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GROUND INVESTIGATION REPORT

26 & 27 KING'S MEWS

LONDON WC1

Report Reference No. C13870A

On behalf of:-

1156 Limited
27 King's Mews
London
WC1N 2JB

September 2023

1156 LIMITED

DCL CONSULTING ENGINEERS LIMITED

REPORT ON A GROUND INVESTIGATION

AT

26 & 27 KING'S MEWS

LONDON WC1

Report Reference No. C13870A **September 2023**

INTRODUCTION

1156 Limited, the client, intends to remodel the existing adjacent commercial buildings, Nos.26 & 27 King's Mews, London WC1. The proposed redevelopment will include the construction of a 3.50m deep basement beneath the footprint of the existing No. 26.

Ground Engineering Limited was instructed by the client to review ground investigations undertaken within and adjacent the site, by Ground Engineering Limited and within other reports in the public realm, and produce a ground investigation report under the direction of DCL Consulting Engineers Limited. This report provides comment on the nature and geotechnical properties of the underlying soils in relation to foundation/basement design and construction, and technical information to support the planning application/basement impact assessment (BIA) for the proposed basement beneath No.26, as required by the London Borough of Camden Planning Guidance 'Basements' document (2021).

This review was also informed by a desk study provided by the client (Ref. MES/2309/DCL004, September 2023).

LOCATION, TOPOGRAPHY, GEOLOGY AND HYDROGEOLOGY OF THE SITE

Location/Description

Nos.26 & 27 King's Mews are situated on the eastern side of the road, some 35m north of its junction with Theobald’s Road, and 25m west of Gray's Inn Road, within the Bloomsbury district of the London Borough of Camden, London WC1. The site is centred at approximate National Grid Reference TQ 30940 81998.

The approximately 14m long and 12m wide rectangular site extends eastwards from its frontage on King's Mews roadway. At the time of the investigation the adjoining pair of two-storey (No.26) and four-storey with basement (No.27), brick buildings occupied the whole of the plot.

The plot was bounded to the north and south by Nos.25 & 28 King's Mews, respectively, and to the east by Nos.1 to 16 The Lincolns.

The site and immediate surrounding area was devoid of vegetation.

Topography

The site stands at an approximate elevation of 20.5mOD on locally gently northward and eastward falling ground, some 1.25km north of the eastward flowing River Thames.

Geology

The 1936 geological map for the area at 1:10,560 scale is based on the 1920 Ordnance Survey London Sheet V SW and shows the site to be covered by Taplow Gravel and underlain by the solid geology of the London Clay. This map also shows the culverted course of the River Fleet, flowing southwards, some 625m east of the site.

The 2006 geological map for the area at 1:50,000 scale, Sheet 256, also shows the site to be covered by the renamed superficial Lynch Hill Gravel Member and underlain by the solid geology of the London Clay Formation.

Well records on the 1936 geological map indicate that the surface cover of made ground and superficial deposits are together about 5m thick beneath this part of London.

Previous ground investigations adjacent the site in Nos.25 and 28 King's Mews, confirmed the presence of 3.60m to 4.00m of made ground, underlain by sand and gravel, and then the London Clay at 5.10m to 6.00m below ground level. The latter was found to at least 25m depth, and groundwater was recorded at about 4.00m below ground level.

<u>Hydrogeology</u>

The site is designated by the Environment Agency (EA) as being underlain by a Secondary (A) Aquifer, the Lynch Hill Gravel, which overlies the Unproductive stratum of the London Clay. Based on the local topography and geology of the site area, the direction of near surface groundwater and surface water flow would be expected to be from west to east, towards the culverted River Fleet.

Well records on the 1936 geological map indicate that the practically impervious Unproductive stratum of the London Clay Formation is 12m to 15m thick beneath this part of London and that the underlying Principal Aquifer of the White Chalk Subgroup lies about 40m below ground level, about -18mOD.

SITE WORK

A single borehole was undertaken at the position depicted on the site plan at the rear of this report. Services information was obtained and referenced in relation to the exploratory hole positions prior to boring/excavation.

The investigation was undertaken following the protocols detailed in British Standards (BS) 'Code of Practice for Site Investigations' (BS5930:2015) and 'Methods of test for soils for engineering purposes' (BS1377:1990).

Borehole

A single borehole (BH A) was undertaken by a restricted access, low headroom cable percussive rig within No. 27 King's Mews on 9th June 2016. The final borehole position was chosen following a scan using a cable avoidance tool (CAT). The concrete floor slab was cored using electrically powered diamond drilling equipment at 250mm diameter, and a starter pit was hand dug to 1.20m depth in order to confirm the absence of buried services.

The borehole was then advanced using weighted claycutter and shell tools, initially working within 150mm diameter casing. Water was added to enable drilling of coarse grained soils. Borehole BH A was completed at the intended depth of 15.00m below ground level.

Standard penetration tests were undertaken in the borehole within made ground and coarse grained soils in order to give an indication of the in-situ relative density/shear strength of the material. The test was made by driving a 50mm diameter solid cone (C) into the soil at the base of the borehole by means of an automatic trip hammer weighing 63.50kg falling freely through 750mm. The penetration resistance was usually determined as the number of blows required to drive the tool the final 300mm of a total penetration of 450mm into the soil ahead of the borehole. Where the full penetration was not achieved the actual penetration and the number of blows were recorded. The results have been tabulated and added to the borehole record.

Undisturbed samples (U) nominally 100mm in diameter were taken in clay. The ends of the samples were capped and sealed to maintain them in as representative condition as possible during transit to the laboratory.

Representative disturbed samples of soil were taken from the boring tools at regular intervals throughout the depth of the borehole and placed in polycarbonate pots/small plastic bags (D samples) and large plastic bags (B samples).

On completion of borehole BH A, a 50mm diameter standpipe was installed to 7.00m below ground level, with a gravel response zone up to 1.00m below ground level. Above the response zone to this installation, the borehole was backfilled with bentonite, whilst the hole beneath the installation was infilled with clean arisings. A protective stopcock cover was concreted into the ground flush with the surface over the top of the installation.

The borehole record gives the descriptions and depths of the various strata encountered, results of the in-situ tests, details of all samples taken, installation details and the groundwater conditions observed during boring, on completion and subsequently in the standpipe. Excess spoil was removed from site and disposed of at a licenced facility.

Gas and Groundwater Monitoring

A single return visit was made on 30th June 2016 in order to monitor methane, carbon dioxide and oxygen gas levels in the borehole standpipe. Ambient pressures and flow rates were recorded together with the depth to groundwater. The water level has been added to the borehole record, whilst the gas/groundwater results are presented following the exploratory hole record.

A sample of groundwater was recovered from the borehole standpipe during the monitoring visit, placed in a plastic bottle, and transported directly to the analysing laboratory.

LABORATORY TESTING

The samples were inspected in the laboratory and assessments of the soil characteristics have been taken into account during preparation of the exploratory hole records. The soil sample descriptions are in accordance with BS5930:2015.

The geotechnical tests were conducted to BS1377:1990 and other industry standards, and the results are presented following the exploratory hole records.

Geotechnical Testing

The particle size distribution of selected samples were obtained by sieve analysis. The results of these tests are given as particle size distribution curves at the end of this report.

Selected test specimens were prepared at full diameter from the undisturbed samples recovered from the borehole. An immediate undrained triaxial compression test was made on each sample at a single cell pressure approximately equivalent to the overburden pressure for that sample's depth. The results have been plotted against depth in Figure 1. The moisture content and bulk densities of these specimens were also determined.

Selected samples of soil were analysed to determine the concentration of soluble sulphates. The pH values were also determined using an electrometric method.

GROUND CONDITIONS

The ground conditions encountered in the borehole were as expected from the known history of the site and geological records with a significant thickness of made ground covering the Lynch Hill Gravel at 3.30m below ground level. This superficial deposit was underlain by the solid geology of the London Clay at 5.90m depth. The latter was found to at least 15.00m depth in the completed BH A. A standing water level was subsequently recorded in the borehole standpipe at 3.04m below ground floor level.

Made Ground

The concrete floor slab was 0.30m thick and was underlain by coarse grained made ground. The latter was generally a very loose, dark brown, slightly clayey, ashy sand and gravel with occasional brick cobbles. The gravel fraction consisted of brick, concrete, ash, flint, mortar, slate and fragments of bone, glass and pottery.

The base of the coarse grained fill was proved at 3.30m below ground level.

Lynch Hill Gravel

The superficial Lynch Hill Gravel was met beneath the made ground at 3.30m and was initially a medium dense, orange brown, silty sand and gravel, with a gravel fraction of angular to sub-rounded flint. Below 4.00m depth the Lynch Hill Gravel became very dense and slightly silty, and this stratum was proved to 5.90m depth in BH A, a recorded thickness of 2.60m, which was consistent with nearby well and borehole records.

London Clay

The solid geology of the London Clay was reached at 5.90m depth and was initially reworked to a stiff, brown, slightly gravelly, silty clay with a gravel fraction of sub-angular to rounded flint. This reworked horizon was 0.50m thick and was followed by a stiff, closely fissured, grey brown clay with occasional silt partings and rare gravel size pyrite nodules. The London Clay became silty below 10.00m depth, and then below 13.00m below ground level was a very stiff, grey brown, slightly sandy, silty clay with occasional silt and fine sand partings, and rare gravel size pyrite nodules. The London Clay was found to at least 15.00m below ground level where the borehole was completed.

Groundwater

The addition of water to enable boring of the Lynch Hill Gravel from 3.60m to 4.00m depth in BH A will have masked any initial water ingress within this stratum, but water was recorded by the driller as being met at 4.00m and rose to 3.60m in the fifteen minutes before drilling resumed. This water was sealed out of the borehole once the casing entered the underlying London Clay, and the 15.00m deep borehole was 'damp' on completion.

The water level recorded in the 7.00m deep standpipe three weeks after installation was 3.04m below ground level.

COMMENTS ON THE GROUND CONDITIONS IN RELATION TO FOUNDATION DESIGN AND CONSTRUCTION

The investigation found a significant thickness of made ground beneath the existing building (No.26), which is bounded to the north (No.25) and south (No.27) by similar existing basements. Foundations for the new 3.50m deep basement will need to penetrate this made ground to reach the top of the underlying medium dense becoming very dense Lynch Hill Gravel, which was met at 3.30m, a minimum of 2.50m above the interface with the underlying stiff solid geology London Clay. A standpipe water level was recorded at 3.04m below the ground level, above the proposed basement floor level. This water level is considered to reflect the depth of 'perched' groundwater within the superficial Lynch Hill Gravel.

Foundations for the envisaged basement will need to penetrate the made ground and be based within the medium dense becoming very dense Lynch Hill Gravel. Existing shallow foundations will need to be underpinned to the same level as the adjacent basements, which should be feasible using traditional underpinning techniques.

Foundation Depths

The exploratory hole encountered natural ground at 3.30m depth within this site although it may locally be expected to lie at slightly greater depths, as previously found beneath the adjacent sites where up to 4.00m of made ground was encountered.

The underlying Lynch Hill Gravel may be regarded as a non-shrinkable stratum. The top of the high volume change potential London Clay was recorded at 5.90m below street level and so will be well below the depth affected by tree root-induced desiccation.

Foundations will need to be taken down through the made ground and into the top of the medium dense, becoming very dense Lynch Hill Gravel, which was met at 3.30m below ground level within this small site. The 3.50m deep proposed basement floor level should therefore be within the top of this stratum.

Bearing Pressure/Capacity

The construction of a 3.50m deep basement on this site should remove most, if not all, of the made ground as its foundations will reach the underlying sand and gravel at 3.30m depth. With a minimum of 1.90m of sand and gravel remaining between the base of the made ground and the top of the London Clay, the superior bearing properties of the Lynch Hill Gravel can be utilised during the design of strip or pad foundations for the proposed basement walls.

The results of the in-situ standard penetration tests indicate that an allowable bearing pressure of $300kN/m^2$ could be applied on 1.00m wide foundations cast at a basement excavation level of 3.50m on the Lynch Hill Gravel. Such a pressure would not overstress the underlying stiff London Clay.

A bearing pressure of $300kN/m^2$ should be more than sufficient to support the likely foundation pressures for the new structure and for adjacent foundations underpinned to the same depth as the proposed and adjacent existing basements.

Basement

The construction of a 3.50m to 4.00m deep basement will remove the made ground. Foundations for the basement walls just below the new basement floor level would be within the very dense Lynch Hill Gravel and could be designed using the previously detailed bearing parameters.

Alternatively a basement raft foundation could be considered for this structure, although it's design would need to take into account the bearing properties of the underlying London Clay. A conservative net safe bearing capacity of $150kN/m^2$, which incorporates a factor of safety of 3.0, could be used for the design of a 6.00m wide raft foundation at 3.50m below existing ground level.

It is estimated that theoretical base heave at the centre of a 12m long and 6m wide, 3.50m deep unconfined basement excavation would be in the order of 15mm, based on the proposed basement dimensions and typical parameters for the underlying London Clay. However, with a minimum of 1.90m of Lynch Hill Gravel remaining below the proposed underside of the 3.50m to 4.00m deep basement floor slab, little, if any, base heave would be expected following the removal of about 65kN/m^2 of overburden pressure within the basement, as any heave would dissipate between inter-grain contacts within the Lynch Hill Gravel.

A likely basement raft loading is unknown but if it were the 65kN/m^2 of removed overburden pressure then no net heave/settlement would be expected. Raft loadings greater than 65kN/m^2 could result in net settlement, whilst conversely loads lower than 65kN/m^2 could result in net heave, although as detailed above this is considered unlikely. Net differential heave/settlement will need to be taken into account in the design of the basement floor. The advice of specialists should be sought in this regard.

Excavations/Groundwater

The excavation of the basement to between 3.50m and 4.00m below existing ground floor level will require the construction of close support to its sides, the control of groundwater, and the need to avoid undermining adjacent structures.

The use of mass concrete basement walls, constructed in alternate panels around the perimeter of the basement could provide support, a limited cut-off to 'perched' water and reduce the scale of any dewatering required within the basement excavation.

An alternative would be to use sheet, contiguous or secant piled walls around the perimeter of the basement, although this may well be problematical on this relatively small restricted access site, which already has adjacent basement walls on its northern and southern sides. Piling to a sufficient depth to mobilise adequate passive pressure below the basement level should be feasible on this site.

The excavation of a 3.50m deep basement could then be undertaken within the mass concrete or piled walls, although it should be noted that mass concrete, contiguous and sheet pile lined excavations may not be water tight.

In order to construct the basement beneath this site it will be necessary to provide permanent support to the adjacent structures, some of which are based on deepened strip and underpinned foundations, whilst others are supported by basement walls. This support can either be provided by underpinning these structures to the same depth as the proposed basement prior to basement construction or by constructing piled walls to the excavation that are adequately propped during construction by temporary support and permanently by the basement and ground floors, to prevent movement at the top of the retaining walls.

Such lateral movement would otherwise be accompanied by settlement of the ground behind the basement walls. CIRIA report C760 'Guidance on Embedded Retaining Wall Design' (2017) indicates very small scale horizontal and vertical movements resulting from the construction of a secant piled wall, as does the use of high support stiffness (high propped walls and top down construction) to the basement excavation. Provided that such a very stiff bracing system is used to prevent deflection of the proposed basement walls, and that the neighbouring structures are of robust construction, the anticipated level of structural damage, if any, would fall within Category 1 'very slight' as described in Table 6.4 of the aforementioned CIRIA document.

The advice of specialist groundworks contractors with experience of constructing such basements should be sought, particularly in respect of other potential methods of providing support to the sides of the basement excavation on this small site.

The basement excavation should be inspected on completion to ensure that the condition of the soil complies with that assumed in design. Should pockets of inferior material be present, they should be removed and replaced with well graded hardcore or lean mix concrete. The excavated surface should be protected from deterioration and a blinding layer of concrete used where foundations are not completed without delay.

The recorded standpipe groundwater level of 3.04m would be just above the proposed floor level of 3.50m, and so potential flotation should not be a problem.

As the water level was recorded above the level of the proposed basement it will be necessary to waterproof the basement in order to prevent the ingress of ‘perched’ water and downward percolating surface water into the completed structure.

Safety precautions should not be neglected especially where personnel are to enter excavations, when close side support will be required in order to maintain excavation stability. All excavations should be undertaken in accordance with CIRIA Report 97 ‘*Trenching Practice*’. This is especially important on this site as excavations are unlikely to stand unsupported even in the short term.

Care should also be taken to ensure that the proposed retaining walls of the basement are not surcharged with plant and equipment or the stockpiling of materials and excavated soils outside of the basement excavation.

Piled Foundations

In the unlikely event that piled foundations are preferred due to practical or economic considerations related to the construction of the basement and underpinning foundations on this site, the ground conditions are considered suitable for bored or CFA, but not driven piles as the vibrations during installation of driven piles could damage the existing dwelling and adjacent structures. The advice of specialist piling contractors should be sought as to their preferred method of pile installation in these conditions on this restricted access site and their attention drawn to the very dense nature of the Lynch Hill Gravel, and the possible presence of concretionary limestone nodules within the London Clay beneath the site.

Preliminary working loads for a single bored pile may be estimated for design and cost purposes using pile bearing coefficients, which are based on the following assumptions.

1) The ultimate load on a pile would be the sum of the side friction/adhesion acting on the pile shaft together with the end bearing load.

2) The pile bearing properties within the depth of the proposed basement have been ignored.

3) The shaft friction of a pile within sand and gravel would be a function of the SPT 'N' values and the overburden pressure. The groundwater level was recorded at about 3.00m depth. End bearing within the very dense Lynch Hill Gravel should not be considered.

4) In the London Clay the shaft adhesion and end bearing would be a function of the lower bound average of the apparent cohesion values determined by triaxial compression strength tests (Figure 1).

5) A factor of safety of at least 2.0 would be used to assess pile working loads. If test loading of selected piles were not practical the factor of safety would be increased to at least 2.5.

Item	**Ultimate Pile Bearing Value kN/m^2**
Shaft adhesion/friction in ground to about 4m	Ignored
Average shaft adhesion in Lynch Hill Gravel	20
Average shaft adhesion in London Clay to 10m	50
Average shaft adhesion in London Clay, 10m to 15m	60
End bearing in London Clay above 10m	900
End bearing in London Clay at 10m	1125

Using these coefficients it is estimated that a single, 300mm diameter bored pile installed to 10m below ground level would have an anticipated working load of 125kN, with a factor of safety of 2.5. Different pile lengths, or diameters, from those detailed above would give different available working loads, which could be tailored to suit the working loads required.

The design of piled foundations on this site will also need to take into account potential tensile stresses in the piles during basement construction where the net change in load is to be reduced.

A piling specialist should undertake the final design of piles.

Retaining Walls

The walls of the proposed basement will act as retaining walls and will need to be designed accordingly. For a permanent retaining wall analysis effective stress parameters would be appropriate, however, in the absence of effective stress testing on samples from this site, published parameters, previous experience and in-situ test results could be used as a conservative approach.

The design of retaining walls around the basement area may be based on the following stress parameters:

Soil Type	Bulk Density (Mg/m^3) γ_B	Effective Shear Strength (kPa) c'	Angle of Shearing Resistance (degrees) ϕ'
Made Ground	1.80	0	28
Lynch Hill Gravel	2.10	0	36
London Clay	2.00	0-2	22

Buried Concrete

Sulphate analysis of the soil samples tested gave results in Design Sulphate Classes DS-1, DS-2 and DS-3 of the BRE Special Digest 1, Table C2 (2005) presented in Appendix 1. The pH results were between 6.7 and 7.4 and so slightly acidic to alkaline. The highest DS-3 results were obtained within the made ground.

The London Clay is listed in this publication as being a stratum that may contain sulphides, such as pyrite, hence oxidation due to disturbance during the excavation of foundations may increase the total potential sulphate content. Visual evidence of pyrite was recorded within the London Clay beneath this site. It should be noted that the use of piled foundations would minimise disturbance of the ground and consequently reduce the potential for the oxidation of any pyritic clay. Pile arisings should not be re-used and placed against foundations.

Using the sulphate and pH results an Aggressive Chemical Environment for Concrete (ACEC) Class of AC-3 would be considered appropriate for buried concrete beneath this site as detailed in the previously cited BRE document.

Slope Stability

The ground within which the level plot is located slopes down gently to the north/north-east and falls from 22.7mOD near the southern end of the parallel John Street to 19.9mOD near the junction of Gray's Inn Road and Northington Street, 100m distant. This is a slope angle of less than 1 degree and hence this slope is not marked on Figure 16 of the London Borough of Camden 'Guidance for subterranean development' (2010), which indicates slopes of greater than 7 degrees.

There is no evidence of historical slope instability, nor would it be expected based on the topography of the immediate surrounding area.

On this site it is considered unlikely that the proposed basement development will induce slope instability.

Other Issues

The basement development beneath this site would only be considered likely to affect the drainage system of the site itself. However, drainage and sewerage records for the surrounding buildings will need to be referenced, if available, or perhaps surveyed to confirm that the site does not share a communal drainage system that runs beneath the site.

The flow of surface water within the surrounding area, from south to north/north-east, should not be changed by the proposed basement on this small site.

As previously described, 'perched' groundwater was recorded within the basal part of the made ground beneath this site at 3.04m below ground level. The proposed 3.50m to 4.00m basement excavation depth therefore does extend below the 'perched' groundwater level. However, little displacement of groundwater will take place by its exclusion from beneath the area of the proposed basement and footings, so little or no rise would be expected in the level at which groundwater currently stands adjacent to the site.

The orientation of the small proposed basement, when considered together with the adjacent existing basements to the immediate north and south of the site, would be across the likely direction of near surface groundwater flow from south to north-north-east on this very gently sloping ground. However, as the proposed 3.50m deep basement does not extend greatly below the recorded 'perched' groundwater level, it is considered that the drainage path will not be substantially increased.

SOIL GAS MONITORING RESULTS

A single return visit to site recorded concentrations of landfill type gasses (methane, carbon dioxide and oxygen), in the BH A standpipe installation. The results are presented to the rear of the exploratory hole record. The recorded concentration of methane was less than 0.1%. The carbon dioxide level was 3.1%. The recorded oxygen concentration within the standpipe was slightly depleted when compared to atmospheric conditions. The in-situ measurement confirmed a gas emission flow rate of <0.1l/hr.

Assuming a 'worst case' positive flow rate of 0.1l/hr, the carbon dioxide result gives a Gas Screening Value (GSV) of 0.0031l/hr. This GSV falls within Characteristic Situation 1 as defined by BS8485:2015+A1:2019 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings', and so no special precautions are required to protect the proposed redevelopment from ingress of soil gases.

GROUND ENGINEERING LIMITED

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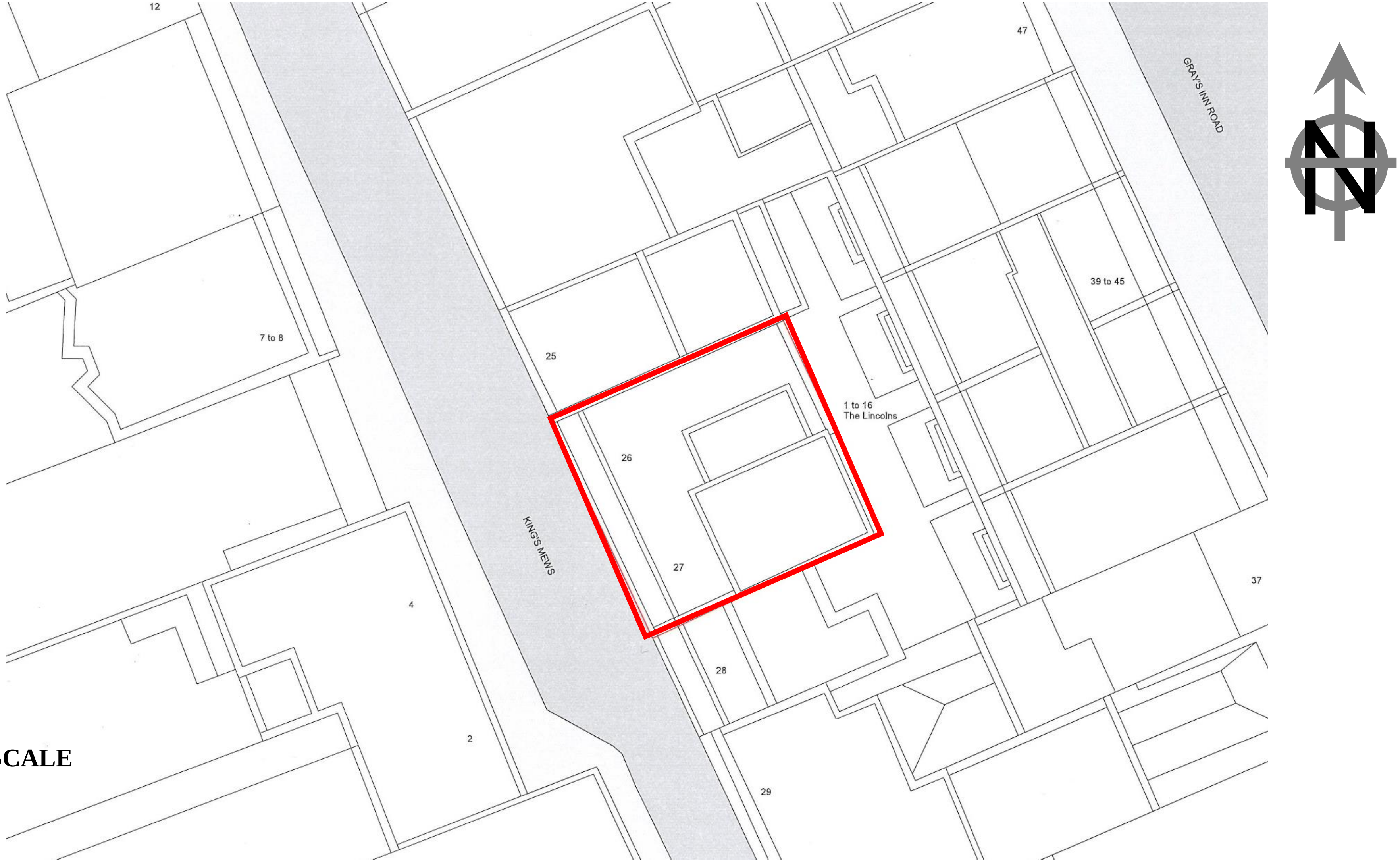
Site Location Plan

Based on a proposed development plan provided by the Engineer



NOT TO SCALE

Project	**26 & 27 King's Mews, London WC1**	**GROUND ENGINEERING LIMITED**	**Project No.**
Client	**1156 Limited**	Peterborough Tel : 01733 566566	**C13870A**

Borehole Location Plan

Based on a plan provided by the Engineer

Key

Borehole

NOT TO SCALE

Project: 26 & 27 King's Mews, London WC1	**GROUND ENGINEERING LIMITED** Peterborough Tel : 01733 566566
Client: 1156 Limited	**Project No.** C13870A

GROUND ENGINEERING LIMITED
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Site: 26 & 27 KING'S MEWS, LONDON WC1

BOREHOLE BHA

Date: 09/06/16

Hole Size: 150mm dia to 15.00m

Ground Level:

Depth m	Type	Blows	(Date) Casing	Description of Strata	Depth m	O.D. Level m
				MADE GROUND - CONCRETE.	0.30	
0.30-1.00	B1			MADE GROUND - Very loose, dark brown, slightly clayey SAND AND GRAVEL with occasional brick cobbles. Gravel of brick, concrete, ash, flint, quartzite, clinker and porcelain.		
1.20-1.70	B2					
1.35-1.65	C	N1				
2.00-2.50	B3					
2.15-2.45	C	N3	1.50			
3.00-3.30	B4					
3.04	W1					
3.15-3.45	C	N28	3.00		3.30	
3.30-3.60	B5			Medium dense, orange brown, silty SAND AND GRAVEL. Gravel of angular to sub-rounded flint. (LYNCH HILL GRAVEL MEMBER)	4.00	
4.20-4.70	B6			Very dense, orange brown, slightly silty SAND AND GRAVEL. Gravel of angular to rounded flint.		
4.35-4.54	C	50*	4.20			
5.00-5.50	B7			(LYNCH HILL GRAVEL MEMBER)		
5.15-5.41	C	50*	5.00		5.90	
5.90-6.20	B8			Stiff, brown, slightly gravelly, silty CLAY. Gravel of sub-angular to rounded flint. (REWORKED LONDON CLAY)		
6.20-6.60	U1	60	6.10		6.40	
6.60	D1			Stiff, closely fissured, grey brown CLAY with occasional silt partings and rare gravel size pyrite nodules.		
7.00-7.45	U2	55	6.10			
7.45	D2					
8.00	D3			(LONDON CLAY FORMATION)		
8.50-8.95	U3	50	6.10			
8.95	D4					
9.50	D5					
10.00-10.45	U4	70	6.10		10.00	

Inst.: BENEATH INSTALLATION

REMARKS
1. Floor slab cored using diamond drilling equipment
2. Excavating a pit from 0.00m to 1.20m for 1.50 hours
3. Water added from 3.60m to 4.00m
4. Borehole cased to 6.10m depth
5. Gas monitoring standpipe installed to 7.00m depth

Project No 13870A

Scale 1:50

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KEY
D - Disturbed Sample
B - Bulk Sample
U - Undisturbed Sample
W - Water Sample
S/C - SPT Spoon/Cone
▽ Water Strike
▼ Water Rise
N/* - SPT Blows for 0.3m or given penetration
ES - Environmental Sample
V - Vane Shear Test Cohesion ( ) kPa
▼c Level on completion
c▼w Level casing withdrawn
▼s Standpipe Level

Groundwater Strikes						Groundwater Observations			
No	Struck	Rose to	Rate	Cased	Sealed	Date	Hole	Casing	Water
1	4.00	3.60	medium	4.00	6.10	09/06/16	15.00	6.10	damp
						30/06/16	7.00	1.00	3.04

GROUND ENGiNEERiNG LIMITED Tel: 01733-566566 www.groundengineering.co.uk	Site: 26 & 27 KING'S MEWS, LONDON WC1		BOREHOLE BHA
	Date: 09/06/16	Hole Size: 150mm dia to 15.00m	Ground Level:

Samples and in-situ Tests: Depth m	Type	Blows	(Date) Casing	Inst.	Description of Strata	Legend	Depth m	O.D. Level m
				BENEATH INSTALLATION	Stiff, closely fissured, grey brown, silty CLAY with rare gravel size pyrite nodules.		10.00	
10.45	D6			BENEATH INSTALLATION				
11.00	D7			BENEATH INSTALLATION				
11.50-11.95	U5	70	6.10	BENEATH INSTALLATION	(LONDON CLAY FORMATION)			
11.95	D8			BENEATH INSTALLATION				
12.50	D9			BENEATH INSTALLATION				
13.00-13.40	U6	80	6.10	BENEATH INSTALLATION			13.00	
				BENEATH INSTALLATION	Very stiff, grey brown, slightly sandy, silty CLAY with occasional silt and fine sand partings, and rare gravel size pyrite nodules.			
13.40	D10			BENEATH INSTALLATION				
14.00	D11			BENEATH INSTALLATION	(LONDON CLAY FORMATION)			
14.50-14.95	U7	75	6.10	BENEATH INSTALLATION				
15.00	D12			BENEATH INSTALLATION			15.00	
					Borehole completed at 15.00m depth			

REMARKS

Project No 13870A

Scale 1:50

Page 2/2

KEY
- D - Disturbed Sample
- B - Bulk Sample
- U - Undisturbed Sample
- W - Water Sample
- S/C - SPT Spoon/Cone
- ▽ Water Strike
- ▼ Water Rise
- N/* - SPT Blows for 0.3m or given penetration
- ES - Environmental Sample
- V - Vane Shear Test Cohesion ( ) kPa
- ▼c Level on completion
- c▼w Level casing withdrawn
- ▼s Standpipe Level

Groundwater Strikes						Groundwater Observations			
Depth m							Depth m		
No	Struck	Rose to	Rate	Cased	Sealed	Date	Hole	Casing	Water

GROUND ENGINEERING LIMITED

Results of Standard/Cone Penetration Tests

C13870A - 26 & 27 King's Mews, London WC1

BH.No.	Depth (m)	Casing Depth (m)	Depth to Water (m)	Type of Test *	Seating Drive Blows /Penetration (mm)	Test Drive: 300mm. Blows for each successive 75mm penetration				N Value	Extra-polated N Value
BHA	1.20-1.65			C	0 / 150	1	0	0	0	1	
	2.00-2.45	1.50		C	1 / 150	1	0	1	1	3	
	3.00-3.45	3.00		C	12 / 150	10	7	6	5	28	
	4.20-4.54	4.20	3.60	C	16 / 150	15	20	15/35			
	5.00-5.41	5.00	4.30	C	10 / 150	12	12	18	8/30		

*** C denotes test using a solid cone**
S denotes test using a split barrel sampler

Groundwater/Gas Monitoring Record **GROUND ENGINEERING LIMITED**

Site: 26 & 27 King's Mews, London WC1

Report Ref: C13870A

Date	Borehole	Methane (% v/v)		Carbon Dioxide (% v/v)		Oxygen (% v/v)		Flow Rate (l/hr)	Atmosph. Pressure (mb)	Depth of Well (m)	Depth to Groundwater (m)
		Peak	Steady	Peak	Steady	Min.	Max.				
30/06/16	BH A	<0.1	<0.1	3.1	3.1	16.9	16.9	<0.1	1002	7.00	3.04#

- Water samples recovered.

LABORATORY TEST RESULTS

CONTRACT 26 & 27 KING'S MEWS, LONDON WC1

Borehole	Sample	Depth m	Classification: Liquid Limit %	Plastic Limit %	Plasticity Index %	Moisture Content %	Density: Bulk Mg/m^3	Dry Mg/m^3	Triaxial Compression: Type	Principal Stress Difference kPa	Cell Pressure kPa	Shear Strength kPa	Angle of Shear Resistance degrees	Sulphates (SO_4): Soil Total % Dry Wt.	Soil Aqueous Extract mg/l	Water mg/l	pH	Remarks
BHA	B2	1.20 - 1.70													1539		6.7	
	B4	3.00 - 3.30													2478		7.4	
	B8	5.90 - 6.20													337		7.4	
	U1	6.20 - 6.60				31	1.96	1.49	Q	183	130	91	0					
	U2	7.00 - 7.45				25	2.05	1.64	Q	228	150	114	0					
	U3	8.50 - 8.95				31	1.97	1.51	Q	178	180	89	0		710		7.4	
	U4	10.00 - 10.45				27	2.01	1.58	Q	262	210	131	0					
	U5	11.50 - 11.95				23	2.04	1.66	Q	241	240	121	0					
	U6	13.00 - 13.40				25	2.08	1.66	Q	398	270	199	0		856		7.1	
	U7	14.50 - 14.95				23	2.08	1.70	Q	346	300	173	0					

U - UNDISTURBED SAMPLE
D - DISTURBED SAMPLE
B - BULK SAMPLE
W - WATER SAMPLE

C.U. - CONSOLIDATED UNDRAINED
C.D. - CONSOLIDATED DRAINED
Q. - IMMEDIATE UNDRAINED
Q.M. - IMMEDIATE UNDRAINED MULTISTAGE

Aqueous Extract 2:1 Water:Soil

13870

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TEST CERTIFICATE

Determination of Particle Size Distribution

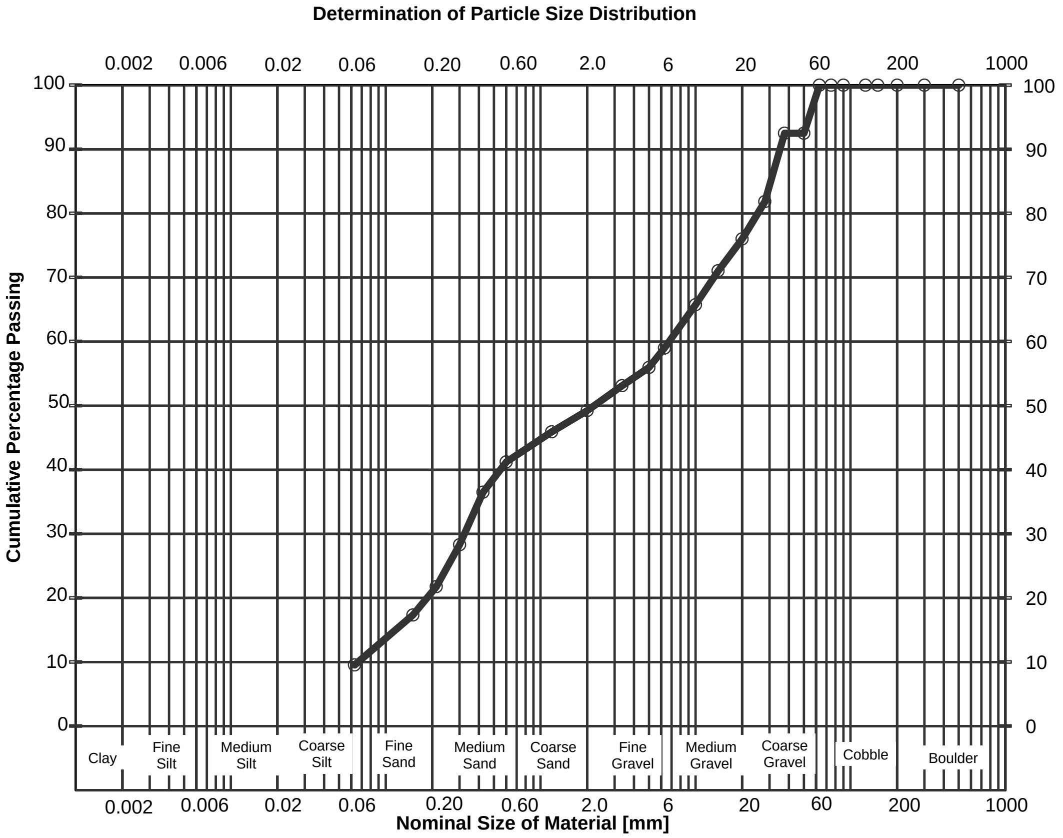
Tested in Accordance with BS 1377-2: 1990: Clause 9.2
Sieved Grading

Client:	Ground Engineering Ltd	Certificate Number:	PL5462-1/1/710-2
Client Address:	Newark Road	Client Reference:	C13870
	Peterborough	Lab Job Number:	PL5462-1
	PE1 5UA	Date Sampled:	Unknown
		Date Received:	16.06.2016
Contact:	Steve Fleming	Date Tested:	06.07.2016
		Certificate of Sampling:	N/A
Site Name:	27 Kings Mews	Sampling Certificate No.:	N/A
Site Address:	London WC1	Sampled By:	Client

TEST RESULTS **Laboratory Reference:** PL5462-1/1 **Pre-treatment for organic material:** N/A
Client Reference: B2

Sample Description: Dark brown slightly clayey SAND and GRAVEL

Material Specification: Not Required **Depth Top:** 1.20m
Location: BHA **Depth Base:** 1.70m
Source: **Supplier:**



Sieve Analysis

Sieve mm	%Passing
125	100
90	100
75	100
63	100
50	93
37.5	93
28	82
20	76
14	71
10	66
6.3	59
5.0	56
3.35	53
2.00	49
1.18	46
0.600	41
0.425	37
0.300	28
0.212	22
0.150	17
0.063	10
0.020	
0.006	
0.002	

Comments:

Approved Signatory: M. Hartnup - Laboratory Manager Signed:

for and on behalf of Ground Engineering Ltd

Date Reported: 11.07.2016 Page 1 of 1
Form Number: GELab/C/709-2 Version 46

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Registration Number: 6929574
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TEST CERTIFICATE

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Determination of Particle Size Distribution

Tested in Accordance with BS 1377-2: 1990: Clause 9.2
Sieved Grading

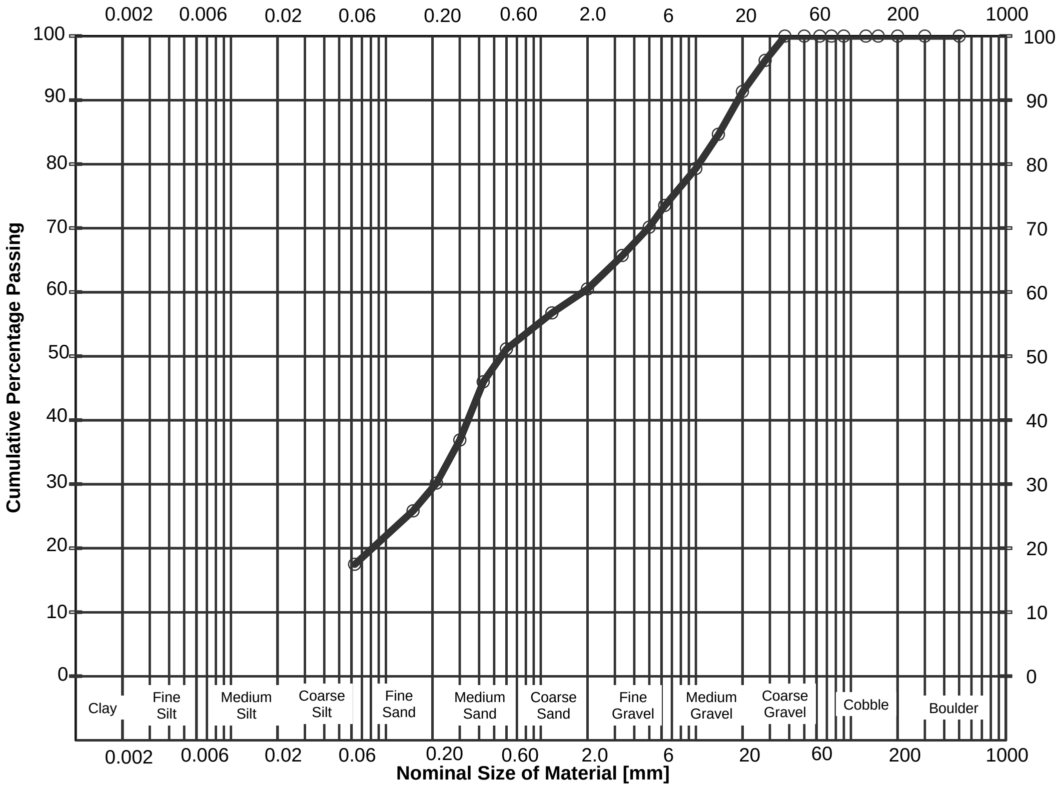
Client:	Ground Engineering Ltd	Certificate Number:	PL5462-1/2/710-2
Client Address:	Newark Road	Client Reference:	C13870
	Peterborough	Lab Job Number:	PL5462-1
	PE1 5UA	Date Sampled:	Unknown
		Date Received:	16.06.2016
Contact:	Steve Fleming	Date Tested:	06.07.2016
		Certificate of Sampling:	N/A
Site Name:	27 Kings Mews	Sampling Certificate No.:	N/A
Site Address:	London WC1	Sampled By:	Client

TEST RESULTS **Laboratory Reference:** PL5462-1/2 **Pre-treatment for organic material:** N/A
Client Reference: B3

Sample Description: Brown clayey very gravelly SAND

Material Specification: Not Required **Depth Top:** 2.00m
Location: BHA **Depth Base:** 2.50m
Source: **Supplier:**

Determination of Particle Size Distribution



Sieve Analysis

Sieve mm	%Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	96
20	91
14	85
10	79
6.3	74
5.0	70
3.35	66
2.00	61
1.18	57
0.600	51
0.425	46
0.300	37
0.212	30
0.150	26
0.063	17
0.020	
0.006	
0.002	

Comments:

Approved Signatory: M. Hartnup - Laboratory Manager Signed:

for and on behalf of Ground Engineering Ltd

Date Reported: 11.07.2016
Form Number: GELab/C/709-2 Version 46

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Determination of Particle Size Distribution

Tested in Accordance with BS 1377-2: 1990: Clause 9.2
Sieved Grading

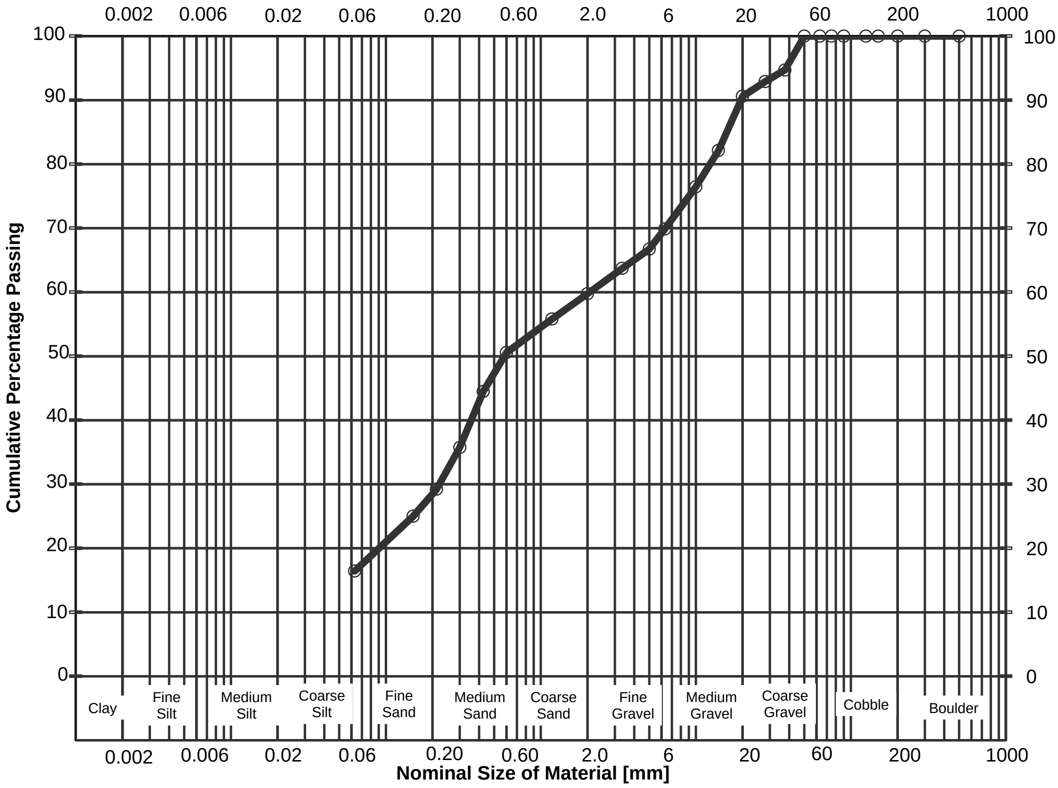
Client:	Ground Engineering Ltd	Certificate Number:	PL5462-1/3/710-2
Client Address:	Newark Road	Client Reference:	C13870
	Peterborough	Lab Job Number:	PL5462-1
	PE1 5UA	Date Sampled:	Unknown
		Date Received:	16.06.2016
Contact:	Steve Fleming	Date Tested:	06.07.2016
		Certificate of Sampling:	N/A
Site Name:	27 Kings Mews	Sampling Certificate No.:	N/A
Site Address:	London WC1	Sampled By:	Client

TEST RESULTS **Laboratory Reference:** PL5462-1/3 **Pre-treatment for organic material:** N/A
Client Reference: B4

Sample Description: Brown clayey very gravelly SAND

Material Specification: Not Required **Depth Top:** 3.00m
Location: BHA **Depth Base:** 3.30m
Source: **Supplier:**

Determination of Particle Size Distribution



Sieve Analysis

Sieve mm	%Passing
125	100
90	100
75	100
63	100
50	100
37.5	95
28	93
20	91
14	82
10	76
6.3	70
5.0	67
3.35	64
2.00	60
1.18	56
0.600	51
0.425	44
0.300	36
0.212	29
0.150	25
0.063	16
0.020	
0.006	
0.002	

Comments:

Approved Signatory: M. Hartnup - Laboratory Manager Signed:

for and on behalf of Ground Engineering Ltd

Date Reported: 11.07.2016 Page 1 of 1
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Determination of Particle Size Distribution

Tested in Accordance with BS 1377-2: 1990: Clause 9.2
Sieved Grading

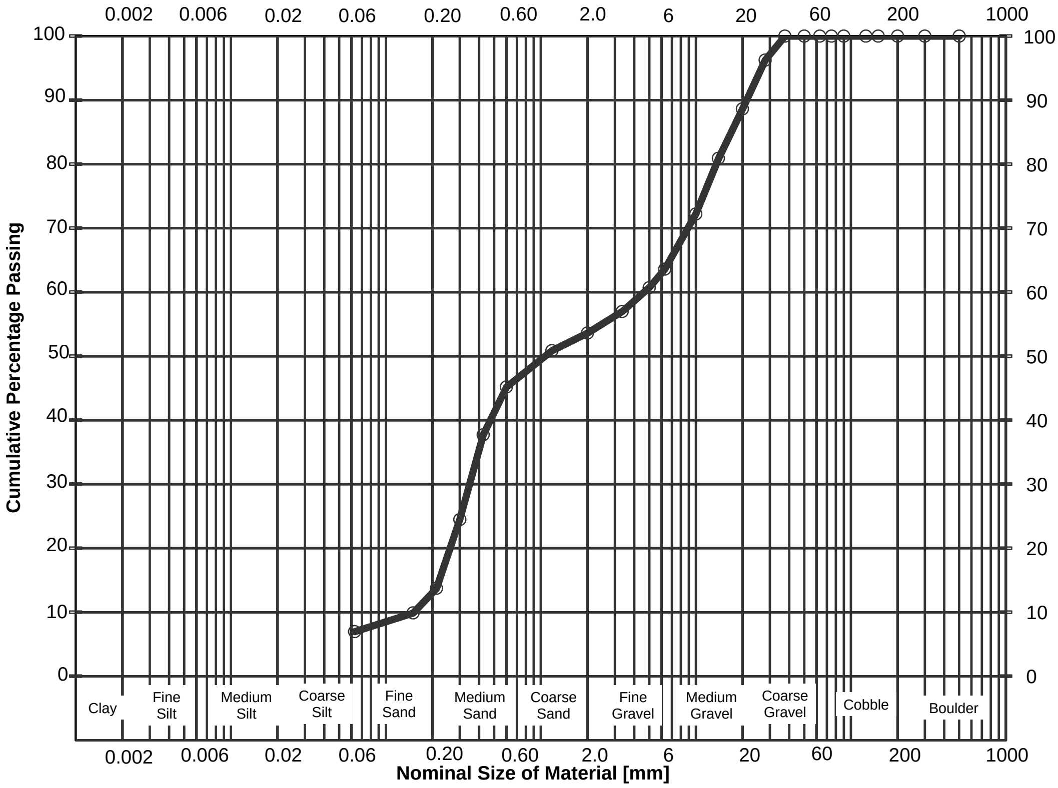
Client:	Ground Engineering Ltd	Certificate Number:	PL5462-1/4/710-2
Client Address:	Newark Road Peterborough PE1 5UA	Client Reference:	C13870
		Lab Job Number:	PL5462-1
		Date Sampled:	Unknown
		Date Received:	16.06.2016
Contact:	Steve Fleming	Date Tested:	06.07.2016
		Certificate of Sampling:	N/A
Site Name:	27 Kings Mews	Sampling Certificate No.:	N/A
Site Address:	London WC1	Sampled By:	Client

TEST RESULTS **Laboratory Reference:** PL5462-1/4 **Pre-treatment for organic material:** N/A
Client Reference: B5

Sample Description: Dark brown slightly clayey SAND and GRAVEL

Material Specification: Not Required **Depth Top:** 3.30m
Location: BHA **Depth Base:** 3.60m
Source: **Supplier:**

Determination of Particle Size Distribution



Sieve Analysis

Sieve mm	%Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	96
20	89
14	81
10	72
6.3	64
5.0	61
3.35	57
2.00	54
1.18	51
0.600	45
0.425	38
0.300	24
0.212	14
0.150	10
0.063	7
0.020	
0.006	
0.002	

Comments:

Approved Signatory: M. Hartnup - Laboratory Manager Signed:

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Date Reported: 11.07.2016 Page 1 of 1
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TEST CERTIFICATE

Determination of Particle Size Distribution

Tested in Accordance with BS 1377-2: 1990: Clause 9.2
Sieved Grading

Client: Ground Engineering Ltd
Client Address: Newark Road, Peterborough, PE1 5UA
Contact: Steve Fleming
Site Name: 27 Kings Mews
Site Address: London WC1

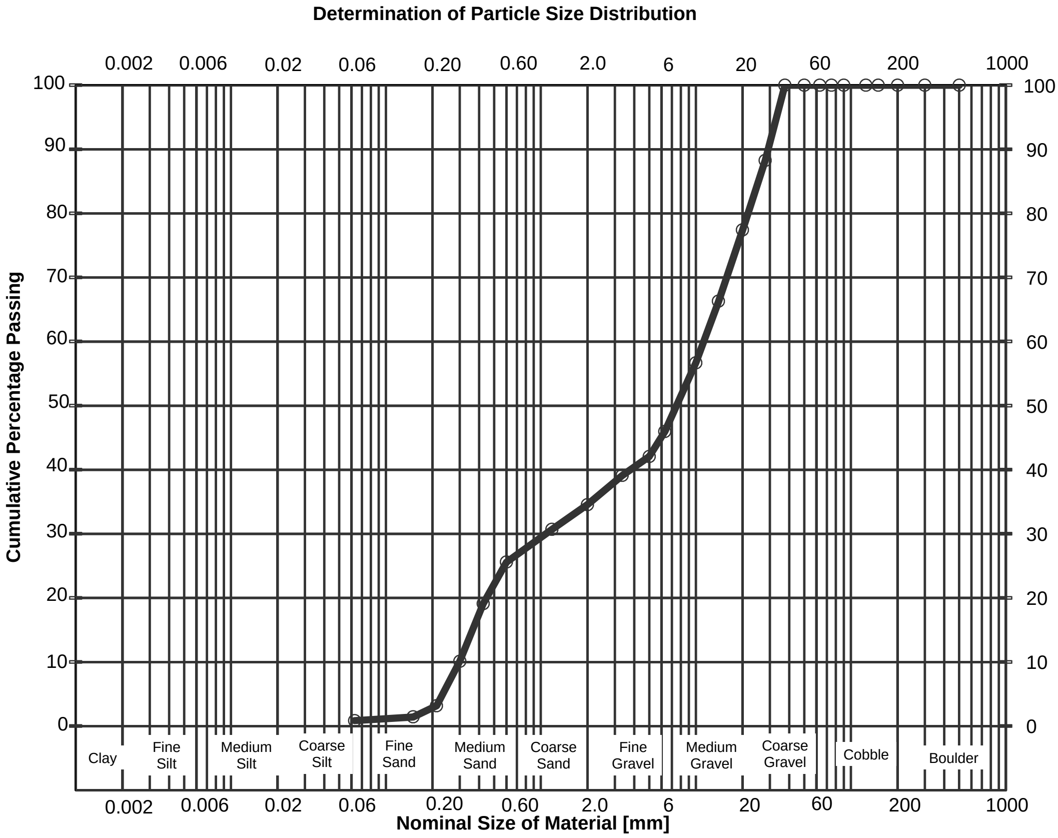
Certificate Number: PL5462-1/5/710-2
Client Reference: C13870
Lab Job Number: PL5462-1
Date Sampled: Unknown
Date Received: 16.06.2016
Date Tested: 06.07.2016
Certificate of Sampling: N/A
Sampling Certificate No.: N/A
Sampled By: Client

TEST RESULTS **Laboratory Reference:** PL5462-1/5
Client Reference: B6
Pre-treatment for organic material: N/A

Sample Description: Brown sandy GRAVEL

Material Specification: Not Required
Location: BHA
Source:

Depth Top: 4.20m
Depth Base: 4.70m
Supplier:



Sieve Analysis

Sieve mm	%Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	88
20	77
14	66
10	57
6.3	46
5.0	42
3.35	39
2.00	35
1.18	31
0.600	26
0.425	19
0.300	10
0.212	3
0.150	1
0.063	1
0.020	
0.006	
0.002	

Comments:

Approved Signatory: M. Hartnup - Laboratory Manager
Signed: [signature]

for and on behalf of Ground Engineering Ltd

Date Reported: 11.07.2016
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TEST CERTIFICATE

Determination of Particle Size Distribution

Tested in Accordance with BS 1377-2: 1990: Clause 9.2
Sieved Grading

Client:	Ground Engineering Ltd	Certificate Number:	PL5462-1/6/710-2
Client Address:	Newark Road	Client Reference:	C13870
	Peterborough	Lab Job Number:	PL5462-1
	PE1 5UA	Date Sampled:	Unknown
		Date Received:	16.06.2016
Contact:	Steve Fleming	Date Tested:	06.07.2016
		Certificate of Sampling:	N/A
Site Name:	27 Kings Mews	Sampling Certificate No.:	N/A
Site Address:	London WC1	Sampled By:	Client

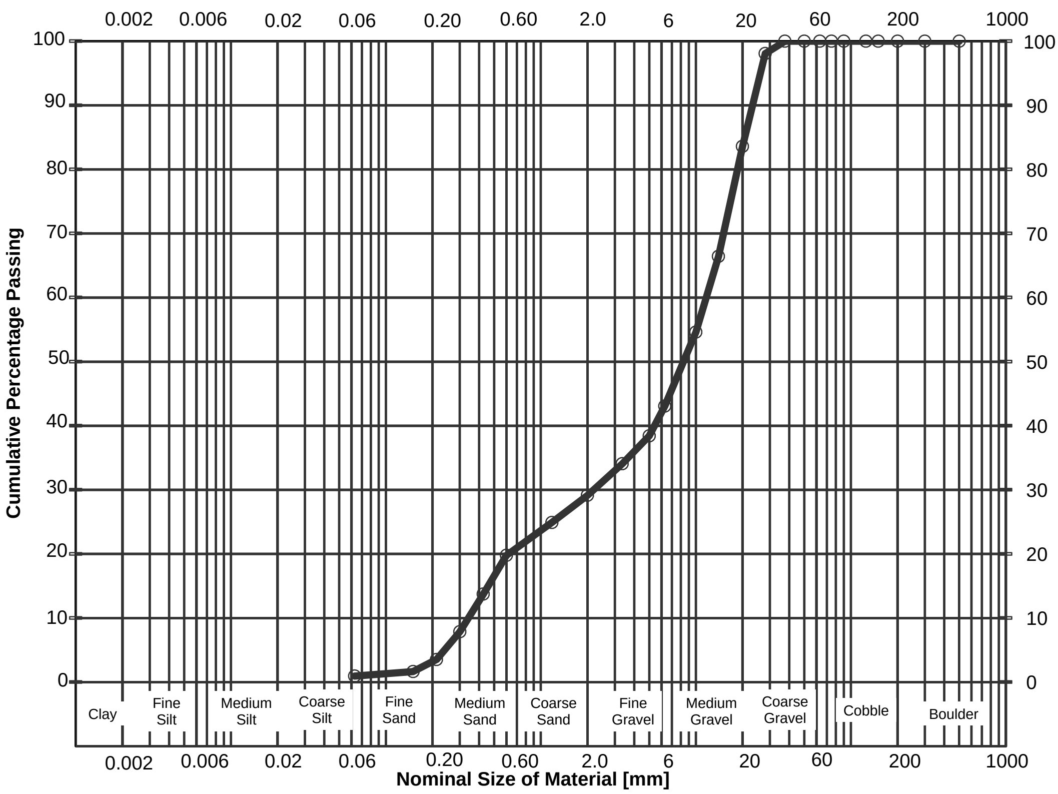
TEST RESULTS **Laboratory Reference:** PL5462-1/6
Client Reference: B7
Pre-treatment for organic material: N/A

Sample Description: Brown sandy GRAVEL

Material Specification: Not Required
Location: BHA
Source:

Depth Top: 5.00m
Depth Base: 5.50m
Supplier:

Determination of Particle Size Distribution



Sieve Analysis

Sieve mm	%Passing
125	100
90	100
75	100
63	100
50	100
37.5	100
28	98
20	84
14	66
10	55
6.3	43
5.0	38
3.35	34
2.00	29
1.18	25
0.600	20
0.425	14
0.300	8
0.212	4
0.150	2
0.063	1
0.020	
0.006	
0.002	

Comments:

Approved Signatory: M. Hartnup - Laboratory Manager

Signed:

for and on behalf of Ground Engineering Ltd

Date Reported: 11.07.2016
Form Number: GELab/C/709-2 Version 46

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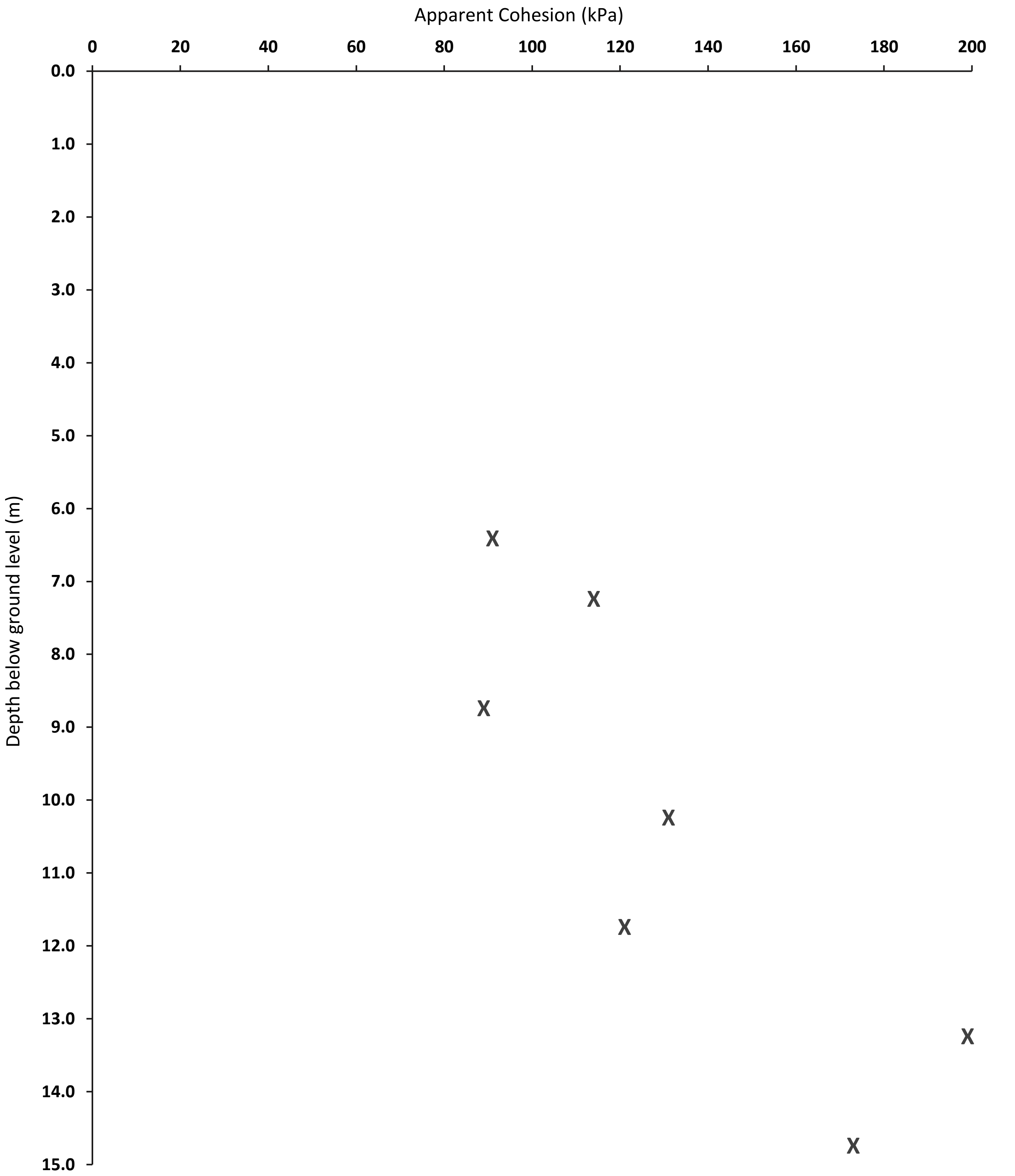

Key: BHA = X

Apparent Cohesion (kPa) v Depth below ground level (m)

SITE:	**26 & 27 King's Mews, London WC1**
CLIENT:	**1156 Limited**

GROUND ENGINEERING LIMITED	Project No. C13870A
Newark Road, Peterborough	Figure 1

APPENDIX 1

CLASSIFICATION OF AGGRESSIVE CHEMICAL ENVIRONMENT FOR BURIED CONCRETE

TABLE C2 – AGGRESSIVE CHEMICAL ENVIRONMENT FOR CONCRETE (ACEC) CLASSIFICATION FOR BROWNFIELD LOCATIONS[a]

Table C2 Aggressive Chemical Environment for Concrete (ACEC) classification for brownfield locations[a]

Sulfate and magnesium						Groundwater		ACEC
Design Sulfate Class for location	2:1 water/soil extract[b]		Groundwater		Total potential sulfate[c]	Static water	Mobile water	Class for location
1	2	3	4	5	6	7	8	9
	(SO_4 mg/l)	(Mg mg/l)	(SO_4 mg/l)	(Mg mg/l)	(SO_4 %)	(pH)[d]	(pH)[d]	
DS-1	< 500		< 400		< 0.24	≥ 2.5		AC-1s
							> 6.5[d]	AC-1
							5.5–6.5	AC-2z
							4.5–5.5	AC-3z
							2.5–4.5	AC-4z
DS-2	500–1500		400–1400		0.24–0.6	> 5.5		AC-1s
							> 6.5	AC-2
						2.5–5.5		AC-2s
							5.5–6.5	AC-3z
							4.5–5.5	AC-4z
							2.5–5.5	AC-5z
DS-3	1600–3000		1500–3000		0.7–1.2	> 5.5		AC-2s
							> 6.5	AC-3
						2.5–5.5		AC-3s
							5.5–6.5	AC-4
							2.5–5.5	AC-5
DS-4	3100–6000	≤ 1200	3100–6000	≤ 1000	1.3–2.4	> 5.5		AC-3s
							> 6.5	AC-4
						2.5–5.5		AC-4s
							2.5–6.5	AC-5
DS-4m	3100–6000	> 1200[e]	3100–6000	> 1000[e]	1.3–2.4	> 5.5		AC-3s
							> 6.5	AC-4m
						2.5–5.5		AC-4ms
							2.5–6.5	AC-5m
DS-5	> 6000	≤ 1200	> 6000	≤ 1000	> 2.4	> 5.5		AC-4s
						2.5–5.5	≥ 2.5	AC-5
DS-5m	> 6000	> 1200[e]	> 6000	> 1000[e]	> 2.4	> 5.5		AC-4ms
						2.5–5.5	≥ 2.5	AC-5m

Notes

a Brownfield locations are those sites, or parts of sites, that might contain chemical residues produced by or associated with industrial production (Section C5.1.3).

b The limits of Design Sulfate Classes based on 2:1 water/soil extracts have been lowered from previous Digests (Box C7).

c Applies only to locations where concrete will be exposed to sulfate ions (SO_4), which may result from the oxidation of sulfides such as pyrite, following ground disturbance (Appendix A1 and Box C8).

d An additional account is taken of hydrochloric and nitric acids by adjustment to sulfate content (Section C5.1.3).

e The limit on water-soluble magnesium does not apply to brackish groundwater (chloride content between 12 000 mg/l and 17 000 mg/l). This allows 'm' to be omitted from the relevant ACEC classification. Seawater (chloride content about 18 000 mg/l) and stronger brines are not covered by this table.

Explanation of suffix symbols to ACEC Class

- Suffix 's' indicates that the water has been classified as static.
- Concrete placed in ACEC Classes that include the suffix 'z' have primarily to resist acid conditions and may be made with any of the cements in Table D2 on page 42.
- Suffix 'm' relates to the higher levels of magnesium in Design Sulfate Classes 4 and 5.