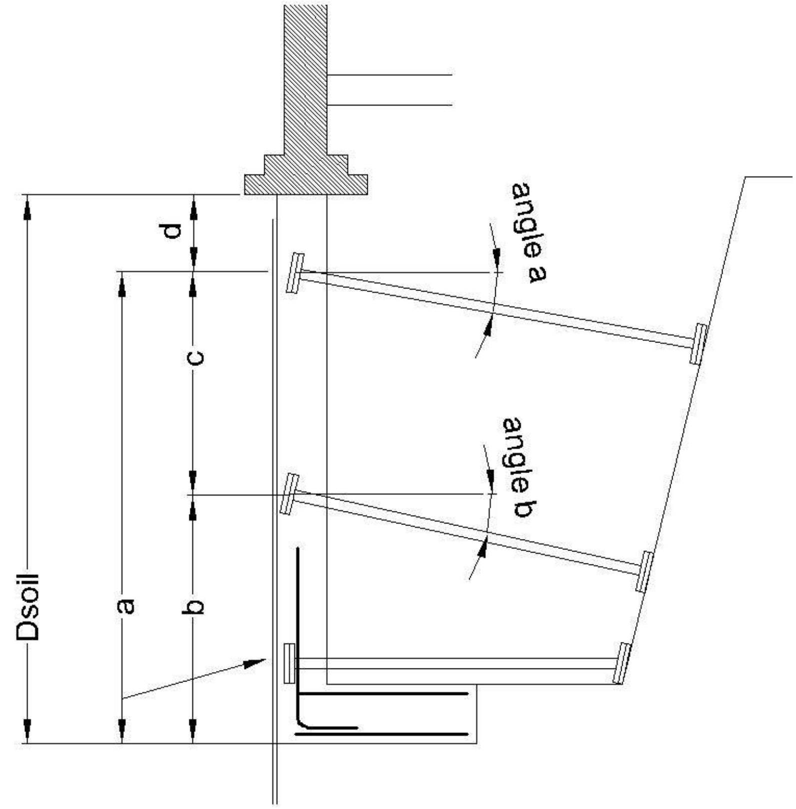
Effective width per sheet (mm)	400
Thickness (mm)	6.0
Depth (mm)	50
Weight per linear metre (kg/m)	21.90
Weight per m² (kg)	55.2
Section modulus per metre width (cm³)	101
Section modulus per sheet (cm³)	40.34
I value per metre width (cm⁴)	250
I value per sheet (cm⁴)	101
Total rolled metres per tonne	45.659

$S_{xx} = 48.3cm^3$

$p_y = 275N/mm^2$

$I_{xx} = 26.9cm^4$

A = $(1m^2 * 55.2kg/m^2) / (400mm * 7750kg/m^3)$ = **17806.452**mm^2

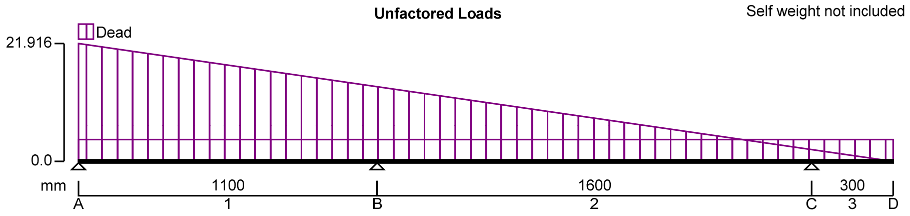


Length a a = **2.700** m

Length b bottom b = **1.100** m

Length c Middle c = a – b = **1.600**m

Length d top d = Dsoil – a = **0.300**m



CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = **3**

Material Properties:

Modulus of elasticity = **205** kN/mm^2 Material density = **7860** kg/m^3

Support Conditions:

Support A	Vertically **"Restrained"**	Rotationally **"Free"**
Support B	Vertically **"Restrained"**	Rotationally **"Free"**
Support C	Vertically **"Restrained"**	Rotationally **"Free"**
Support D	Vertically **"Free"**	Rotationally **"Free"**

Span Definitions:

Span 1	Length = **1100** mm	Cross-sectional area = **17806** mm^2	Moment of inertia = **269.×10^3** mm^4
Span 2	Length = **1600** mm	Cross-sectional area = **17806** mm^2	Moment of inertia = **269.×10^3** mm^4

Span 3 Length = **300** mm Cross-sectional area = **17806** mm^2 Moment of inertia = **269.×10^3** mm^4

LOADING DETAILS

Beam Loads:

Load 1 VDL Dead load **21.9** kN/m to **0.0** kN/m

Load 2 UDL Dead load **4.1** kN/m

LOAD COMBINATIONS

Load combination 1

Span 1 1×Dead

Span 2 1×Dead

Span 3 1×Dead

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

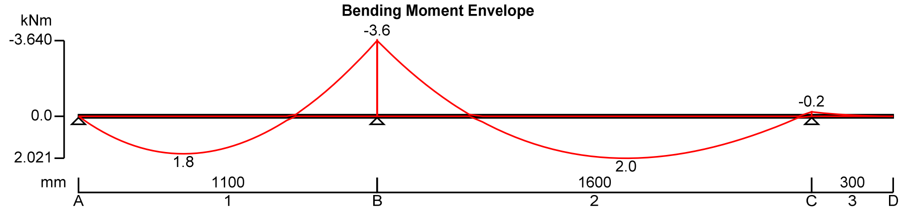
Support A	Max react = **-9.5** kN	Min react = **-9.5** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support B	Max react = **-28.0** kN	Min react = **-28.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support C	Max react = **-7.5** kN	Min react = **-7.5** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support D	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm

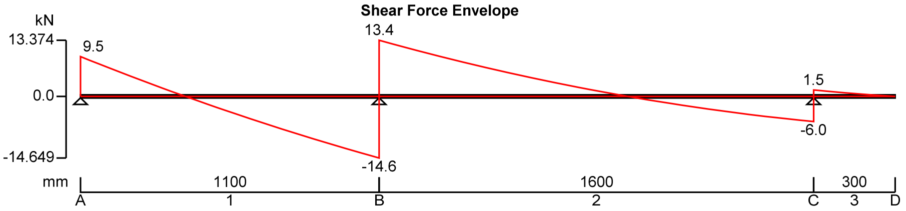
Beam Max/Min results - Combination Summary

Maximum shear = **13.4** kN Minimum shearF_{min} = **-14.6** kN

Maximum moment = **2.0** kNm Minimum moment = **-3.6** kNm

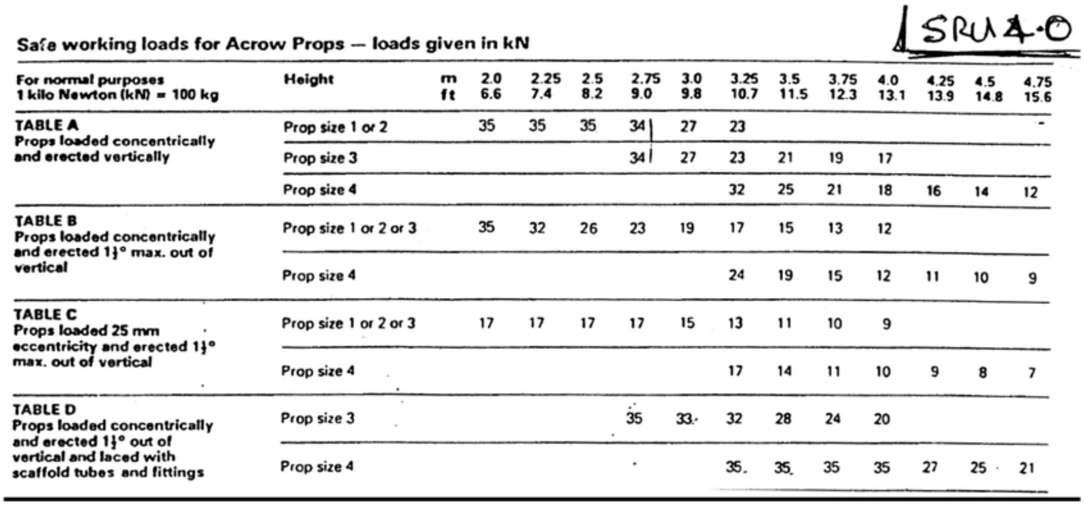
Maximum deflection = **7.7** mm Minimum deflection = **-4.9** mm





Number of sheets Nos = 2

Mallowable = Sxx * py * Nos = **26.565**kNm



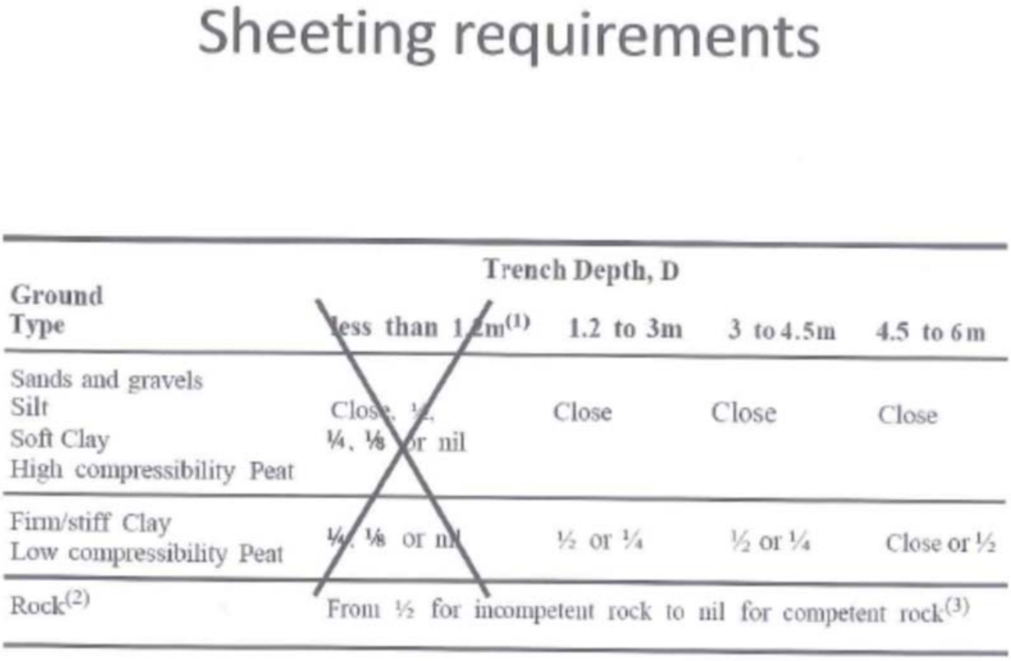
SRU4.0

Safe working loads for Acrow Props — loads given in kN

For normal purposes 1 kilo Newton (kN) = 100 kg	Height	m	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0	4.25	4.5	4.75
		ft	6.6	7.4	8.2	9.0	9.8	10.7	11.5	12.3	13.1	13.9	14.8	15.6
TABLE A Props loaded concentrically and erected vertically	Prop size 1 or 2		35	35	35	34	27	23						-
	Prop size 3					34	27	23	21	19	17			
	Prop size 4							32	25	21	18	16	14	12
TABLE B Props loaded concentrically and erected 1½° max. out of vertical	Prop size 1 or 2 or 3		35	32	26	23	19	17	15	13	12			
	Prop size 4							24	19	15	12	11	10	9
TABLE C Props loaded 25 mm eccentricity and erected 1½° max. out of vertical	Prop size 1 or 2 or 3		17	17	17	17	15	13	11	10	9			
	Prop size 4							17	14	11	10	9	8	7
TABLE D Props loaded concentrically and erected 1½° out of vertical and laced with scaffold tubes and fittings	Prop size 3					35	33	32	28	24	20			
	Prop size 4							35	35	35	35	27	25	21

Shear V = (14.6kN + 13.4kN) /2 = 14.000kN

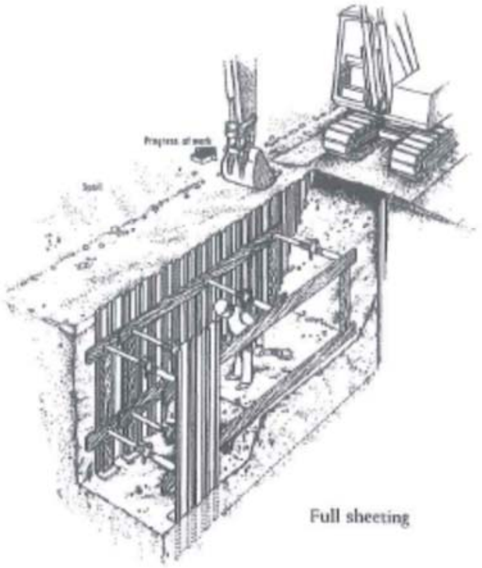
Any Acro Prop is accetpable



Sheeting requirements

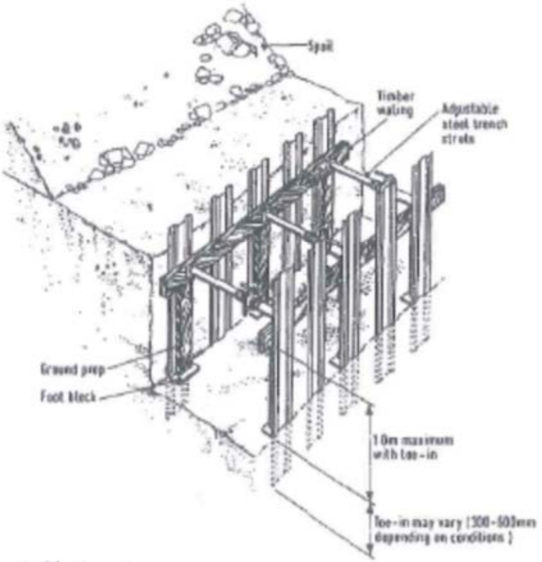
Ground Type	Trench Depth, D ~~less than 1.2m$^{(1)}$~~	1.2 to 3m	3 to 4.5m	4.5 to 6m
Sands and gravels Silt Soft Clay High compressibility Peat	~~Close, ½, ¼, ⅛ or nil~~	Close	Close	Close
Firm/stiff Clay Low compressibility Peat	~~¼, ⅛ or nil~~	½ or ¼	½ or ¼	Close or ½
Rock$^{(2)}$	From ½ for incompetent rock to nil for competent rock$^{(3)}$			

Sheeting requirements



Full sheeting

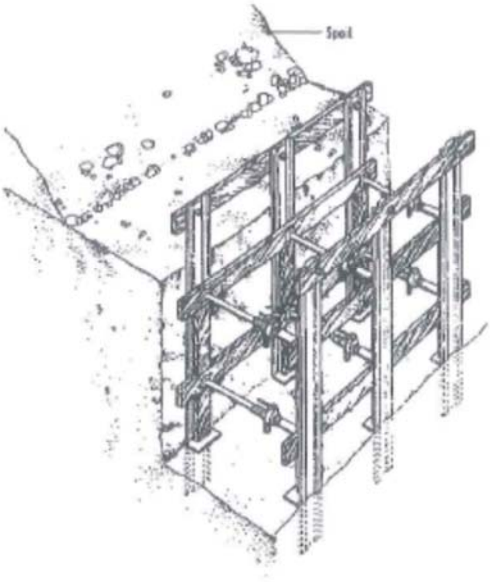
Sheeting requirements



Half sheeting
shown for 1.5 m deep trench

11/04/2012

Sheeting requirements

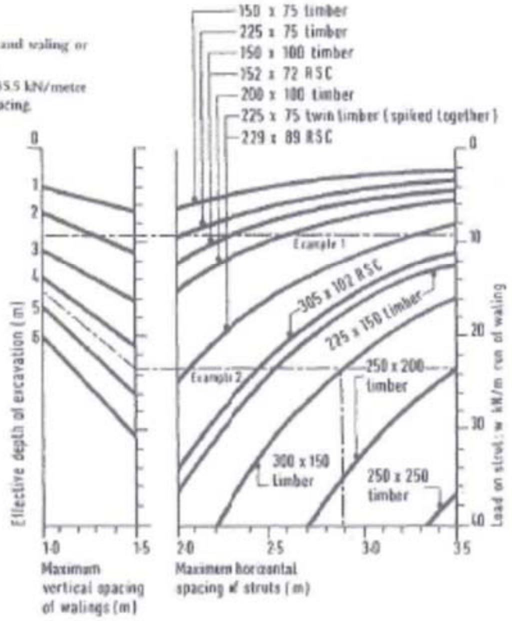


Quarter sheeting

Design to CIRIA 97

Note:
For standard Speedshore hydraulic strut and waling or equivalent use the curve for 229 x 89 RSC.
Heavy duty Speedshores have a capacity of 35.5 kN/metre run of waling at 3.2 m horizontal strut spacing.

BEWARE Any proprietary system should be checked against manufacturer's latest information.



Use for:
Granular soils
Mixed soils
Short term trenches in clay
(see notes opposite)

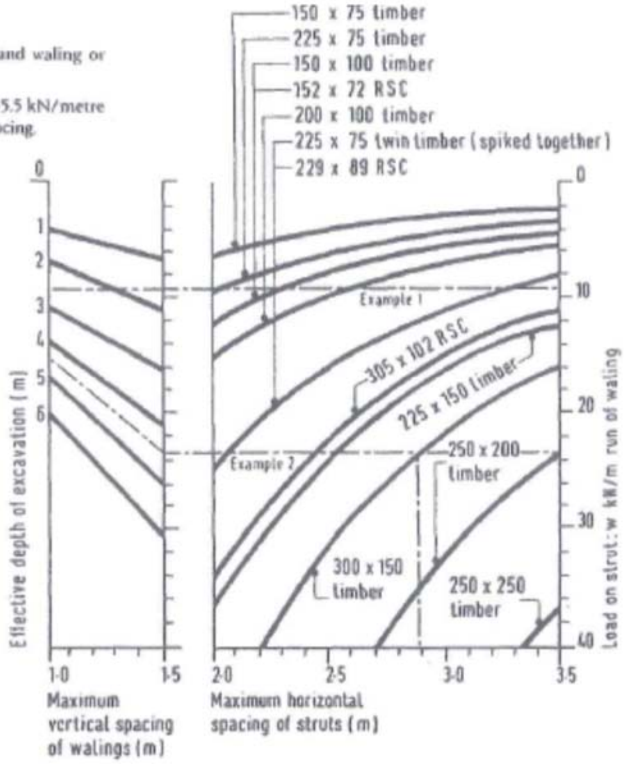
Note:
For standard Speedshore hydraulic strut and waling or equivalent use the curve for 229 x 89 RSC.

Heavy duty Speedshores have a capacity of 35.5 kN/metre run of waling at 3.2 m horizontal strut spacing.

BEWARE

Any proprietary system should be checked against manufacturer's latest information.

Use for:
Granular soils
Mixed soils
Short term trenches in clay
(see notes opposite)



Appendix E

Soil Investigation Report

GROUND INVESTIGATION REPORT

for the site at

14F AVENUE ROAD, PRIMROSE HILL, LONDON NW8 6BP

on behalf of

KHALID ZAKY C/O CROFT STRUCTURAL ENGINEERS LIMITED

Report Reference: GWPR1072/GIR/December 2014		Status: DRAFT
Issue:	Prepared By:	Verified By:
V1.01 December 2014		T. Williams
	Roger Foord BA (Hons) MSc DIC FGS MSoBRA Senior Geotechnical Engineer	Francis Williams M.Geol. (Hons) FGS CEnv AGS MSoBRA Director
File Reference: Ground and Water/Project Files/ GWPR1072 14F Avenue Road, London		

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FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 General

Ground and Water Limited were instructed by Khalid Zaky c/o Croft Structural Engineers Limited on the 24th October 2014 to undertake a Ground Investigation on a site at 14F Avenue Road, Primrose Hill, London NW8 6BP. The scope of the investigation was detailed within the Ground and Water Limited fee proposal ref: GWQ2245, dated 24th October 2014

1.2 Aims of the Investigation

The aim of the investigation was understood to be to supply the client and their designers with information regarding the ground conditions underlying the site to assist them in preparing an appropriate scheme for development.

The investigation was to be undertaken to provide parameters for the design of foundations by means of in-situ and laboratory geotechnical testing undertaken on soil samples recovered from trial holes.

The requirements of the London Borough of Camden, Camden Geological, Hydrogeological and Hydrological Study, Guidance for Subterranean Development (November 2010) was reviewed with respect to this report.

A Desk Study and full scale contamination assessment were not part of the remit of this report.

The techniques adopted for the investigation were chosen considering the anticipated ground conditions and development proposals on-site, and bearing in mind the nature of the site, limitations to site access and other logistical limitations.

1.3 Conditions and Limitations

This report has been prepared based on the terms, conditions and limitations outlined within Appendix A.

2.0 SITE SETTING

2.1 Site Location

The site comprised a 130m^2 rectangular shaped plot of land, orientated in a north-east to south-west direction, set back from Avenue Road to the north-east. The site was located in the northern corner of a development of eight residential houses in the former location of No. 14 Avenue Road. The site was located in the Primrose Hill area of the London Borough of Camden, north-west London.

The national grid reference for the centre of the site was approximately TQ 27378 83537. A site location plan is given within Figure 1 and a plan.

2.2 Site Description

The site was occupied by a mid terrace three to four storey brick built residential house. A single raised pedestrian terrace was noted to front the property at an elevation of ~3.0m above the tarmac access road off Avenue Road. A sunken garage structures was noted to the south-west of the property. A single storey rear extension was noted beyond which there was a grassed garden. Mature and semi-mature trees were noted along the north-eastern boundary of the site. A topographic survey of the site is shown in Figure 2. An aerial view of the site is provided within Figure 3.

The topographic survey indicated the rear of the site was located at ~39.44 – 39.61m AOD with the front at ~40.01 – 40.04m AOD.

2.3 Proposed Development

At the time of reporting, December 2014, the proposed redevelopment is understood to comprise the construction of a basement beneath the rear of the existing building and extending into the rear garden. The basement will be ~11.0m long and ~5.0m wide. The basement slab is anticipated to be formed at ~3.45-3.60m below ground level (bgl). A plan view of the proposed development can be seen in Figure 4.

The proposed development fell within Geotechnical Design Category 2 in accordance with Eurocode 7. The proposed foundation loads were not known to Ground and Water Limited at the time of reporting but are likely to range from 75 – 150kN/m^2.

The proposed development was understood not to involve any re-profiling of the site and its immediate environs. It is understood that no trees will be removed to facilitate the construction of the basement.

2.4 Geology

The geology map of the British Geological Survey of Great Britain for the North London area (Sheet 256) revealed the site to be situated on the London Clay Formation.

Figure 3 of the Camden Geological, Hydrogeological and Hydrological Study indicated that no Made Ground or Worked Ground was noted within a close proximity of the site.

London Clay Formation

The London Clay Formation comprises stiff grey fissured clay, weathering to brown near surface. Concretions of argillaceous limestone in nodular form (Claystones) occur throughout the formation. Crystals of gypsum (Selenite) are often found within the weathered part of the London Clay Formation, and precautions against sulphate attack to concrete are sometimes required.

The lowest part of the formation is a sandy bed with black rounded gravel and occasional layers of sandstone and is known as the Basement Bed.

A 20.0m deep BGS borehole ~50m south of the site revealed ~2.50m of Made Ground over a stiff to very stiff brown silty clay with occasional yellow-brown silt parting. The deposits were noted to be dark grey, with carbonaceous impurities, from 11.20m bgl.

2.5 Slope Stability and Subterranean Developments

The site itself was not situated within an area where a natural or man-made slope of greater than 7^o was present (Figure 16 Camden Geological, Hydrogeological and Hydrological Study). However, slopes of greater than 7^o were shown ~100m east of the site surrounding a covered reservoir on Primrose Hill

Figure 17 of the Camden Geological, Hydrogeological and Hydrological Study indicated the site was not situated within an area prone to landslides.

Figure 18 of the Camden Geological, Hydrogeological and Hydrological Study indicated that no major subterranean infrastructure (including existing and proposed tunnels) was noted within close proximity to the site. The map showed that an over ground train line was present ~125m south of the site.

2.6 Hydrogeology and Hydrology

A study of the aquifer maps on the Environment Agency website revealed the site to be located on **Unproductive Strata** comprising the bedrock of the London Clay Formation. No designation was given for any superficial deposits due to their likely absence.

Unproductive strata are rock layers with low permeability that have negligible significance for water supply or river base flow. These were formerly classified as non-aquifers.

Superficial (Drift) deposits are permeable unconsolidated (loose) deposits, for example, sands and gravels. The bedrock is described as solid permeable formations e.g. sandstone, chalk and limestone.

Examination of the Environment Agency records showed that the site did not fall within a Groundwater Source Protection Zone as classified in the Policy and Practice for the Protection of Groundwater.

The closest surface water feature was the Regents Canal located ~115m to the south of the site.

A surface water feature comprising the Regents Canal was noted ~115m south of the site in Figure 12 of the Camden Geological, Hydrogeological and Hydrological Study. Figure 11 revealed the site was not located close to any existing or “lost” watercourses.

Figure 14 of the Camden Geological, Hydrogeological and Hydrological Study revealed the site was not located within the catchment of Hampstead Ponds.

From analysis of hydrogeological and topographical maps groundwater was anticipated to be encountered at moderate to deep depth (4-6m below existing ground level (bgl)) and it was considered that the groundwater was flowing in a southerly direction in accordance with the local topography.

Examination of the Environment Agency records showed that the site was not situated within a floodplain or flood warning area. Figure 15 the Camden Geological, Hydrogeological and Hydrological Study revealed no historical flooding in a close proximity to the site.

2.7 Radon

BRE 211 (2007) Map 5 of the London, Sussex and west Kent area revealed the site was located within an area where mandatory protection measures against the ingress of Radon were **not** required.

3.0 FIELDWORK

3.1 Scope of Works

Fieldwork was undertaken on the 27th October 2014 and comprised the drilling of one window sampler boreholes (WS1) to a depth of 6.00m bgl, the logging of two trial pit foundation exposures (TP/FE1 and TP/FE2) excavated by others and the excavation and logging of one additional trial pit foundation exposure internally (TP/FE3). A Heavy Dynamic Probe (HDP) (DP1) was undertaken adjacent to WS1 to 10.00m bgl.

A groundwater monitoring standpipe was installed in WS1 to a depth of 5.00m bgl to enable the measurement of standing groundwater levels.

The construction of the well installed can be seen tabulated below.

Combined Bio-gas and Groundwater Monitoring Well Construction

Trial Hole	Depth of Installation (m bgl)	Thickness of slotted piping with gravel filter pack (m)	Depth of plain piping with bentonite seal (m bgl)	Piping external diameter (mm)
WS1	5.00m	4.00m	1.00m	19

The approximate locations of the trial holes can be seen within Figure 6.

Prior to commencing the ground investigation, a walkover survey was carried out to identify the presence of underground services and drainage. Where underground services/drainage were suspected and/or positively identified, exploratory positions were relocated away from these areas.

Upon completion of the site works, the trial holes were backfilled and made good/reinstated in relation to the surrounding area.

3.2 Sampling Procedures

Small disturbed samples were recovered from the trial holes at the depths shown on the trial hole records. Soil samples were generally retrieved from each change of strata and/or at specific areas of concern. Samples were also taken at approximately 0.5m intervals during broad homogenous soil horizons.

A selection of samples were despatched for geotechnical testing purposes.

4.0 ENCOUNTERED GROUND CONDITIONS

4.1 Soil Conditions

All exploratory holes were logged by David McMillan of Ground and Water Limited generally in accordance with BS EN 14688 'Geotechnical Investigation and Testing – Identification and Classification of Soil'.

The ground conditions encountered within the trial holes constructed on the site generally conformed to that anticipated from examination of the geology map. A capping of Made Ground was noted to overlie the London Clay Formation.

The ground conditions encountered during the investigation are described in this section. For more complete information about the Made Ground and the London Clay Formation at particular points, reference must be made to the individual trial hole logs within Appendix B.

The trial hole location plan can be viewed in Figure 5.

For the purposes of discussion the succession of conditions encountered in the trial holes in descending order can be summarised as follows:

Made Ground
London Clay Formation (BH1 only)

Made Ground

Made Ground was encountered from ground surface in WS1, and below a 0.17m thick concrete slab in TP/FE3, to a depth of 0.60m bgl in WS1 and for the full depth of TP/FE3, a depth of 1.50m bgl. The Made Ground generally comprised a dark brown to orange brown slightly sandy gravelly clay. The sand was fine to coarse grained and the gravel was rare to abundant, fine to coarse, rounded to angular flint, brick, concrete and carbonaceous material (clinker).

Within TP/FE3 below the capping of concrete a 0.23m layer of pink brown to light brown sandy gravel sub-base was noted. The sand was fine to coarse grained and the gravel was abundant, fine to coarse, sub-rounded to angular brick, concrete and tile fragments.

London Clay Formation

Soils of the London Clay Formation comprising an orange brown to brown silty clay, with occasional blue/grey mottling, was encountered underlying the Made Ground for the remaining depth of WS1, a depth of 6.00m bgl. Selenite crystals were noted from 2.50m bgl.

4.2 Foundation Exposures

A description of the foundation layout and ground conditions encountered within the hand dug trial pit/foundation exposures are given within this section of the report.

TP/FE1

Trial pit foundation exposure, TP/FE1, had been previously hand excavated by others from ground level on the party wall with 14G Avenue Road close to the centre of the property. The exact location of the trial hole can be seen in Figure 6 and a section drawing of the foundation encountered during TP/FE1 can be seen in Figure 7.

The foundation exposure was measured from ground level.

The foundation layout encountered consisted of a brick wall to ground level. From ground level to a depth of 2.47m bgl a brick wall was noted which rested upon a brick step. It was not possible to determine the final bearing stratum given the depth of the trial pit.

TP/FE2 – Front Wall

Trial pit foundation exposure TP/FE2 Front Wall, had been previously hand excavated by others from ground level on the party wall with 14E Avenue Road at the front of the property. The exact location of the trial hole can be seen in Figure 6 and a section drawing of the foundation encountered during TP/FE2 – Front Wall can be seen in Figure 8.

The foundation exposure was measured from ground level.

The foundation layout encountered consisted of a brick wall to ground level. From ground level to a depth of 0.97m bgl a brick wall was noted to rest upon a concrete footing which was at least 0.17m in thickness and stepped out by 0.05m. It was not possible to determine the final bearing stratum given the depth of the trial pit.

TP/FE2 – Side Wall

Trial pit foundation exposure, TP/FE2 Side Wall, had been previously hand excavated by others from ground level on the party wall with 14E Avenue Road at the front of the property. The exact location of the trial hole can be seen in Figure 6 and a section drawing of the foundation encountered during TP/FE2 – side wall can be seen in Figure 9.

The foundation exposure was measured from ground level.

The foundation layout encountered consisted of a brick wall to ground level. From ground level to a depth of at least 1.14m bgl a brick wall was noted. A pipe encased in concrete was noted to pass through the wall at a depth of 0.60m bgl. It was not possible to determine the final bearing stratum given the depth of the trial pit.

TP/FE3

Trial pit foundation exposure, TP/FE3, was hand excavated internally from ground level on the rear wall of the existing property on the party wall with 14E Avenue Road. The exact location of the trial hole can be seen in Figure 6 and a section drawing of the foundations encountered during TP/FE3 can be seen in Figure 10 and Figure 11.

The foundation exposure was measured from ground level.

The foundation layout encountered consisted of a brick wall to ground level. From ground level to a depth of 0.84m bgl a brick wall was noted to rest upon a concrete footing which was at least 0.66m in thickness and stepped out by 0.40m. It was not possible to determine the final bearing stratum given the depth of the trial pit. The ground conditions encountered directly surrounding the foundation are shown in Figure 10.

A neighbouring brick wall was noted to directly site on the concrete slab present. This can be seen in Figure 11.

4.3 Roots Encountered

Roots were encountered to a depth of 2.50m bgl in BH1.

It must be noted that the chance of determining actual depth of root penetration through a narrow diameter borehole is low. Roots may be found to greater depths at other locations on the site, particularly close to trees and/or trees that have been removed both within the site and its close environs.

4.4 Groundwater Conditions

Groundwater was not encountered during the intrusive investigation on the 27th October 2014 or during a return site visit on the 31st October 2014 to measure groundwater levels in the standpipe installed in BH1. The results of a second monitoring shall follow as an addendum to this report

Changes in groundwater level occur for a number of reasons including seasonal effects and variations in drainage. Exact groundwater levels may only be determined through long term measurements from monitoring wells installed on-site. The investigation was undertaken in September and October 2014, when groundwater levels are rising from their annual minimum (lowest elevation).

Isolated pockets of groundwater may be perched within any Made Ground found at other locations around the site.

4.5 Obstructions

No artificial or natural sub-surface obstructions were noted during construction of the trial holes.

5.0 INSITU AND LABORATORY GEOTECHNICAL TESTING

5.1 In-Situ Geotechnical Testing

A Heavy Dynamic Probe (HDP) (DP1) was undertaken adjacent to WS1 to 10.10m bgl. The test results are presented on the borehole log within Appendix B.

Window Sampler Boreholes provide samples of the ground for assessment but they do not give any engineering data. Dynamic Probing involves the driving of a metal cone into the ground via a series of steel rods. These rods are driven from the surface by a hammer system that lifts and drops a 50.0kg hammer onto the top of the rods through a set height, thus ensuring a consistent energy input. The number of hammer blows that are required to drive the cone down by each 100mm increment are recorded. These blow counts then provide a comparative assessment from which correlations have been published, based on dynamic energy, which permits engineering parameters to be generated. *(The Dynamic Probe 'Heavy' (HDP) Tests were conducted in accordance with BS 1377; 1990; Part 9, Clause 3.2).*

The cohesive soils of the Made Ground and London Clay Formation were classified based on the table below.

Undrained Shear Strength from Field Inspection/equivalent SPT derived from HDP results Cohesive Soils (EN ISO 14688-2:2004 & Stroud (1974))

Classification	Undrained Shear Strength (kPa)	Field Indications
Extremely High	>300	-
Very High	150 – 300	Brittle or very tough
High	75 – 150	Cannot be moulded in the fingers
Medium	40 – 75	Can be moulded in the fingers by strong pressure
Low	20 – 40	Easily moulded in the fingers
Very Low	10 – 20	Exudes between fingers when squeezed in the fist
Extremely Low	<10	-

An interpretation of the in-situ geotechnical testing results is given in the table below.

In-Situ Geotechnical Testing Results Summary

Strata	Equivalent SPT "N" Blow Counts derived from HDP	Undrained Shear Strength kPa (based on Stroud, 1974)	Soil Type		Trial Hole
			Cohesive	Granular	
Made Ground	2 – 4	10 – 20	Ext. Low/V Low – V Low/Low	-	WS/DP1 (GL – 0.60m bgl)
London Clay Formation	2 – 10	10 – 50	Ext. Low/V Low – Medium	-	WS/DP1 (0.60 – 6.00m bgl)
Assumed London Clay Formation*	10 - 30	50 – 150	Medium – High/V High	-	BH1 (6.00 – 10.10m bgl)

*Assumed London Clay Formation based on the results of the dynamic probing.

It must be noted that field measurements of undrained shear strength are dependent on a number of variables including disturbance of sample, method of investigation and also the size of specimen or test zone etc.

5.2 Laboratory Geotechnical Testing

A programme of geotechnical laboratory testing, scheduled by Ground and Water Limited and carried out by K4 Soils Laboratory and QTS Environmental Limited, was undertaken on samples recovered from the London Clay Formation. The results of the tests are presented in Appendix C.

The test procedures used were generally in accordance with the methods described in BS1377:1990.

Details of the specific tests used in each case are given below:

Standard Methodology for Laboratory Geotechnical Testing		
Test	**Standard**	**Number of Tests**
Atterberg Limit Tests	BS1377:1990:Part 2:Clauses 3.2, 4.3 & 5	4
Moisture Content	BS1377:1990:Part 2:Clause 3.2	5
One Dimensional Consolidation Test (Swelling Test)	BS1377:1990:Part 5:Clause 3 and 4	1
Water Soluble Sulphate & pH	BS1377:1990:Part 3:Clause 5	1
BRE Special Digest 1 (incl. Ph, Electrical Conductivity, Total Sulphate, W/S Sulphate, Total Chlorine, W/S Chlorine, Total Sulphur, Ammonium as NH4, W/S Nitrate, W/S Magnesium)	BRE Special Digest 1 “Concrete in Aggressive Ground (BRE, 2005).	2

5.2.1 Atterberg Limit Tests

A précis of Atterberg Limit Tests undertaken on four samples of the London Clay Formation can be seen tabulated below.

Atterberg Limit Tests Results Summary							
Stratum/Depth	**Moisture Content (%)**	**Passing 425 µm sieve (%)**	**Modified PI (%)**	**Soil Class**	**Consistency Index (Ic)**	**Volume Change Potential**	
						NHBC	**BRE**
London Clay Formation	29 – 33	100	46 – 50	CV	Stiff	High	High

NB: NP – Non-plastic
BRE Volume Change Potential refers to BRE Digest 240 (based on Atterberg results)
Soil Classification based on British Soil Classification System.
Consistency Index (Ic) based on BS EN IS0 14688-2:2004.

5.2.2 Comparison of Soil’s Moisture Content with Index Properties

5.2.2.1 Liquidity Index Analyses

The results of the Atterberg Limit tests undertaken on four samples of the London Clay Formation were analysed to determine the Liquidity Index of the samples. This gives an indication as to whether the samples recovered showed a moisture deficit and their degree of consolidation. The results are tabulated overpage.

The test results are presented within Appendix C.

Liquidity Index Calculations Summary					
Stratum/Trial Hole/Depth	**Moisture Content (%)**	**Plastic Limit (%)**	**Modified Plasticity Index (%)**	**Liquidity Index**	**Result**
London Clay Formation **WS1/2.00m bgl** (Brown CLAY).	29	27	46	0.044	Heavily Overconsolidated.
London Clay Formation **WS1/3.00m bgl** (Brown CLAY with blue grey veins).	32	29	48	0.063	Heavily Overconsolidated.
London Clay Formation **WS1/4.00m bgl** (Brown CLAY).	33	30	50	0.060	Heavily Overconsolidated.
London Clay Formation **WS1/6.00m bgl** (Brown CLAY with blue grey veins)	31	30	47	0.021	Heavily Overconsolidated.

Liquidity Index testing revealed no evidence for moisture deficit within the heavily overconsolidated samples of the London Clay Formation tested.

5.2.2.2 Liquid Limit

A comparison of the soil moisture content and the liquid limit can be seen tabulated below.

Moisture Content vs. Liquid Limit				
Strata/Trial Hole/Depth/Soil Description	**Moisture Content (MC) (%)**	**Liquid Limit (LL) (%)**	**40% Liquid Limit (LL)**	**Result**
London Clay Formation **WS1/2.00m bgl** (Brown CLAY).	29	73	29.2	**MC < 0.4 x LL** **(Potentially significant moisture deficit)**
London Clay Formation **WS1/3.00m bgl** (Brown CLAY with blue grey veins).	32	77	30.8	MC > 0.4 x LL (No significant moisture deficit)
London Clay Formation **WS1/4.00m bgl** (Brown CLAY).	33	80	32.0	MC = 0.4 x LL (No significant moisture deficit)
London Clay Formation **WS1/6.00m bgl** (Brown CLAY with blue grey veins)	31	77	30.8	MC > 0.4 x LL (No significant moisture deficit)

The results in the table above indicate that a potential significant moisture deficit was present within one sample of the London Clay Formation tested (WS1/2.00m bgl) since the moisture content value was marginally below 40% of the liquid limit.

The sample was described as a brown clay. Roots were noted to 2.50m bgl within WS1. Therefore, the possible affect of the roots on the London Clay Formation in WS1 to 2.50m bgl cannot be completely discounted.

The results in the table above indicate that the remaining samples of the London Clay Formation tested from WS1 showed no evidence of a significant moisture deficit.

5.2.3 Moisture Content Profiling

The moisture content versus depth plot for WS1 can be seen within Figure 12.

Figure 12 shows a possible moisture deficit in WS1 at a depth of ~1.50-2.50m bgl due to a lowering of the moisture content. Roots were noted to a depth of 2.50m bgl by the supervising engineer. The strata in the borehole, to that depth, was generally described as an orange brown, becoming brown, silty clay with occasional blue grey mottling. Testing has shown the soils were heavily overconsolidated. Therefore the apparent moisture deficit could be a result of a combination of the heavily overconsolidated nature of the soils of the London Clay Formation and the water demand from the roots.

5.2.4 Swelling Test

A One Dimensional Swelling Test was undertaken on a disturbed sample obtained from WS1 at a depth of 3.50m bgl.

The results of the test are tabulated below.

One Dimensional Consolidation Test - Swelling

Stratum/Depth		Height (mm)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)	Void Ratio	Degree of Saturation (%)	Particle Density (Mg/m^3)	Swelling Pressure (kpa)
London Clay Formation/ BH1/4.10m bgl	Initial	16.01	31	2.16	1.65	0.66	127.9	2.74	70
	Final	17.04	38	2.14	1.55	0.77	-	-	-

It must be noted that the sample was remoulded and this must be taken into account in final design.

5.2.5 Sulphate and pH Tests

A sulphate and pH test was undertaken on one sample from the London Clay Formation (WS1/3.00m). A sulphate concentration of 2900mg/l with a pH of 7.9 was determined.

5.2.6 BRE Special Digest 1

In accordance with BRE Special Digest 1 ‘Concrete in Aggressive Ground’ (BRE, 2005) two samples of the London Clay Formation (WS1/2.50m and WS1/4.50m bgl) were scheduled for laboratory analysis to determine parameters for concrete specification.

The results are given within Appendix C and a summary is tabulated overpage.

Summary of Results of BRE Special Digest Testing			
Determinand	**Unit**	**Minimum**	**Maximum**
pH	-	8.1	8.6
Ammonium as NH_4	mg/kg	4.2	7.4
Sulphur	mg/kg	1763	4474
Chloride (water soluble)	mg/kg	84	86
Magnesium (water soluble)	g/l	0.1530	0.1960
Nitrate (water soluble)	mg/kg	4	42
Sulphate (water soluble)	g/l	0.78	2.49
Sulphate (total)	mg/kg	3533	9562

6.0 ENGINEERING CONSIDERATIONS

6.1 Soil Characteristics and Geotechnical Parameters

Based on the results of the intrusive investigation and geotechnical laboratory testing the following interpretations have been made with respect to engineering considerations.

- Made Ground was encountered from ground surface in WS1, and below a 0.17m thick concrete slab in TP/FE3, to a depth of 0.60m bgl in WS1 and for the full depth of TP/FE3, a depth of 1.50m bgl. The Made Ground generally comprised a dark brown to orange brown slightly sandy gravelly clay. The sand was fine to coarse grained and the gravel was rare to abundant, fine to coarse, rounded to angular flint, brick, concrete and carbonaceous material (clinker).

  As a result of the inherent variability of Made Ground, 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 a suitable underlying natural stratum of adequate bearing characteristics.

- Soils of the London Clay Formation comprising an orange brown to brown silty clay, with occasional blue/grey mottling, was encountered underlying the Made Ground for the remaining depth of WS1, a depth of 6.00m bgl. Selenite crystals were noted from 2.50m bgl.

  The results of the in-situ testing showed the undrained shear strength of the London Clay Formation comprised extremely low/very low to medium undrained shear strength (10-50Pa) soils from 0.60-6.00m bgl, becoming medium to high/very high undrained shear strength (50-150kPa) soils from 6.00-10.00m bgl.

  The soils of the London Clay Formation were shown to have a **high** potential for volume change in accordance both BRE240 and NHBC Standards Chapter 4.2.

  Consistency Index calculations indicated the cohesive London Clay Formation to be stiff. Liquidity Index testing revealed the soils to be heavily overconsolidated.

  Geotechnical analysis revealed a potential root exacerbated moisture deficit may have been present within WS1 at ~2.50m bgl.

  The soils of the London Clay Formation are heavily overconsolidated cohesive soils and are therefore likely to be a suitable stratum for the proposed traditional strip, mat or piled foundations for the basement or foundations structurally unattached to the basement. The settlements induced on loading are likely to be low to moderate.

  The final design of foundations will need to take into account the volume change potential of the soil, the depth of root penetration and/or moisture deficit and the likely serviceability and settlement requirements of the proposed structure. These parameters for design are discussed in the next section of this report.

- Roots were encountered to a depth of 2.50m bgl in BH1.

- Groundwater was not encountered during the intrusive investigation on the 27th October

2014 or during a return site visit on the 31st October 2014 to measure groundwater levels in the standpipe installed in BH1. The results of a second monitoring shall follow as an addendum to this report

6.2 Basement Foundations

At the time of reporting, December 2014, the proposed redevelopment is understood to comprise the construction of a basement beneath the rear of the existing building and extending into the rear garden. The basement will be ~11.0m long and ~5.0m wide. The basement slab is anticipated to be formed at ~3.45-3.60m below ground level (bgl). A plan view of the proposed development can be seen in Figure 4.

The proposed development fell within Geotechnical Design Category 2 in accordance with Eurocode 7. The proposed foundation loads were not known to Ground and Water Limited at the time of reporting but are likely to range from 75 – 150kN/m^2.

Foundations should be designed in accordance with soils of **high volume change potential** in accordance with BRE Digest 240 and NHBC Chapter 4.2.

Given the cohesive nature of the shallow deposits foundations must therefore **not** be placed within cohesive root penetrated and/or desiccated soils and the influence of the trees surrounding the site must be taken into account (NHBC Standards Chapter 4.2). It is recommended that foundations are taken at least 300mm into non-root penetrated strata.

Where trees are mentioned in the text this means existing trees, recently removed trees (approximately 15 years to full recovery on cohesive soils) and those planned as part of the site landscaping. Should trees be removed from the footprint of the proposed building then an alternative foundation system, such as piles or isolated pads should be considered.

Geotechnical analysis revealed a potential root exacerbated moisture deficit may have been present within WS1 at ~1.50-2.50m bgl. Roots were encountered to a depth of 2.50m bgl in WS1, therefore a minimum foundation depth of ~2.80m bgl is recommended.

It is considered likely the proposed basement will be constructed with load bearing concrete retaining walls with semi-ground bearing concrete floors. The following bearing capacities could be adopted for 5.0m long by 0.75m and 1.00m wide footings constructed at 3.50m bgl.

Limit State: Bearing Capacities Calculated (Based on WS/DP1)		
Depth (m BGL)	**Foundation System**	**Limit Bearing Capacity (kN/m^2)**
3.50m	5.00m by 0.75m Strip	135.02
	5.00m by 1.00m Strip	135.02

Serviceability State: Settlement Parameters Calculated (Based on WS/DP1)			
Depth (m BGL)	**Foundation System**	**Limit Bearing Capacity (kN/m^2)**	**Settlement (mm)**
3.50m	5.00m by 0.75m Strip	120	<23
	5.00m by 1.00m Strip	120	<20

It must be noted that a bearing capacity of less than 50kN/m^2 at 3.00m bgl and 55kN/m^2 at 3.50m bgl may results in heave of the underlying soils. A swelling pressure of 80kpa was determined at 4.10m bgl based on the result of a remoulded sample.

Groundwater was not encountered during the intrusive investigation on the 27th October 2014 or during a return site visit on the 31st October 2014 to measure groundwater levels in the standpipe installed in BH1. The results of a second monitoring shall follow as an addendum to this report

Based on the groundwater readings taken during this investigation to-date, it was considered unlikely that groundwater would be encountered during basement construction.

Perched groundwater may be encountered within the Made Ground. The advice of a reputable dewatering contractor, familiar with the type of ground and groundwater conditions encountered on this site, should be sought prior to finalising the design of the excavation for the basement.

It must be mentioned that it was assumed that excavations will be kept dry and either concreted or blinded as soon after excavation as possible. If water were allowed to accumulate on the formation for even a short time not only would an increase in heave occur resulting from the soil increasing in volume by taking up water, but also the shear strength and hence the bearing capacity would also be reduced.

The basement must be suitably tanked to prevent ingress of any groundwater, if applicable, and also surface water run-off. The basement must also be designed to take into account pressure exerted by the presence of groundwater in and around the basement, if applicable.

6.3 Piled Foundations

Based on the results of the intrusive investigation piled foundations are unlikely to be required at the site.

6.4 Basement Excavations & Stability

Shallow excavations in the Made Ground and London Clay Formation are likely to be marginally stable at best. Long, deep excavations, through both of these strata are likely to become unstable.

The excavation of the basement must not affect the integrity of the adjacent structures beyond the boundaries. The excavation must be supported by suitably designed retaining walls. It is considered unlikely that battering the sides of the excavation, casting the retaining walls and then backfilling to the rear of the walls would be suitable given the close proximity of the party walls.

The retaining walls for the basement will need to be constructed based on cohesive soils with an appropriate angle of shear resistance (*Φ*’) for the ground conditions encountered.

The excavations must not affect the integrity of the adjacent structures beyond the boundaries. The excavations must be supported by suitably designed retaining walls. The retaining walls will need to be constructed based on soils encountered with an appropriate angle of shear resistance (*Φ*’) and effective cohesion (*C*’) for the ground conditions encountered.

Based on the ground conditions encountered within WS1 the following parameters could be used in the design of retaining walls. These have been designed based on the equivalent SPT profile recorded, results of geotechnical classification tests and reference to literature.

Retaining Wall/Basement Design Parameters					
Strata	Unit Volume Weight (kN/m^3)	Cohesion Intercept (c') (kPa)	Angle of Shearing Resistance (Ø)	Ka	Kp
Made Ground	~15	0	12	0.66	1.52
London Clay Formation	~20-22	0	24	0.42	2.37

Unsupported earth faces formed during excavation may be liable to collapse without warning and suitable safety precautions should therefore be taken to ensure that such earth faces are adequately supported before excavations are entered by personnel.

Groundwater was not encountered during the intrusive investigation on the 19th September 2014 or during a return site visit on the 31st October 2014 to measure groundwater levels in the standpipe installed in BH1. Based on the groundwater readings taken during this investigation to-date, it was considered unlikely that groundwater would be encountered during basement construction.

Perched groundwater may be encountered within the Made Ground. The advice of a reputable dewatering contractor, familiar with the type of ground and groundwater conditions encountered on this site, should be sought prior to finalising the design of the excavation for the basement.

6.5 Hydrogeological Effects

The proposed development is located on **Unproductive Strata** relating to the London Clay Formation.

The ground conditions encountered generally comprised a capping of cohesive Made Ground over cohesive London Clay Formation. Based on a visual appraisal of the soils encountered the permeability of the London Clay Formation was likely to be negligible.

Groundwater was not encountered during the intrusive investigation on the 27th October 2014 or during a return site visit on the 31st October 2014 to measure groundwater levels in the standpipe installed in BH1. The results of a second monitoring shall follow as an addendum to this report

The Environment Agency records show that the highest recorded tide for the nearest river station on the River Thames at Westminster is 4.50m AOD with high tides generally at ~3.00m AOD. The elevation of the site is ~39.50m AOD. Based on a maximum 3.50m bgl deep basement slab a formation level of 36.00m AOD is assumed. This means that the basement will be constructed above general high tide levels of the River Thames.

Based on the above it is considered likely that perched water will be encountered in the Made Ground during basement construction, but the basement will not be constructed below the groundwater table. In relation to the basement, once constructed, the Made Ground will act as a slightly porous medium for water to migrate; however, additional drainage should be considered as the London Clay Formation will act as a barrier for groundwater migration.

6.6 Sub-Surface Concrete

Sulphate concentrations measured in 2:1 water/soil extracts taken from the Made Ground and London Clay Formation, from both the geotechnical and chemical laboratory testing, fell into Classes

DS-2 to DS-3 of the BRE Special Digest 1, 2005, *'Concrete in Aggressive Ground'.*

Table C1 of the Digest indicated an ACEC (Aggressive Chemical Environment for Concrete) classification of AC-2s. For the classification given, the "static" and "natural" case was adopted given the presence of the cohesive soils and residential use of the site. The sulphate concentration in the samples ranged from 780-2900mg/l with a pH range of 7.9-8.6. The total potential sulphate concentrations ranged from 0.35-0.96%.

Concrete to be placed in contact with soil or groundwater must be designed in accordance with the recommendations of Building Research Establishment Special Digest 1, 2005, *'Concrete in Aggressive Ground'* taking into account the pH of the soils.

It is prudent to note that pyrite nodules may be present within the London Clay Formation. Pyrite can oxidise to gypsum and this normally only occurs in the upper weathered layer, but excavation allows faster oxidation and water soluble sulphate values can rapidly increase during construction. Therefore rising sulphate values should be taken into account should ferruginous staining/pyrite nodules be encountered within the London Clay Formation.

6.7 Surface Water Disposal

Infiltration tests were beyond the scope of the investigation.

Soakaway construction within the cohesive soils of the London Clay Formation is unlikely to prove satisfactory due to negligible to low anticipated infiltration rates. Therefore an alternative method of surface water disposal is required.

Consultation with the Environment Agency must be sought regarding any use that may have an impact on groundwater resources.

At the time of reporting, December 2014, the proposed redevelopment is understood to comprise the construction of a basement beneath the rear of the existing building and extending into the rear garden. Therefore the proposed development will increase the areas of hardstanding present.

The principles of sustainable urban drainage system (SUDS) should be applied to reduce the risk of flooding from surface water ponding and collection associated with the construction of the basement.

6.8 Discovery Strategy

There may be areas of contamination that have not been identified during the course of the intrusive investigation. For example, there may have been underground storage tanks (UST's) not identified during the Ground Investigation for which there is no historical or contemporary evidence.

Such occurrences may be discovered during the demolition and construction phases for the redevelopment of the site.

Groundworkers should be instructed to report to the Site Manager any evidence for such contamination; this may comprise visual indicators, such as fibrous materials within the soil, discolouration, or odours and emission. Upon discovery advice must be taken from a suitably qualified person before proceeding, such that appropriate remedial measures and health and safety protection may be applied.

Should a new source of contamination be suspected or identified then the Local Authority will need to be informed.

6.9 Waste Disposal

The excavation of foundations is likely to produce waste which will require classification and then recycling or removal from site.

Under the Landfill (England and Wales) Regulations 2002 (as amended), prior to disposal all waste must be classified as;

- Inert;
- Non-hazardous, or;
- Hazardous.

The Environment Agency's Hazardous Waste Technical Guidance (WM2) document outlines the methodology for classifying wastes.

Once classified the waste can be removed to the appropriately licensed facilities, with some waste requiring pre-treatments prior to disposal.

INERT waste classification should be undertaken to determine if the proposed waste confirms to INERT or NON-HAZARDOUS Waste Acceptable Criteria (WAC).

6.10 Imported Material

Any soil which is to be imported onto the site must undergo chemical analysis to prove that it is suitable for the purpose for which it is intended.

The Topsoil must be fit for purpose and must either be supplied with traceable chemical laboratory test certificates or be tested, either prior to placing (ideally) or after placing, to ensure that the human receptor cannot come into contact with compounds that could be detrimental to human health.

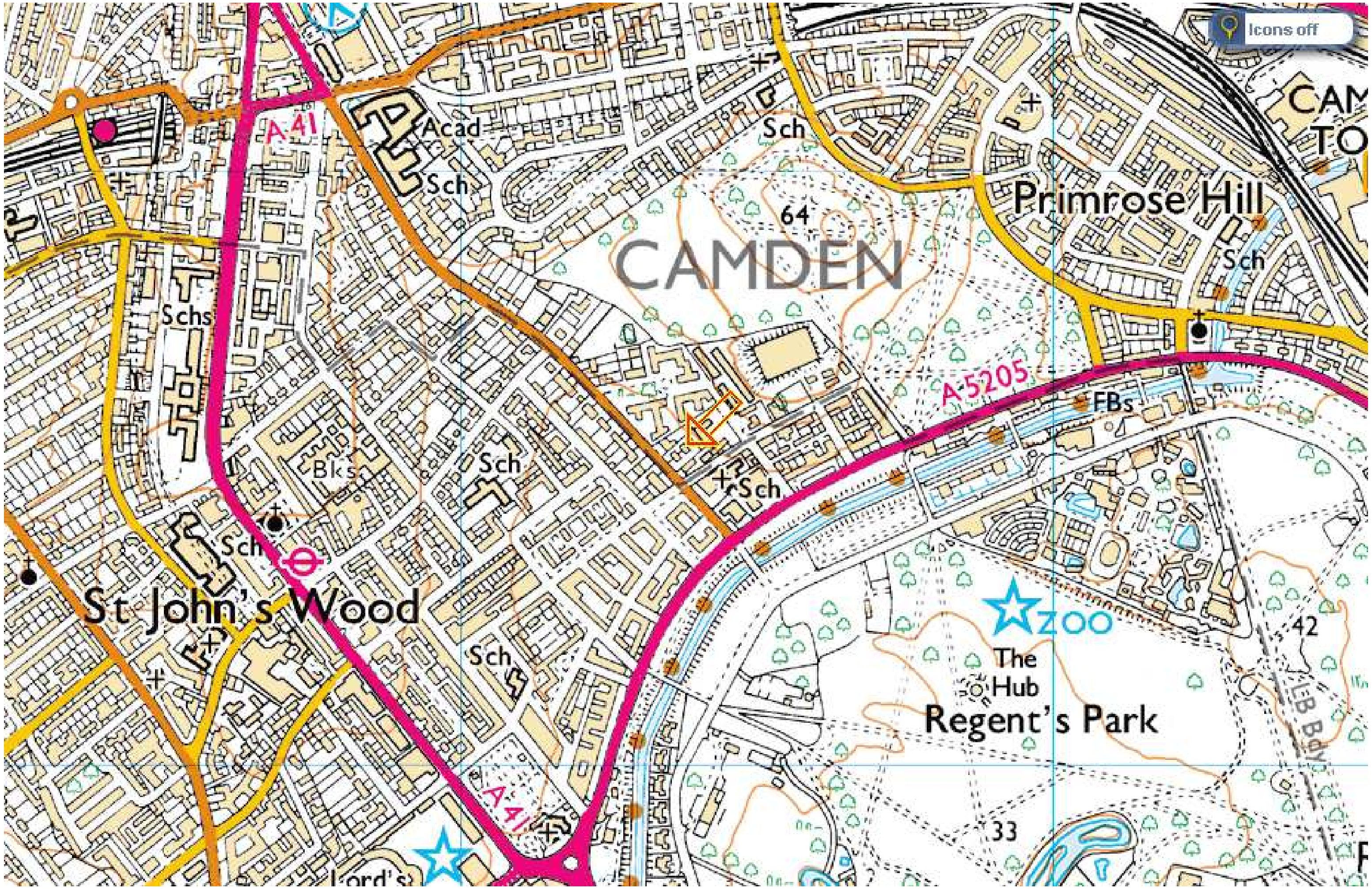
6.11 Duty of Care

Groundworkers must maintain a good standard of personal hygiene including the wearing of overalls, boots, gloves and eye protectors and the use of dust masks during periods of dry weather.

To prevent exposure to airborne dust by both the general public and construction personnel the site should be kept damp during dry weather and at other times when dust were generated as a result of construction activities.

The site should be securely fenced at all times to prevent unauthorised access. Washing facilities should be provided and eating restricted to mess huts.

N



Approximate Site Boundary

NOT TO SCALE

Project: 14F Avenue Road, Primrose Hill, London NW8 6BP

Figure 1

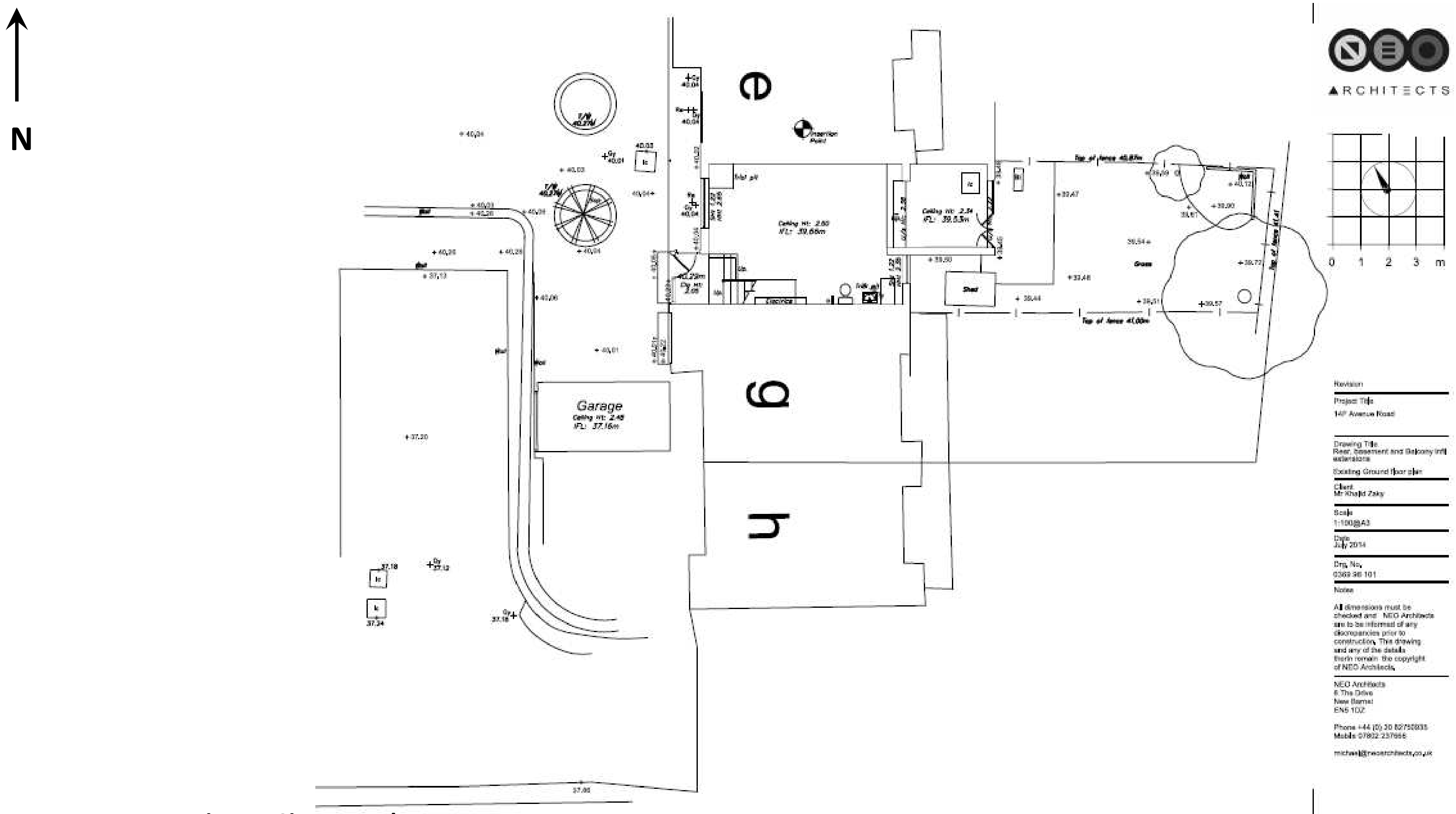
ground&water

Client: Khalid Zaky c/o Croft Structural Engineers Limited

Date: December 2014

Site Location Plan

Ref: GWPR1072



Approximate Site Boundary

NOT TO SCALE

Project:

14F Avenue Road, Primrose Hill, London NW8 6BP

Figure 2

Client:

Khalid Zaky c/o Croft Structural Engineers Limited

Date:

December 2014

Site Development Area

Ref:

GWPR1072

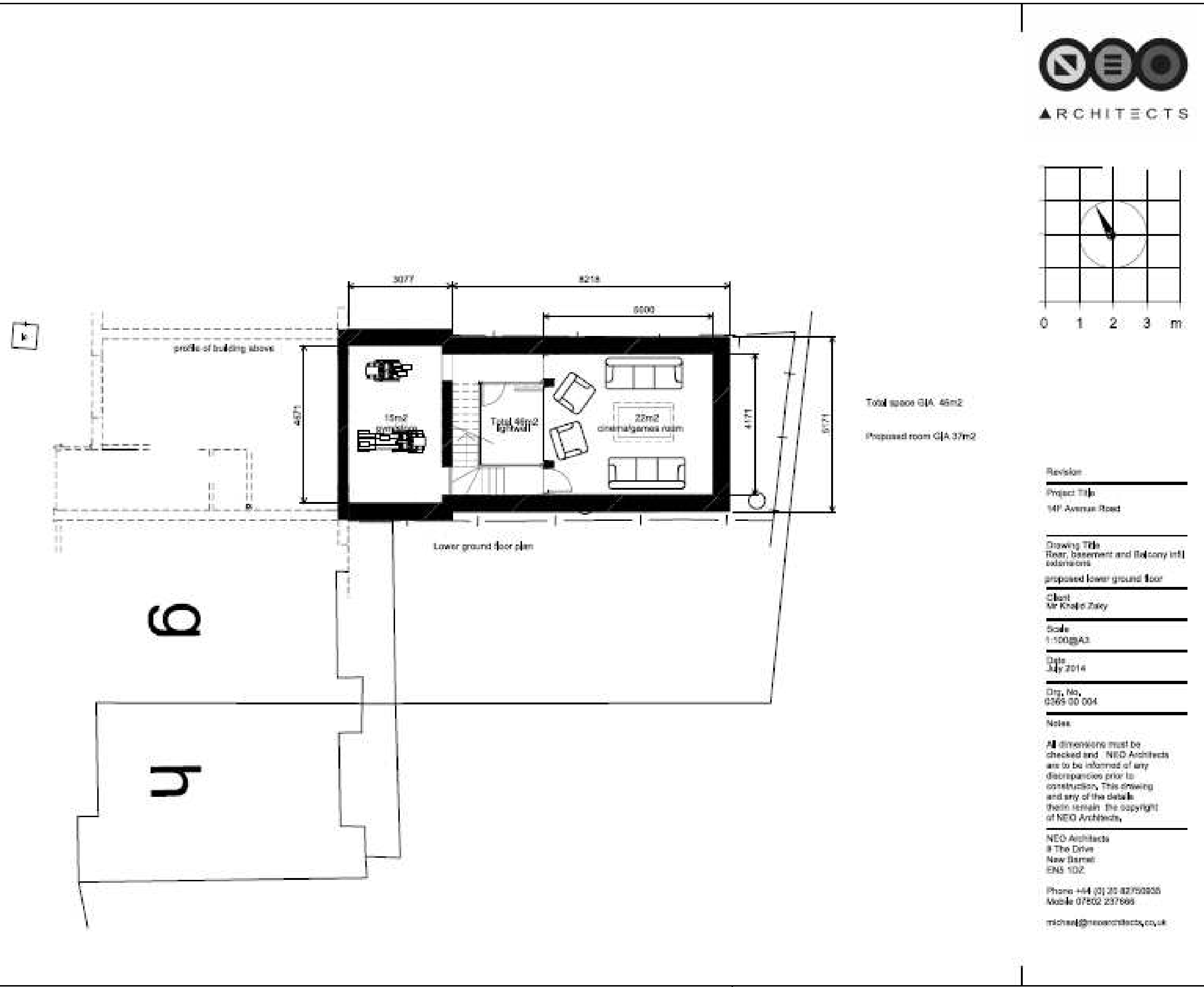
N

🟥 Approximate Site Boundary

NOT TO SCALE

Project: 14F Avenue Road, Primrose Hill, London NW8 6BP	**Figure 3**
Client: Khalid Zaky c/o Croft Structural Engineers Limited **Date:** December 2014	ground&water
Aerial View of the Site **Ref:** GWPR1072	

N



🟥 **Approximate Site Boundary**

NOT TO SCALE

Project:

14F Avenue Road, Primrose Hill, London NW8 6BP

Client:

Khalid Zaky c/o Croft Structural Engineers Limited

Date:

December 2014

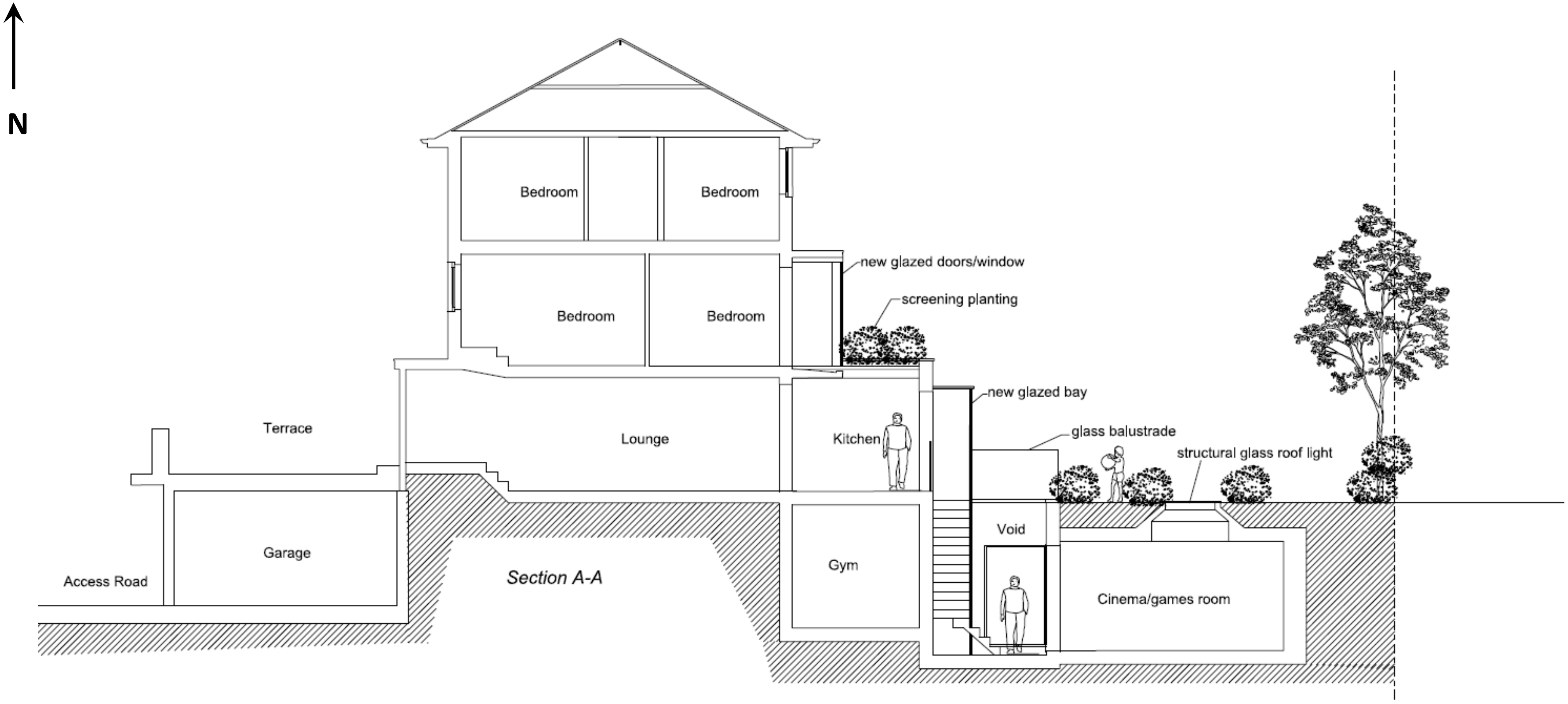
Proposed Development Plan – Plan View

Ref:

GWPR1072

Figure 4

ground&water

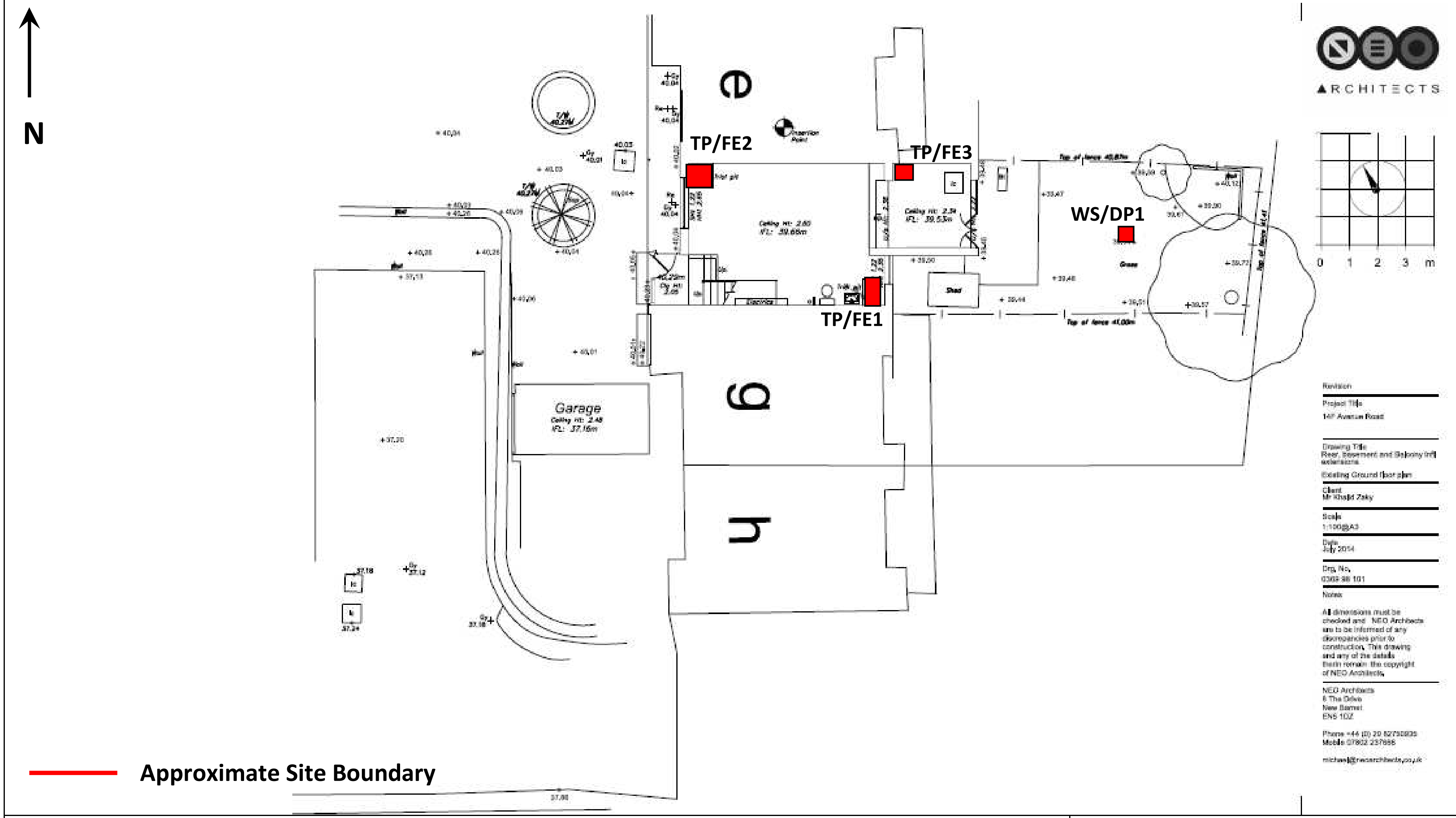


🟥 Approximate Site Boundary

NOT TO SCALE

Project: 14F Avenue Road, Primrose Hill, London NW8 6BP	**Figure 5**
Client: Khalid Zaky c/o Croft Structural Engineers Limited	**Date:** December 2014
Proposed Development Plan – Section View	**Ref:** GWPR1072

ground&water



Approximate Site Boundary

NOT TO SCALE

Project:

14F Avenue Road, Primrose Hill, London NW8 6BP

Client:

Khalid Zaky c/o Croft Structural Engineers Limited

Date:

December 2014

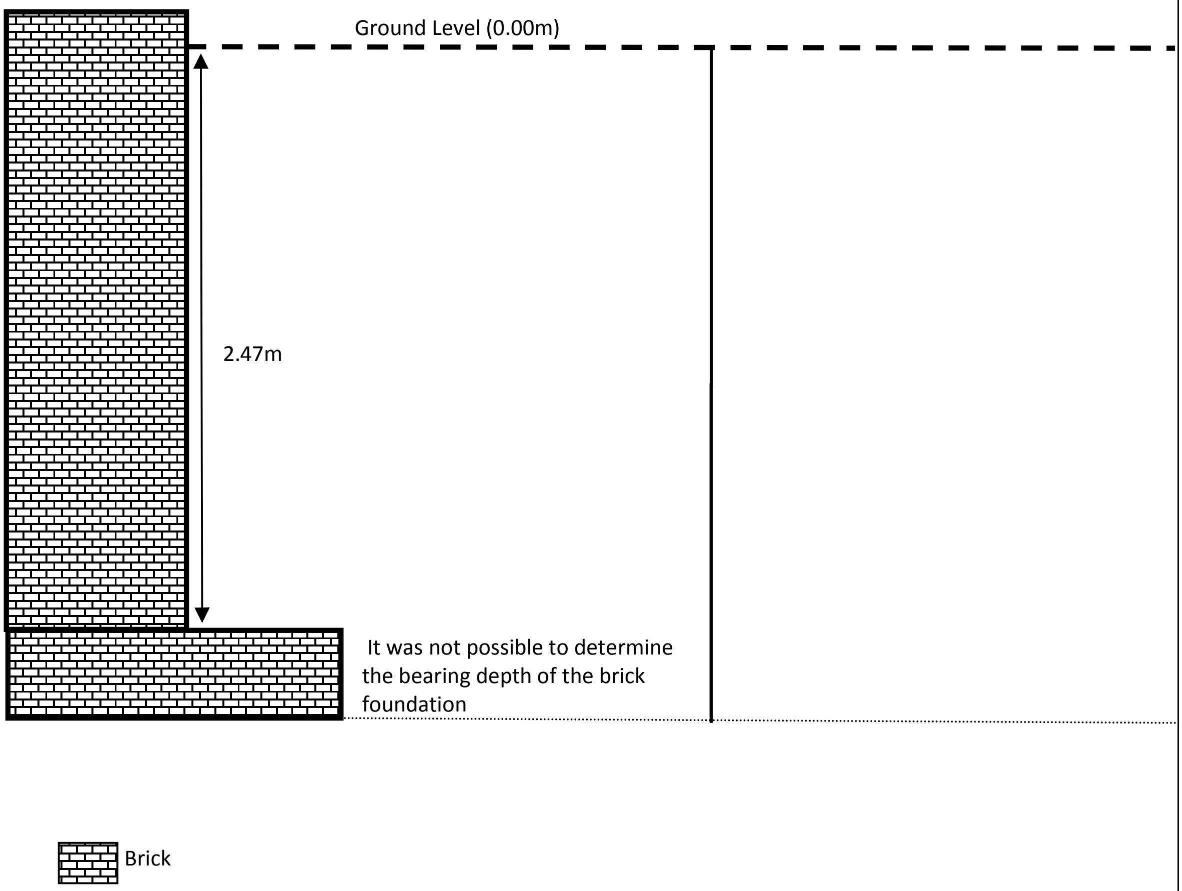
Trial Hole Location Plan

Ref:

GWPR1072

Figure 6

ground&water



NOTE: NOT TO SCALE

Project:
14F Avenue Road, Primrose Hill, London NW8 6BP

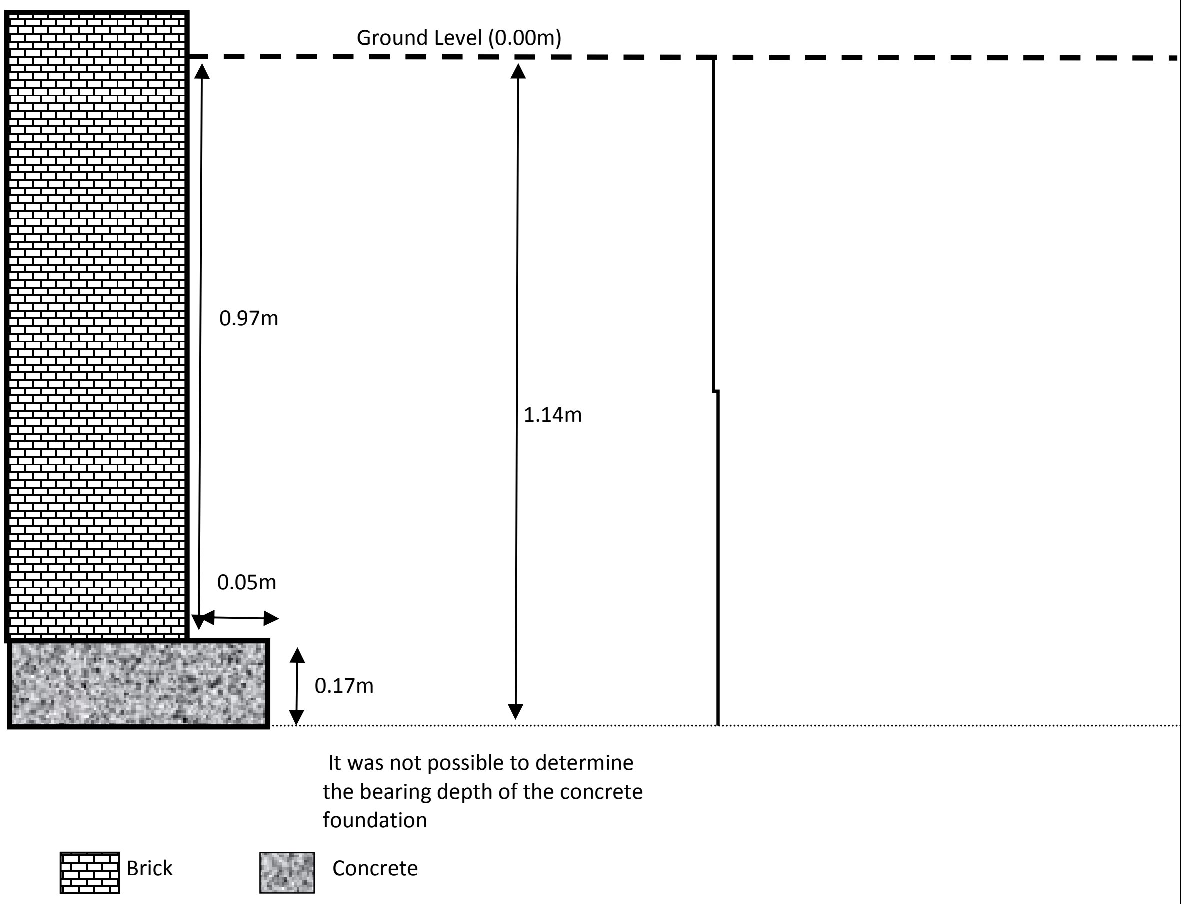
Figure 7

Client:
Khalid Zaky c/o Croft Structural Engineers Limited

Date:
December 2014

Section Drawing: Foundation Exposure TP/FE1

Ref:
GWPR1072



It was not possible to determine the bearing depth of the concrete foundation

NOTE: NOT TO SCALE

Project:
14F Avenue Road, Primrose Hill, London NW8 6BP

Figure 8

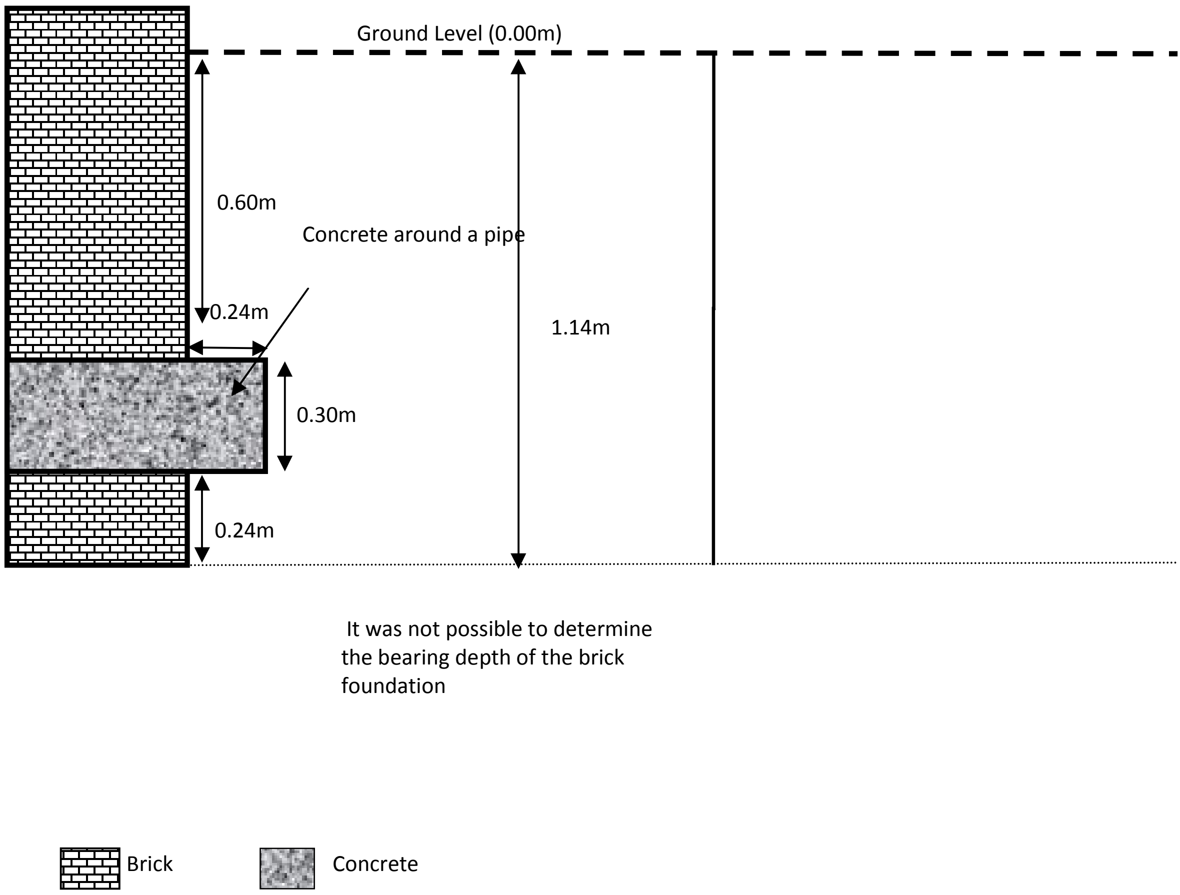
ground&water

Client:
Khalid Zaky c/o Croft Structural Engineers Limited

Date:
December 2014

Section Drawing: Foundation Exposure TP/FE2 – Front Wall

Ref:
GWPR1072



It was not possible to determine the bearing depth of the brick foundation

NOTE: NOT TO SCALE

Project:
14F Avenue Road, Primrose Hill, London NW8 6BP

Client:
Khalid Zaky c/o Croft Structural Engineers Limited

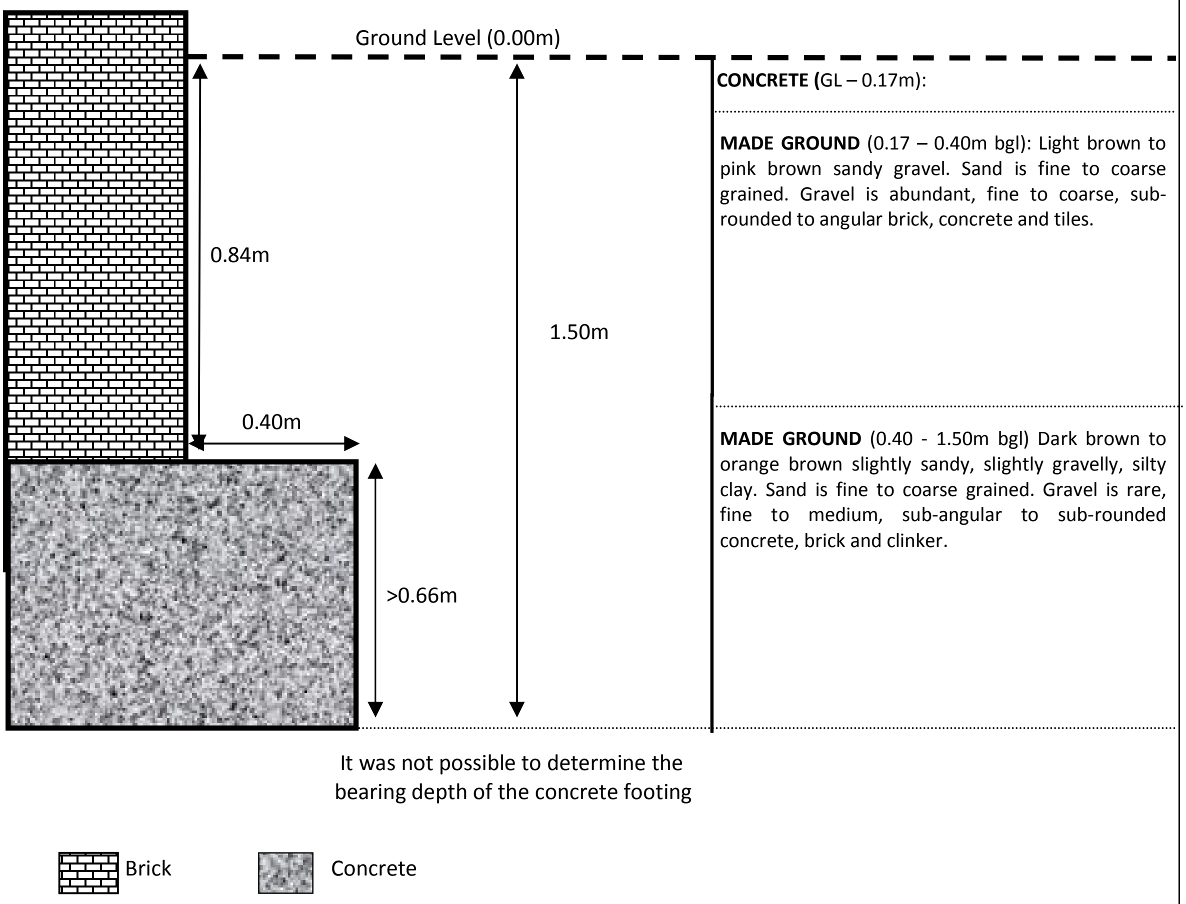
Date:
December 2014

Section Drawing: Foundation Exposure TP/FE2 – Side Wall

Ref:
GWPR1072

Figure 9

ground&water



CONCRETE (GL – 0.17m):

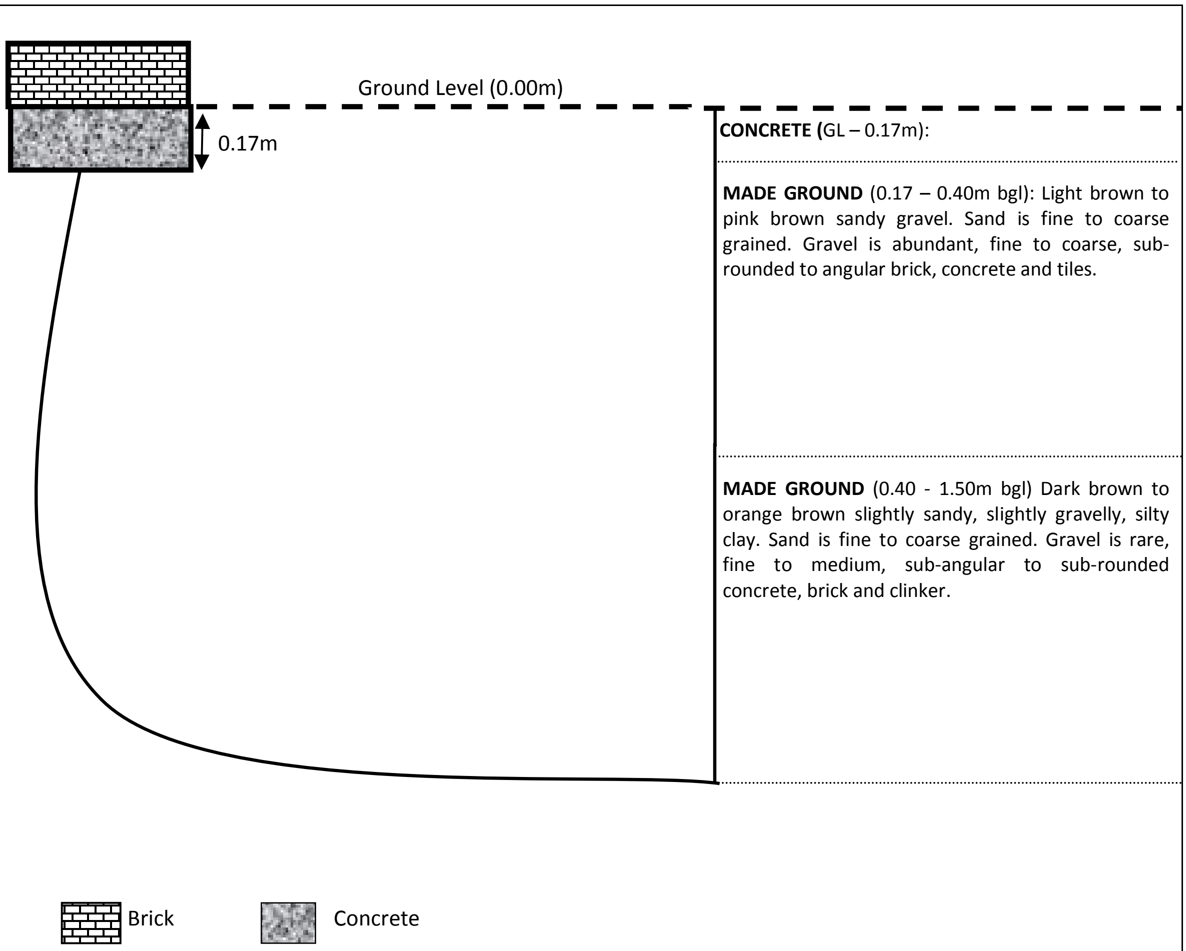
MADE GROUND (0.17 – 0.40m bgl): Light brown to pink brown sandy gravel. Sand is fine to coarse grained. Gravel is abundant, fine to coarse, sub-rounded to angular brick, concrete and tiles.

MADE GROUND (0.40 - 1.50m bgl) Dark brown to orange brown slightly sandy, slightly gravelly, silty clay. Sand is fine to coarse grained. Gravel is rare, fine to medium, sub-angular to sub-rounded concrete, brick and clinker.

It was not possible to determine the bearing depth of the concrete footing

NOTE: NOT TO SCALE

Project: **14F Avenue Road, Primrose Hill, London NW8 6BP**	**Figure 10** ground&water
Client: **Khalid Zaky c/o Croft Structural Engineers Limited**	**Date:** **December 2014**
Section Drawing: Foundation Exposure TP/FE3 (A)	**Ref:** **GWPR1072**



CONCRETE (GL – 0.17m):

MADE GROUND (0.17 – 0.40m bgl): Light brown to pink brown sandy gravel. Sand is fine to coarse grained. Gravel is abundant, fine to coarse, sub-rounded to angular brick, concrete and tiles.

MADE GROUND (0.40 - 1.50m bgl) Dark brown to orange brown slightly sandy, slightly gravelly, silty clay. Sand is fine to coarse grained. Gravel is rare, fine to medium, sub-angular to sub-rounded concrete, brick and clinker.

NOTE: NOT TO SCALE

Project:
14F Avenue Road, Primrose Hill, London NW8 6BP

Figure 11

ground&water

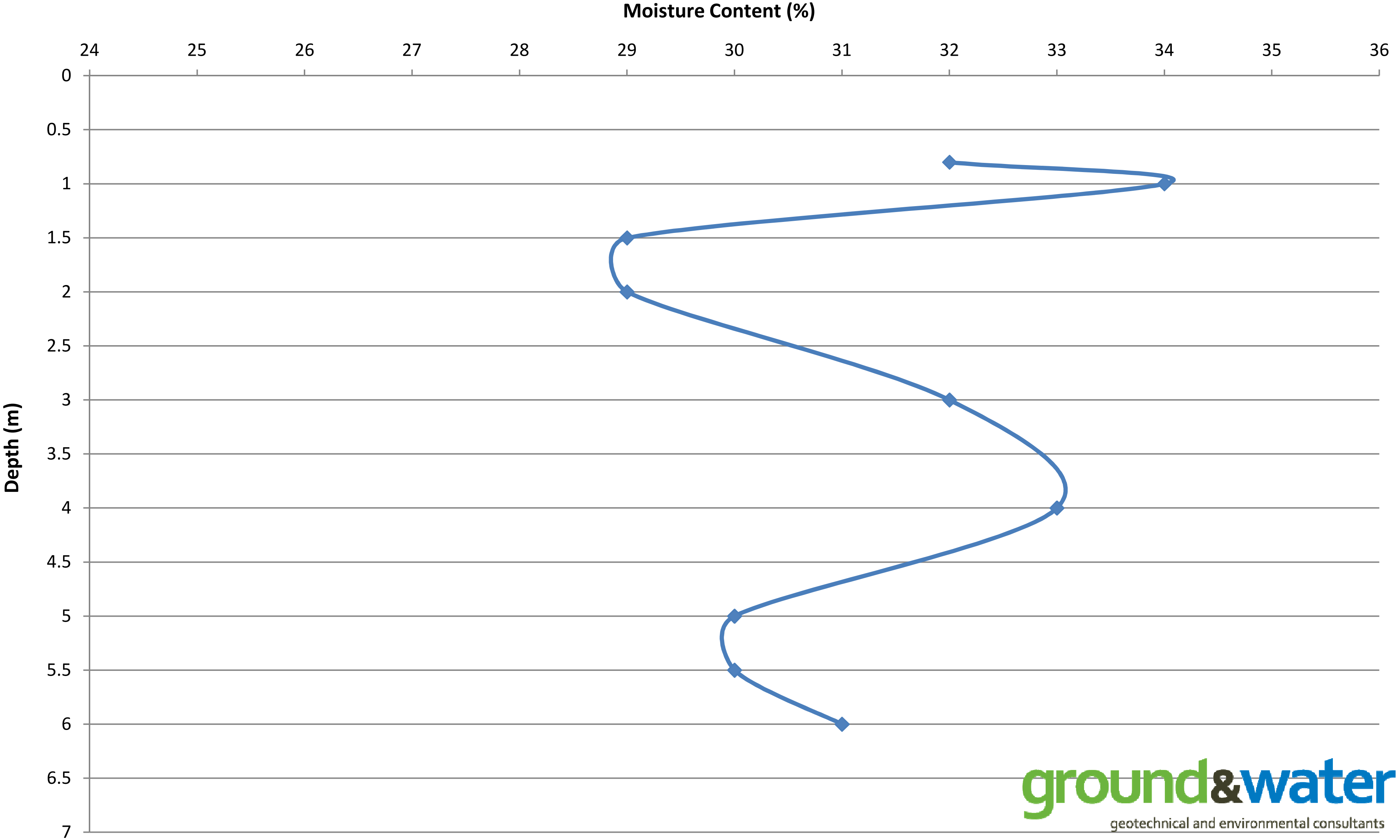
Client:
Khalid Zaky c/o Croft Structural Engineers Limited

Date:
December 2014

Section Drawing: Foundation Exposure TP/FE3 (B)

Ref:
GWPR1072

Figure 12: Change in Moisture Content With Depth Within WS1



ground&water

geotechnical and environmental consultants

APPENDIX A
Conditions and Limitations

The ground is a product of continuing natural and artificial processes. As a result, the ground will exhibit a variety of characteristics that vary from place to place across a site, and also with time. Whilst a ground investigation will mitigate to a greater or lesser degree against the resulting risk from variation, the risks cannot be eliminated.

The investigation, interpretations, and recommendations given in this report were prepared for the sole benefit of the client in accordance with their brief; as such these do not necessarily address all aspects of ground behaviour at the site. No liability is accepted for any reliance placed on it by others unless specifically agreed in writing.

Current regulations and good practice were used in the preparation of this report. An appropriately qualified person must review the recommendations given in this report at the time of preparation of the scheme design to ensure that any recommendations given remain valid in light of changes in regulation and practice, or additional information obtained regarding the site.

This report is based on readily available geological records, the recorded physical investigation, the strata observed in the works, together with the results of completed site and laboratory tests. Whilst skill and care has been taken to interpret these conditions likely between or below investigation points, the possibility of other characteristics not revealed cannot be discounted, for which no liability can be accepted. The impact of our assessment on other aspects of the development required evaluation by other involved parties.

The opinions expressed cannot be absolute due to the limitations of time and resources within the context of the agreed brief and the possibility of unrecorded previous in ground activities. The ground conditions have been samples or monitored in recorded locations and tests for some of the more common chemicals generally expected. Other concentrations of types of chemicals may exist. It was not part of the scope of this report to comment on environment/contaminated land considerations.

The conclusions and recommendations relate to 14F Avenue Road, Primrose Hill, London NW8 6BP.

Trial hole is a generic term used to describe a method of direct investigation. The term trial pit, borehole or window sampler borehole implies the specific technique used to produce a trial hole.

The depth to roots and/or of desiccation may vary from that found during the investigation. The client is responsible for establishing the depth to roots and/or of desiccation on a plot-by-plot basis prior to the construction of foundations. Where trees are mentioned in the text this means existing trees, recently removed trees (approximately 15 years to full recovery on cohesive soils) and those planned as part of the site landscaping.

Ownership of copyright of all printed material including reports, laboratory test results, trial pit and borehole log sheets, including drillers log sheets, remain with Ground and Water Limited. Licence is for the sole use of the client and may not be assigned, transferred or given to a third party.

APPENDIX B
Fieldwork Logs

Ground and Water Ltd
Tel: 0333 600 1221
email: enquiries@groundandwater.co.uk
www.groundandwater.co.uk

Borehole No
WS1
Sheet 1 of 1

Project Name 14F Avenue Road,	Project No. GWPR1072	Co-ords: -		Hole Type WS
Location: Primrose Hill, London NW8 6BF		Level: 39.54 m AOD		Scale 1:50
Client: Mr Khalid Zaky c/o Croft Structural Engineers		Dates: 27/10/2014		Logged By DM

Well	Water Strikes	Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
		Depth (m)	Type	Results					
		0.25	D					MADE GROUND: Dark brown slightly sandy gravelly clay. Sand is fine to coarse grained. Gravel is occasional to abundant, fine to coarse, rounded to angular flint, brick and concrete.	
		0.50	D						
					0.60	38.94		LONDON CLAY FORMATION: Orange brown silty CLAY.	
		0.80	D						
		1.00	D						1
					1.30	38.24		LONDON CLAY FORMATION: Brown, with occasional blue grey mottling, silty CLAY with silt partings. Selenite crystals noted from 2.80m bgl.	
		1.50	D						
		2.00	D						2
		2.50	D						
		3.00	D						3
		3.50	D						
		4.00	D						4
		4.50	D						
		5.00	D						5
		5.50	D						
		6.00	D		6.00	33.54		End of Borehole at 6.00 m	6
									7
									8
									9
			Type	Results					

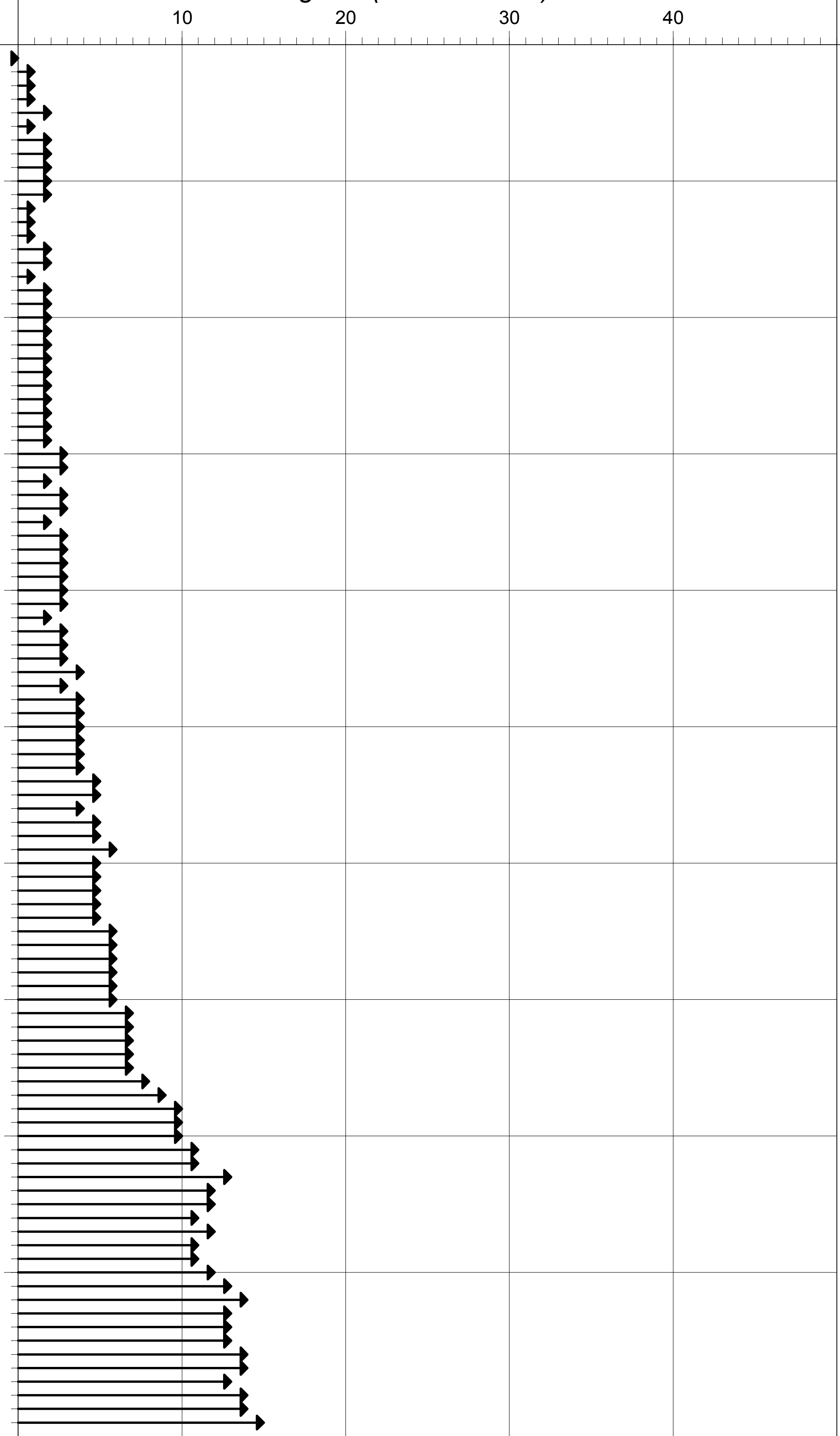
Remarks: Roots noted by drillers to 1.70m bgl. Noted by supervising engineer to 2.50m bgl.
No groundwater encountered.
19mm well installed to 5.00m bgl.

DYNAMIC PROBING

Probe No	**DP1**
Client	**Mr Khalid Zaky c/o Croft Structural Engineers**
Sheet 1 of 1	
Site	**14F Avenue Road,**
Project No	**GWPR1072**
E	**-**
N	**-**
Level	**-**
Date	**27/10/2014**
Logged by	**SJM**

Depth (m)	*Readings Blows/100mm*				
	0	1	1	1	2
	1	2	2	2	2
1.0	2	1	1	1	2
	2	1	2	2	2
2.0	2	2	2	2	2
	2	2	2	2	3
3.0	3	2	3	3	2
	3	3	3	3	3
4.0	3	2	3	3	3
	4	3	4	4	4
5.0	4	4	4	5	5
	4	5	5	6	5
6.0	5	5	5	5	6
	6	6	6	6	6
7.0	7	7	7	7	7
	8	9	10	10	10
8.0	11	11	13	12	12
	11	12	11	11	12
9.0	13	14	13	13	13
	14	14	13	14	14
	15				

Diagram (N100 Values)



Torque (Nm)

0

Ground and Water Ltd
Tel: 0333 600 1221
email: enquiries@groundandwater.co.uk
www.groundandwater.co.uk

Fall Height	**500**	*Cone Base Diameter*	**50**
Hammer Wt	**50.00**	*Final Depth*	**10.00**
Probe Type	**DPH**	*Log Scale*	1:50

APPENDIX C
Geotechnical Laboratory Test Results

Project Name: 14F Avenue Road, London NW8		**Samples Received:**	14/11/2014
		Project Started:	14/11/2014
Client: Ground and Water Ltd		**Testing Started:**	25/11/2014
Project No: GWPR1072	**Our job/report no:** 17830	**Date Reported:**	28/11/2014

K4 SOILS

Borehole No:	Sample No:	Depth (m)	Description	Moisture content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Passing 0.425 mm (%)	Remarks
WS1	-	0.80	Brown slightly gravelly slightly sandy CLAY with occasional rootlets (gravel is fm and sub-angular to sub-rounded)	32					
WS1	-	1.00	Brown slightly gravelly slightly sandy CLAY with occasional rootlets (gravel is fm and sub-angular to sub-rounded)	34					
WS1	-	1.50	Brown slightly sandy CLAY	29					
WS1	-	2.00	Brown CLAY	29	73	27	46	100	
WS1	-	3.00	Brown CLAY with blue grey veins	32	77	29	48	100	
WS1	-	4.00	Brown CLAY	33	80	30	50	100	
WS1	-	5.00	Brown CLAY with scattered traces of selenite crystals	30					
WS1	-	5.50	Brown CLAY with scattered traces of selenite crystals	30					
WS1	-	6.00	Brown CLAY with blue grey veins	31	77	30	47	100	

UKAS TESTING 2519

Summary of Test Results

BS 1377 : Part 2 : Clause 4.4 : 1990 Determination of the liquid limit by the cone penetrometer method.
BS 1377 : Part 2 : Clause 5 : 1990 Determination of the plastic limit and plasticity index.
BS 1377 : Part 2 : Clause 3.2 : 1990 Determination of the moisture content by the oven-drying method.

Checked and Approved
Initials: K.P
Date: 28/11/2014

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

Test Results relate only to the sample numbers shown above. Approved Signatories: K.Phaure (Tech.Mgr) J.Phaure (Lab.Mgr)

Client name & address:	**Samples Received** 14/11/2014	**K4 SOILS**	
Ground and Water Ltd	**Project Started** 14/11/2014		
Project Name: 14F Avenue Road, London NW8	**Testing Started** 04/12/2014		
Project No: GWPR1072 **Our Job / report no:** 17830	**Date Reported:** 11/12/2014		
Sample description:	**Sample no/ type:** -	**BH no:**	WS1
Brown CLAY		**Depth (m):**	3.50

Test details

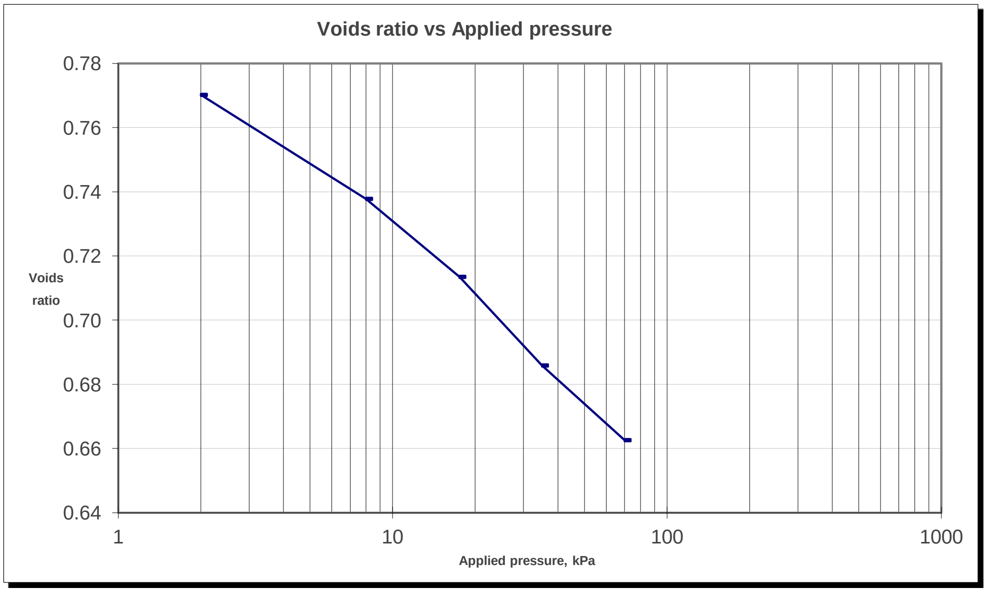
Depth within original sample m : 3.60 Orientation within original sample : Vertical

Specimen details

		Initial	Final
Height	mm :	16.01	17.04
Diameter	mm :	75	-
Bulk density	Mg/m3 :	2.16	2.14
Moisture content	% :	31	38
Dry density	Mg/m3 :	1.65	1.55
Voids Ratio	:	0.66	0.77
Degree of saturation	% :	127.9	-
Particle density	Mg/m3 :	2.74	-
Swelling pressure	kPa :	70	-

Consolidation Stage

Stage number	Applied Pressure kPa	Voids Ratio	Coefficient of Consolidation m2/year	Coefficient of Compressibility m2/MN	Stage number	Applied Pressure kPa	Voids Ratio	Coefficient of Consolidation m2/year	Coefficient of Compressibility m2/MN
1	70	0.6626	-	-	11				
2	35	0.6859	0.04	0.400	12				
3	18	0.7135	0.04	0.936	13				
4	8	0.7378	0.03	1.493	14				
5	2	0.7702	0.03	3.108	15				
6					16				
7					17				
8					18				
9					19				
10					20				



UKAS TESTING 2519

One-Dimensional Consolidation Test

BS 1377 : Part 5 : Clause 3 & 4 : 1990

Determination of the one-dimensional consolidation properties

Approved by

Initials : kp
Date : 11/12/2014

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

Test Results relate only to the sample numbers shown above. Approved Signatories: K.Phaure (Tech.Mgr) J.Phaure (Lab.Mgr)

Project Name: 14F Avenue Road, London NW8

Client: Ground and Water Ltd
Project no: GWPR1072
Our job no: 17830

K4 SOILS

Borehole No:	Sample No:	Depth m	Description	pH	Sulphate content (g/l)
WS1	-	3.00	Brown CLAY with blue grey veins	7.9	2.90

Date
28/11/2014

Summary of Test Results

BS 1377 : Part 3 :Clause 5 : 1990

Determination of sulphate content of soil and ground water : gravimetric method

Checked and Approved
Initials : kp

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: 14-26605

Site Reference: 14F Avenue Road, London, NW8

Project / Job Ref: GWPR1072

Order No: None Supplied

Sample Receipt Date: 17/11/2014

Sample Scheduled Date: 17/11/2014

Report Issue Number: 1

Reporting Date: 21/11/2014

Authorised by:

Russell Jarvis
Director
On behalf of QTS Environmental Ltd

Authorised by:

Kevin Old
Director
On behalf of QTS Environmental Ltd

Soil Analysis Certificate

QTS Environmental Report No: 14-26605	**Date Sampled**	27/10/14	27/10/14			
Ground & Water Ltd	**Time Sampled**	None Supplied	None Supplied			
Site Reference: 14F Avenue Road, London, NW8	**TP / BH No**	WS1	WS1			
Project / Job Ref: GWPR1072	**Additional Refs**	None Supplied	None Supplied			
Order No: None Supplied	**Depth (m)**	2.50	4.50			
Reporting Date: 21/11/2014	**QTSE Sample No**	126084	126085			

Determinand	**Unit**	**RL**	**Accreditation**					
pH	pH Units	N/a	**MCERTS**	8.6	8.1			
Total Sulphate as SO_4	mg/kg	< 200	NONE	3533	9562			
W/S Sulphate as SO4 (2:1)	g/l	< 0.01	**MCERTS**	0.78	2.49			
Total Sulphur	mg/kg	< 200	NONE	1763	4477			
Ammonium as NH_4	mg/kg	< 0.5	NONE	4.2	7.4			
W/S Chloride (2:1)	mg/kg	< 1	**MCERTS**	84	86			
Water Soluble Nitrate (2:1) as NO_3	mg/kg	< 3	**MCERTS**	42	4			
W/S Magnesium	g/l	< 0.0001	NONE	0.1530	0.1960			

Analytical results are expressed on a dry weight basis where samples are 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

Soil Analysis Certificate - Sample Descriptions

QTS Environmental Report No: 14-26605
Ground & Water Ltd
Site Reference: 14F Avenue Road, London, NW8
Project / Job Ref: GWPR1072
Order No: None Supplied
Reporting Date: 21/11/2014

QTSE Sample No	TP / BH No	Additional Refs	Depth (m)	Moisture Content (%)	Sample Matrix Description
$ 126084	WS1	None Supplied	2.50	19.8	Light brown clay
$ 126085	WS1	None Supplied	4.50	19.9	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

4480

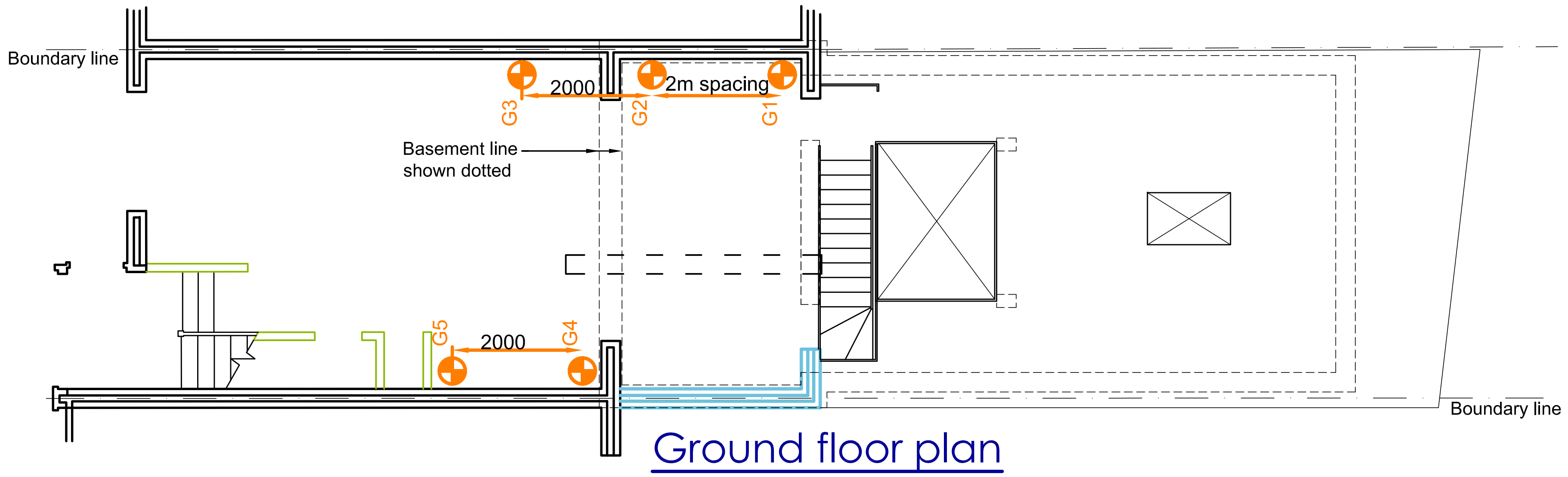
Soil Analysis Certificate - Methodology & Miscellaneous Information
QTS Environmental Report No: 14-26605
Ground & Water Ltd
Site Reference: 14F Avenue Road, London, NW8
Project / Job Ref: GWPR1072
Order No: None Supplied
Reporting Date: 21/11/2014

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	Determination of acetone/hexane extractable hydrocarbons by GC-FID	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	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge	E004
Soil	AR	TPH LQM	Determination of hexane/acetone extractable hydrocarbons by GC-FID fractionating with SPE cartridge	E004
Soil	AR	VOCs	Determination of volatile organic compounds by headspace GC-MS	E001
Soil	AR	VPH (C6 - C10)	Determination of hydrocarbons C6-C10 by headspace GC-MS	E001

D Dried
AR As Received

Appendix F

Basement Monitoring



Ground floor plan

scale 1:100

⊕ Key

Denotes position of Leveling Targets, fixed to party wall 500mm & 2000mm above Ground Floor Level.Additional monitoring may be required for any cracking noted in the Party Wall Surveyor's survey.

Location:	Date:						
	Initial:						Final:
G1							
G2							
G3							
G4							
G5							

Monitoring Table

Settlement limit along length of wall	Category	Action
0-2mm	Green	Carry on Works. Record values in table below.
2-5mm	Amber	Carry out a local structural review; Contract Croft Engineer and publish results to PWS. Preparation for the implementation of remedial measures should they be required.
>5mm	Red	Implement structural support as required; Cease works within a 5m zone of the affected section; Review monitoring data and implement revised method of works. Inform Croft Structural Engineers.

	11.14	ISSUE FOR BIA
Rev	Date	Amendments

Job nos 141005

Dwg Nos M-10

date 10.14

drawn EJ

Chk'd CT

Scale 1:100 @ A3

Rev -

Client: Mr Khalid Zaky

Project: 14F Avenue Road

Title : Monitoring

Croft
Structural
Engineers
Clockshop Mews,
r/o 60 Saxon Rd,
London, SE25 5EH.

020 8684 4744
www.croftse.co.uk

Job Number: 141005
Date: 30.10.2014

CROFT
STRUCTURAL
ENGINEERS

Croft Structural Engineers
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Structural Monitoring Statement

14F Avenue Road NW8 6BP

Mr Khalid Zaky
CO Empire Estates
Empire Court
29-30 Norfolk Place
London
W2 1QH

Revision	Date	Comment

Contents

14 F Avenue Road

1. Introduction

Basement works are intended to the above address. To undertake these works, structural works will be undertaken that require party wall awards.

2. Risk assessment

The purpose of this risk assessment is to consider the impact of the proposed works and how they impact the party wall. There are varying levels of inspection that can be undertaken and not all works, soil conditions and properties require the same level of protection.

Monitoring Level proposed	Type of Works.
Monitoring 4 Visual inspection and production of condition survey by Party wall surveyors at the beginning of the works and also at the end of the works. Visual inspection of existing party wall during the works. Inspection of the footing to ensure that the footings are stable and adequate. Vertical monitoring movement by standard optical equipment Lateral movement between walls by laser measurements	New basements greater than 2.5m and shallower than 4m Deep in gravels Basements up to 4.5m deep in clays Underpinning works to grade I listed building

3. Scheme Details

This document has been prepared by Croft Structural Engineers Ltd. It covers the proposed construction of a new basement underneath the existing structure at 14f Avenue Road.

Scope of Works

The works comprise:

- Visual Monitoring of the party wall
- Attachment of Tell tales or Demec Studs to accurately record movement of significant cracks.
- Attachment of levelling targets to monitor settlement.
- The monitoring of the above instrumentation is in accordance with Appendix A. The number and precise locations of instrumentation may change during the works; this shall be subject to agreement with the Principal Contractor (PC).
- All instruments are to be adequately protected against any damage from construction plant or private vehicles using clearly visible markings and suitable head protection e.g. manhole

rings or similar. Any damaged instruments are to be immediately replaced or repaired at the contractors own cost.
- Reporting of all data in a manner easily understood by all interested parties.
- Co-ordination of these monitoring works with other site operations to ensure that all instruments can be read and can be reviewed against specified trigger values both during and post construction.
- Regular site meetings by the Principal Contractor (PC) and the Monitoring Surveyor (MS) to review the data and their implications.
- Review of data by Croft Structural Engineers

In addition, the PC will have responsibility for the following:

- Review of methods of working/operations to limit movements, and
- Implementation of any emergency remedial measures if deemed necessary by the results of the monitoring.

The Monitoring Surveyor shall allow for settlement and crack monitoring measures to be installed and monitored on various parts of the structure described in Table 1 as directed by the PC and Party Wall Surveyor (PWS) for the Client.

Item	Instrumentation Type
Party Wall Brickwork	
Settlement monitoring	Levelling equipment & targets
Crack monitoring	Visual inspection of cracking,
	Demec studs where necessary

Table 1: Instrumentation

General

The site excavations and substructure works up to finished ground slab stage have the potential to cause vibration and ground movements in the vicinity of the site due to the following:

a) Removal of any existing redundant foundations / obstructions;
b) Installation of reinforced concrete retaining walls under the existing footings;
c) Excavations within the site

The purpose of the Monitoring is a check to confirm building movements are not excessive.

This Specification is aimed at providing a strategy for monitoring of potential ground and building movements at the site.

This Specification is intended to define a background level of monitoring. The PC may choose to carry out additional monitoring during critical operations. Monitoring that is to be carried out is as follows:

a) Visual inspection of the party wall and any pre-existing cracking
b) Settlement of Party Wall

All instruments are to be protected from interference and damage as part of these works.

Access to all instrumentation or monitoring points for reading shall be the responsibility of the Monitoring Surveyor (MS). The MS shall be in sole charge for ensuring that all instruments or monitoring points can be read at each visit and for reporting of the data in a form to be agreed with the PWS. He shall inform the PC if access is not available to certain instruments and the PC will, wherever possible, arrange for access. He shall immediately report to the PC any damage. The Monitoring Surveyor and the Principal Contractor will be responsible for ensuring that all the instruments that fall under their respective remits as specified are fully operational at all times and any defective or damaged instruments are immediately identified and replaced.

The PC shall be fully responsible for reviewing the monitoring data with the MS, before passing onto the Croft Structural Engineers, determining its accuracy and assessing whether immediate action is to be taken by him and/or other contractors on site to prevent damage to instrumentation or to ensure safety of the site and personnel. All work shall comply with the relevant legislation, regulations and manufacturer's instructions for installation and monitoring of instrumentation.

Applicable Standards and References

The following British Standards and civil engineering industry references are applicable to the monitoring of ground movements related to activities on construction works sites:

1. BS 5228: Part 1: 1997 - Noise and Vibration Control on Construction and Open Sites -Part 1.Code of practice for basic information and procedures for noise and vibration control, Second Edition, BSI 1999.
2. BS 5228: Part 2: 1997 - Noise and Vibration Control on Construction and Open Sites -Part 2.Guide to noise and vibration control legislation for construction and demolition including road construction and maintenance, Second Edition, BSI 1997.
3. BS 7385-1: 1990 (ISO 4866:1990) - Evaluation and measurement for vibration in buildings - Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings, First Edition, BSI 1990.
4. BS 7385-2: 1993 - Evaluation and measurement for vibration in buildings - Part 2: Guide to damage levels from ground-borne vibration, First Edition, BSI 1999.
5. CIRIA SP 201 - Response of buildings to excavation-induced ground movements, CIRIA 2001.

SPECIFICATION FOR INSTRUMENTATION

General

The Monitoring Contractor is required to monitor, protect and reinstall instruments as described. The readings are to be recorded and reported. The following instruments are defined:

a) Automatic level and targets: A device which allows the measurement of settlement in the vertical axis. To be installed by the MS.

b) Tell-tales and 3 stud sets: A device which allows measurement of movement to be made in two axes perpendicular to each other. To be installed by the MS.

Monitoring of existing cracks

The locations of tell-tales or Demec studs to monitor existing cracks shall be agreed with Croft Structural Engineers.

Instrument Installation Records and Reports

Where instrumentation is to be installed or reinstalled, the Monitoring Surveyor, or the Principal Contractor, as may be applicable, shall make a complete record of the work, including the position and level of each instrument. The records shall include base readings and measurements taken during each monitoring visit. Both tables and graphical outputs of these measurements shall be presented in a format to be agreed with the CM. The report shall include photographs of each type of instrumentation installed and clear scaled sections and plans of each instrument installed. This report shall also include the supplier's technical fact sheet on the type of instrument used and instructions on monitoring.

Two signed copies of the report shall be supplied to the PWS within one week of completion of site measurements for approval.

Installation

All instruments shall be installed to the satisfaction of the PC. No loosening or disturbance of the instrument with use or time shall be acceptable. All instruments are to be clearly marked to avoid damage.

All setting out shall be undertaken by the Monitoring Surveyor or the Principal Contractor as may be applicable. The precise locations will be agreed by the PC prior to installation of the instrument.

The installations are to be managed and supervised by the Instrumentation Engineer or the Measurement Surveyor as may be applicable.

Monitoring

The frequencies of monitoring for each Section of the Works are given in Appendix A.

The following accuracies/ tolerances shall be achieved:

Party Wall settlement	±1.5mm
Crack monitoring	±0.75mm

REPORT OF RESULTS AND TRIGGER LEVELS

General

Within 24 hours of taking the readings, the Monitoring Surveyor will submit a single page summary of the recorded movements. All readings shall be immediately reviewed by Croft Structural Engineers prior to reporting to the PWS.

Within one working day of taking the readings the Monitoring Contractor shall produce a full report (see below).

The following system of control shall be employed by the PC and appropriate contractors for each section of the works. The Trigger value, at which the appropriate action shall be taken, for each section, is given in Table 2, below.

The method of construction by use of sequential underpins limits the deflections in the party wall. The maximum movement across the length of the party wall must not exceed 5 mm.

Between the trigger points, which are no greater than 2 m apart, there should be no more than 3 mm movement.

During works measurements are taken, these are compared with the limits set out below:

Movement	CATEGORY	ACTION
0mm-7mm	Green	No action required
7mm-12mm	AMBER	Crack Monitoring: Carry out a local structural review; Preparation for the implementation of remedial measures should be required.
>12mm	RED	Crack Monitoring: Implement structural support as required; Cease works with the exception of necessary works for the safety and stability of the structure and personnel; Review monitoring data and implement revised method of works

Table 2 – Movement limits between adjacent sets of Tell-tales or stud sets

Any movements which exceed the individual amber trigger levels for a monitoring measure given in Table 2 shall be immediately reported to the PWS, and a review of all of the current monitoring data for all monitoring measures must be implemented to determine the possible causes of the trigger level being exceeded. Monitoring of the affected location must be increased and the actions described above implemented. Assessment of exceeded trigger levels must not be carried out in isolation from an assessment of the entire monitoring regime as the monitoring measures are inter-related. Where required, measures may be implemented or prepared as determined by the specific situation and combination of observed monitoring measurement data.

Appendix B is explaining how these values are within the allowable and follows the theory from Skempton and MacDonald (1956).

Standard Reporting

1 No. electronic copy of the report in PDF format shall be submitted to the PWS.

The Monitoring Surveyor shall report whether the movements are within (or otherwise) the Trigger Levels indicated in Table 2. A summary of the extent of completion of any of the elements of works and any other significant events shall be given. These works shall be shown in the form of annotated plans (and sections) for each survey visit both local to the instrumentation and over a wider area. The associated changes to readings at each survey or monitoring point shall be then regulated to the construction activity so that the cause of any change, if it occurs, can be determined.

The Monitoring Surveyor shall also give details of any events on site which in his opinion could affect the validity of the results of any of the surveys.

The report shall contain as a minimum, for each survey visit the following information:

a) The date and time of each reading:
b) The weather on the day:
c) The name of the person recording the data on site and the person analysing the readings together with their company affiliations;
d) Any damage to the instrumentation or difficulties in reading;
e) Tables comparing the latest reading with the last reading and the base reading and the changes between these recorded data;
f) Graphs showing variations in crack width with time for the crack measuring gauges; and
g) Construction activity as described. It is very important that each set of readings is associated with the extent of excavation and construction at that time. Readings shall be accompanied by information describing the extent of works at the time of readings. This shall be agreed with the PC.

Spread-sheet columns of numbers should be clearly labelled together with units. Numbers should not be reported to a greater accuracy than is appropriate. Graph axis should be linear and clearly labelled together with units. The axis scales are to be agreed with the PC before the start of monitoring and are to remain constant for the duration of the job unless agreed otherwise. The specified trigger values are also to be plotted on all graphs.

The reports are to include progress photographs of the works both general to the area of each instrument and globally to the main Works. In particular, these are to supplement annotated plans/sections described above. Wherever possible the global photographs are to be taken from approximately the same spot on each occasion. The locations of these points on site are to be Croft Structural Engineers drawing M-10.

Erroneous Data

All data shall be checked for errors by the Monitoring Surveyor prior to submission. If a reading that appears to be erroneous (i.e. it shows a trend which is not supported by the surrounding instrumentation), he shall notify the PC immediately, resurvey the point in question and the neighbouring points and if the error is repeated, he shall attempt to identify the cause of the error. Both sets of readings shall be processed and submitted, together with the reasons for the errors and details of remedial works. If the error persists at subsequent survey visits, the Monitoring Surveyor shall agree with the PC how the data should be corrected. Correction could be achieved by correcting the readings subsequent to the error first being identified to a new base reading.

The Monitoring Surveyor shall rectify any faults found in or damage caused to the instrumentation system for the duration of the specified monitoring period, irrespective of cause, at his own cost.

Trigger Values

Trigger values for maximum movements as listed in Table 2. If the movement exceeds these values then action may be required to limit further movement. The PC should be immediately advised of the movements in order to implement the necessary works.

It is important that all neighbouring points (not necessarily a single survey point) should be used in assessing the impact of any movements which exceed the trigger values, and that rechecks are carried out to ensure the data is not erroneous. A detailed record of all activities in the area of the survey point will also be required as specified elsewhere.

Responsibility for Instrumentation

The Monitoring Surveyor shall be responsible for: managing the installation of the instruments or measuring points, reporting of the results in a format which is user friendly to all parties; and immediately reporting to all parties any damage. The Monitoring Surveyor shall be responsible for informing the PC of any movements which exceed the specified trigger values listed in Table 2 so that the PC can implement appropriate procedures. He shall immediately inform the PWS of any decisions taken.

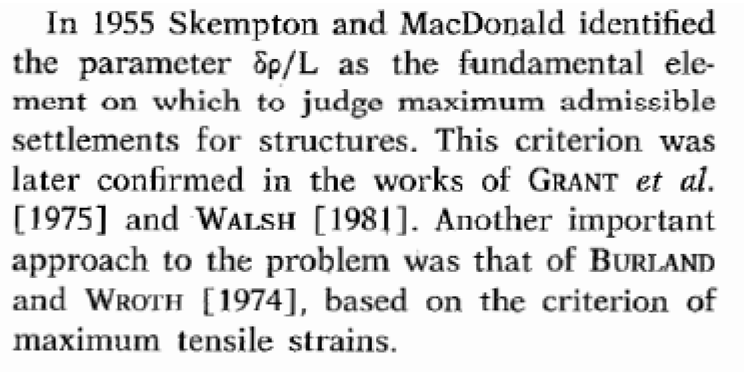
APPENDIX A
MONITORING FREQUENCY

INSTRUMENT	FREQUENCY OF READING
Settlement monitoring and Monitoring existing cracks	**Pre-construction** Monitored once. **During construction** Monitored after every pin is cast for first 4 no. pins to gauge effect of underpinning. If all is well, monitor after every other pin. **Post construction works** Monitored once.

APPENDIX B

An Analysis on allowable settlements of structures (Skempton and MacDonald (1956))

The most comprehensive studies linking self-weight settlements of buildings to structural damage were carried out in the 1950's by Skempton and MacDonald (1956) and Polshin and Tokar. These studies show that damage is most often caused by differential steelments rather than absolute settlements. More recently, similar empirical studies by Boscardin and Cording (1989) and Boone (1996) have linked structural damage to ground movements induced by excavations and tunnelling activities.



In 1955 Skempton and MacDonald identified the parameter $\delta\rho/L$ as the fundamental element on which to judge maximum admissible settlements for structures. This criterion was later confirmed in the works of GRANT *et al.* [1975] and WALSH [1981]. Another important approach to the problem was that of BURLAND and WROTH [1974], based on the criterion of maximum tensile strains.

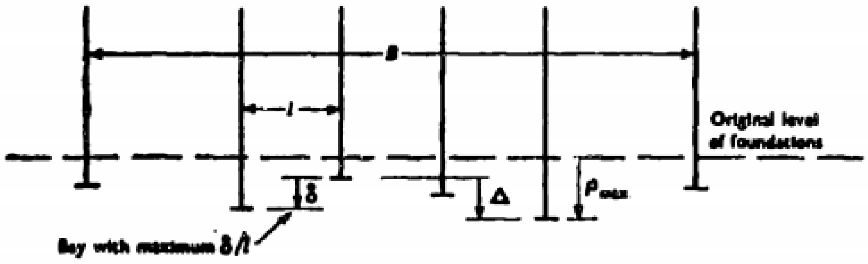


Figure 2.1 – Diagram illustrating the definitions of maximum angular distortion, δ/l, maximum settlement, ρ_{max}, and greatest differential settlement, Δ, for a building with no tilt (Skempton and MacDonald, 1956).

Figure 1: Diagram illustrating the definitions of maximum angular distrortion, δ/l, maximum settlement, pmax, and greatest differential settlement ,Δ , for a building with no tilt (Skempton and MacDonald, 1956)

The differential settlement is defined as the greatest vertical distance between two points on the foundation of a structure that has settled,w hile the angular distortion, is the difference in elevation between two points, divided by the distance between those points.

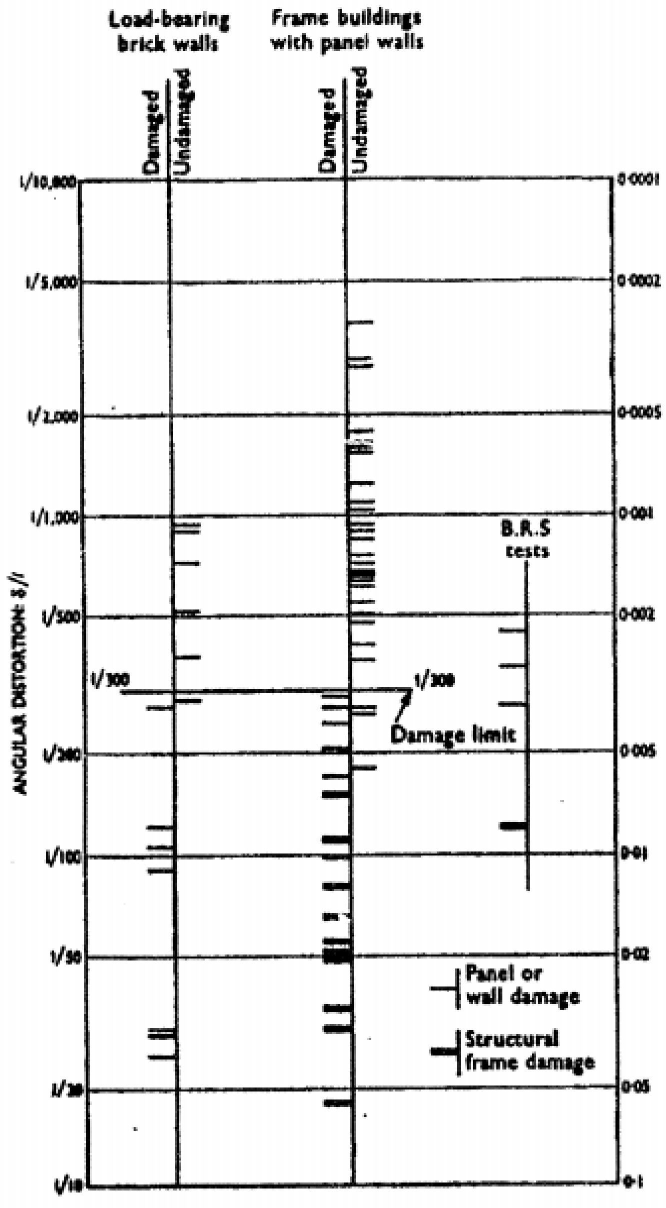
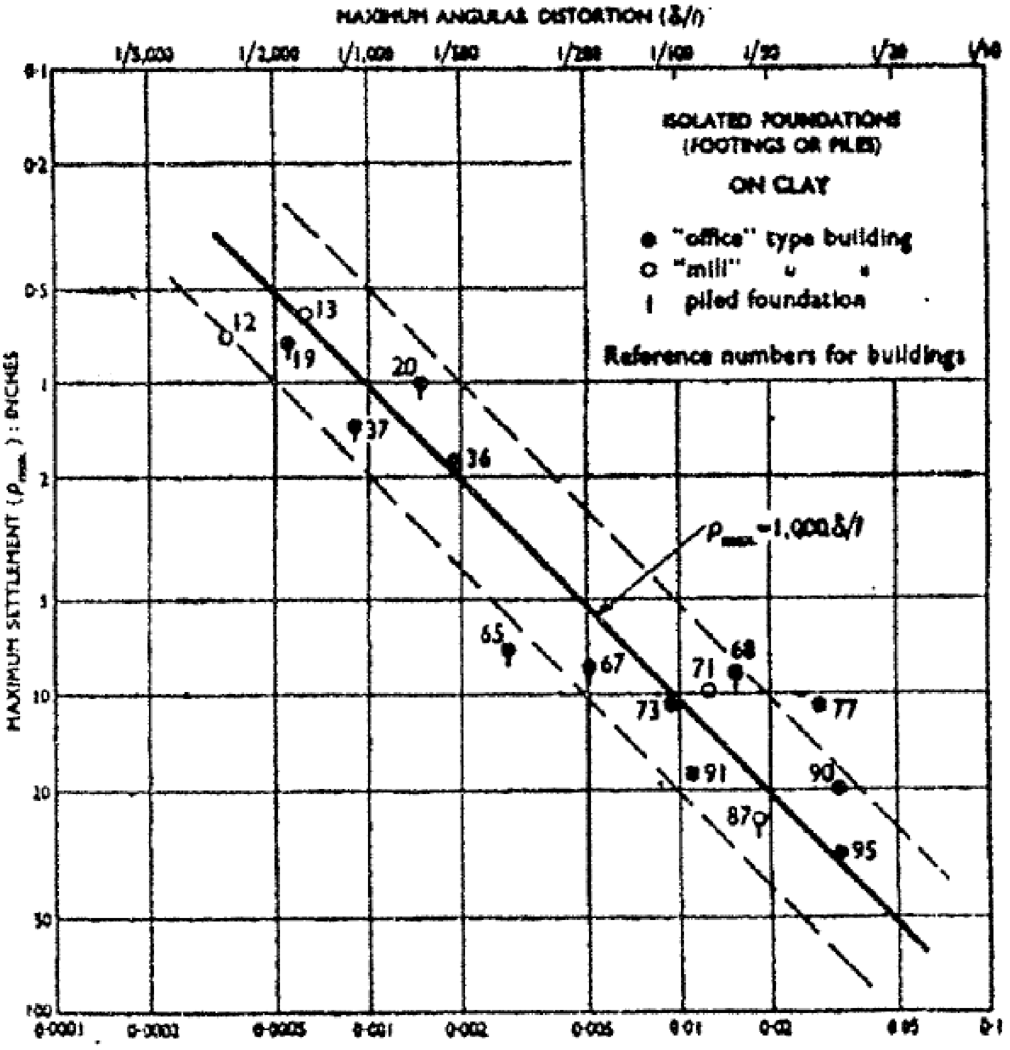
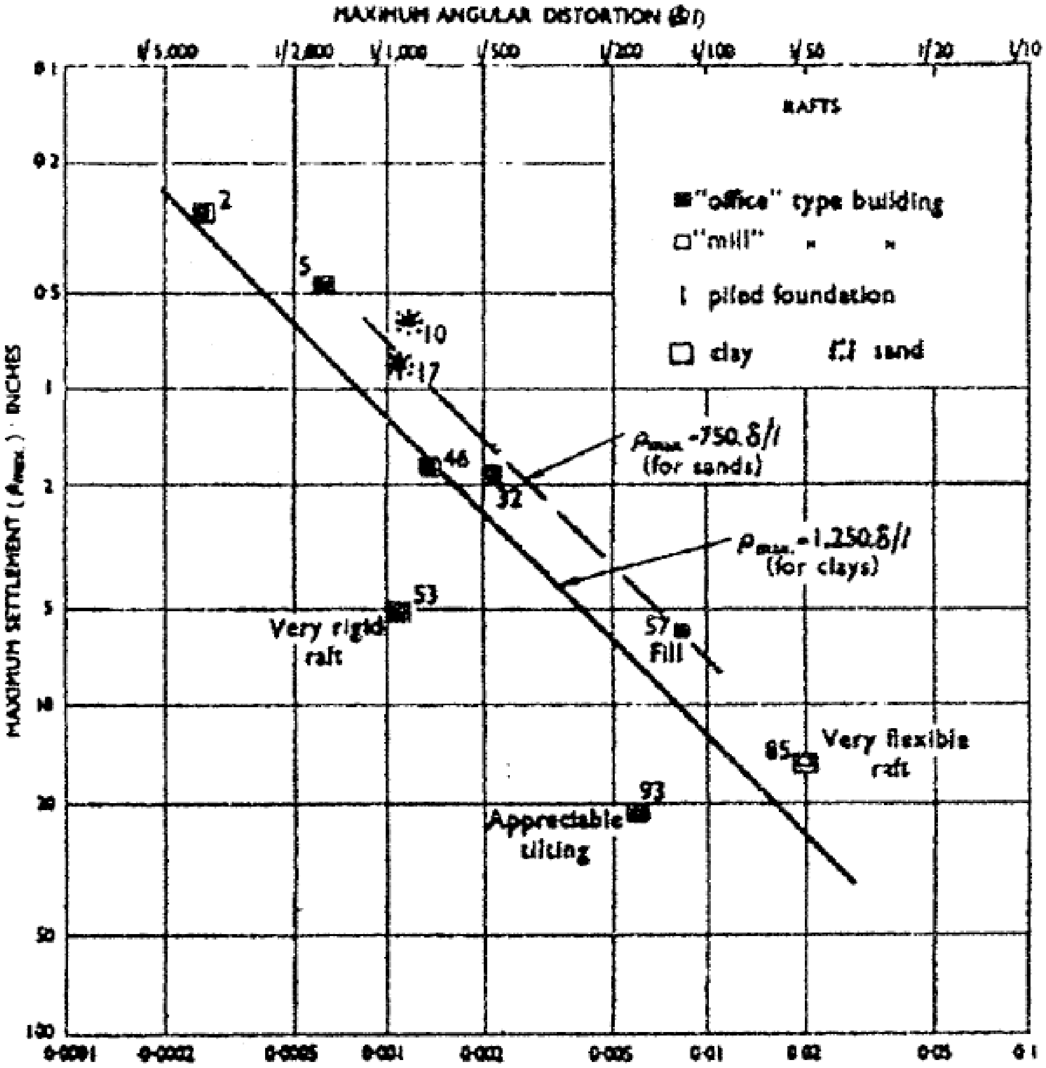


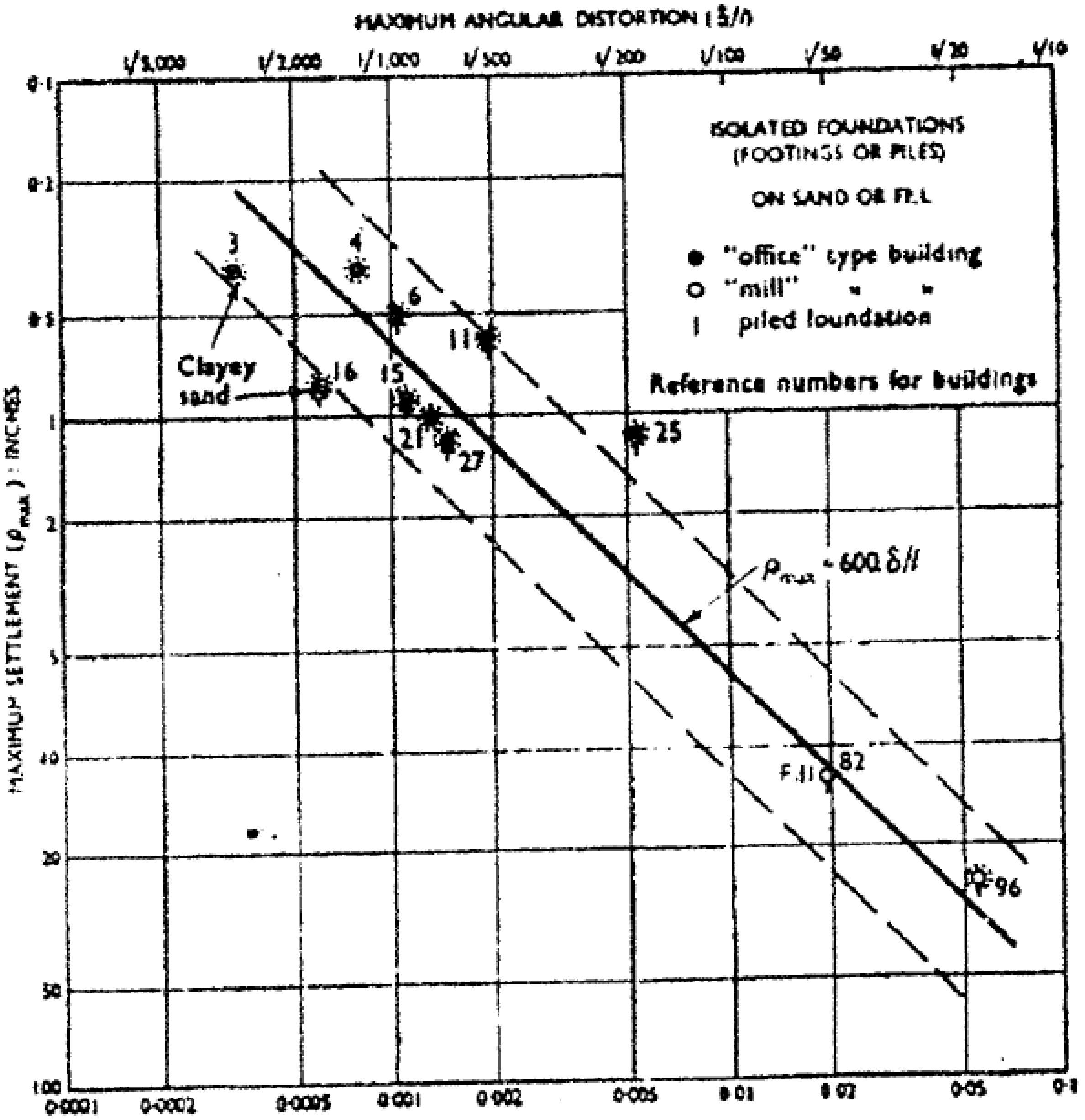
Figure 2: Skempton and MacDonald's analysis of field evidence of damage on traditional frame buildings and loadbearing brick walls

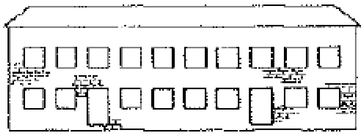
Data from Skempton abnd MacDonald's work suggest that the limiting value of angular distortion is 1/300. Angular distortion, greater than 1/300 produced visible cracking in the majority of buildings studied, regardless of whether it was a load bearing or a frame structure. As shown in the figure 2.

Other key findings by Skempton and MacDonald include limiting values of δ/l for structure, and a relationship between maximum settlement, ρmax and δ/l for structures founded on sands and clays. The charts below show these relations for raft foundations and isolated footings.

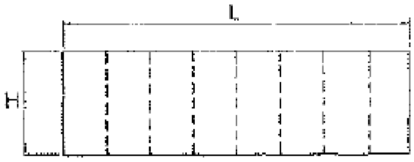



MAXIMUM ANGULAR DISTORTION (δ/l)
1/5,000
1/2,800
1/1,000
1/500
1/200
1/100
1/50
1/20
1/10
RAFTS
■ "office" type building
□ "mill" " "
I piled foundation
□ clay
sand
2
5
10
17
46
32
53
Very rigid raft
57
Fill
85
Very flexible raft
93
Appreciable tilting
ρmax = 750 δ/l (for sands)
ρmax = 1,250 δ/l (for clays)
MAXIMUM SETTLEMENT (ρmax) · INCHES
0·1
0·2
0·5
1
2
5
10
20
50
100
0·0001
0·0002
0·0005
0·001
0·002
0·005
0·01
0·02
0·05
0·1


MAXIMUM ANGULAR DISTORTION (δ/l)
1/5,000
1/2,000
1/1,000
1/500
1/200
1/100
1/50
1/20
1/10
ISOLATED FOUNDATIONS
(FOOTINGS OR PILES)
ON SAND OR FILL
● "office" type building
○ "mill" " "
I piled foundation
Reference numbers for buildings
MAXIMUM SETTLEMENT (ρmax) : INCHES
0·1
0·2
0·5
1
2
5
10
20
50
100
0·0001
0·0002
0·0005
0·001
0·002
0·005
0·01
0·02
0·05
0·1
3
4
6
11
Clayey sand
16
15
21
27
25
ρmax = 600 δ/l
F.II
82
96



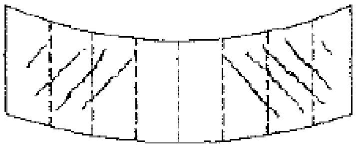
Actual building



Beam - simple idealization of building

Deflected shape of soffit of beam

Bending deformation with cracking due to direct tensile strain



Shear deformation with cracking due to diagonal tensile strain

TABLE I

Angular distorsion	Characteristic situation
1/300	Cracking of the panels in frame buildings of the traditional type, or of the walls in load-bearing wall buildings;
1/150	Structural damage to the stanchions and beams;
1/500	Design limit to avoid cracking;
1/1000	Design limit to avoid any settlement damage.