

Richard Music Centre – Highgate School

Sustainable Urban Drainage Statement

16th January 2023

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00	16/01/2023	For planning	N Hill	F Wyatt	F Labbé

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1 Introduction

This Sustainable Urban Drainage Statement has been prepared by Expedition to support the planning application for the proposed re-development of the Richard Music Centre, as part of the Highgate School campus, in Highgate, North London.

This drainage statement has been developed in consultation with the London Borough of Haringey, the lead local Flood Authority (LLFA), during a meetings on 23 January 2020 and more recently on 4th March 2022 and 21st June 2022..

This report is structured as follows:

- Section 2 describes the site and ground conditions
- Section 3 describe the existing drainage arrangements
- Section 4 describes the proposed development
- Section 5 describes the proposed surface water drainage strategy
- Section 6 describes the proposed foul water drainage strategy
- Section 7 describes the maintenance strategy

2 Site Description

2.1 Existing site and surveys

The existing site is located adjacent to Bishopswood Road, N6 4PR as shown on the site location plan in Appendix A. The site is approximately 1,900m² in area and is currently occupied by the single-storey Richards Music Centre building, along with the school's IT hub. These buildings are to be demolished, with the IT facilities being accommodated elsewhere on the school campus. A topographical survey of the site has been carried out in September 2015 and is included in Appendix A.

The existing school building and hardstanding access ways occupy approximately 1,200m² (or 63% of the site), which is considered to be impermeable. The remainder of the site consists of maintained grassland, which is considered to be partially permeable.

The site is situated in Flood Zone 1 of the Environment Agency Flood Maps and has a low probability of surface water flooding (Appendix B). A side-wide Flood Risk Assessment (FRA) has been carried out for the Highgate School Campus by Edenvale Young and a site specific flood risk note has been produced by Expedition to address the Supplementary Planning Document requirements. No significant risk of flooding has been identified for the site.

2.2 Ground conditions

A geotechnical report has been prepared by Soil Consultants working to a brief prepared by Expedition and A-Squared (Expedition's specialist geotechnical consultant). The site works undertaken by Soil Consultants consisted of boreholes, window sampling and several trial pits to ascertain the ground conditions and as-built geometry of the retaining wall to the northern edge of the site at the interface with the existing sports pitch. Soil Consultants final site investigation report was issued on 3rd June 2016 and is included in Appendix C

Three cable percussion boreholes have been drilled at depth of 20 to 30m. Seven trial pits have also been excavated and 3 window samples have been taken. The site is underlain by Made Ground of varying thickness (less than 1m to 2.2m), consisting of silty sandy clay or clayey sand with variable amounts of gravel, brick/concrete fragments, clinker and occasional metal fragments. The Claygate formation (silty clay, occasionally sandy) was encountered below the Made Ground. The London Clay formation was encountered below the Claygate formation at depths of 3.90m and 4.50m below ground.

Infiltration tests have been carried out in two of the trial pits. No significant infiltration was observed during the tests. Infiltration drainage is therefore not feasible.

Groundwater levels were recorded as being variable, with levels ranging between 0.6m and 2.4m below existing ground levels. This is above the proposed basement finished floor level.

3 Existing drainage arrangement

3.1 Existing arrangement

Our understanding of the existing drainage arrangement is based on the following information:

- Topographical survey of the site including existing services (Appendix A).
- Thames Water (TW) asset information obtained by AECOM in January 2016 (Appendix D).
- Results of a CCTV survey of the TW surface and foul sewers crossing the sports pitch further to the North carried out by Lanes Group Plc in April 2009 and Direct Drain Services in July 2014 (Appendix E).
- The further findings of a CCTV survey carried out on 5th of August 2016 by Direct Drains Services.

Foul drainage flows from the existing building are collected into an existing 100mm diameter sewer running along the back of the existing building. This sewer outfalls to the 225mm diameter TW foul sewer along Bishopswood Road.

The recent CCTV survey identified that the majority of the roof drainage flows also discharge into the 100mm combined sewer running along the back of the existing building. A drainage connection under the building takes the drainage flows from rainwater pipes to the front of the building to the pipe run at the back of the building. Roof drainage flows are therefore currently discharged into the TW foul sewer through an existing combined connection. A couple of rainwater pipes possibly drain to a surface water sewer crossing the sports pitch, however this has not been confirmed.

The recent survey identified that the existing connection to the TW foul sewer has been lined, with the liner showing some minor cracks. The diameter of the existing connection remains to be confirmed.

Critically, the survey showed no incoming connection from the neighbouring properties into the site drainage system. The system is therefore fully private up to the boundary line and therefore any diversion or decommissioning does not require consultation with TW.

Although a 300mm diameter surface water sewer runs along Bishopswood Road, the recent survey did not identify any connection from the site into that sewer.

It is understood that a land drain runs along the back of the retaining wall at the southern edge of the pitch to relieve groundwater pressure on the retaining wall.

3.2 Existing surface water peak discharge rates

There is no attenuation of surface water drainage flows, hence surface water drainage flows are discharged at an unrestricted rate to the public sewer, limited only by the capacity of the site stormwater drainage.

Although to today's standards, the site drainage system would be designed for no flooding for the 1 in 30 year design return period, given the age of the existing facilities, it is likely that a lower level of service would have been adopted, such as a 1 in 10 year return period. Therefore, the peak discharge rate to the combined sewer from the site has been estimated for the 1 in 10 year and 1 in 30 year return periods.

Without any attenuation storage, the shortest 15 minute duration storm would generate highest discharge. Based on the FEH data, the rainfall intensities for the 15 minute duration storms are 0.0194l/sm² for the 1 in 10 year return period and 0.0268l/sm² for the 1 in 30 year return period.

Peak runoff rate has been calculated using the modified rational method as described in the Wallingford procedure. This procedure recommends using a combined runoff coefficient of between 0.8-1.0 for impermeable surfaces. In this case, a conservatively low value of 0.85 has been used. A value of 0.2 has been used for green surfaces.

Table 1 summarises the estimated existing peak surface water discharge into the public sewers. The calculations for these can be found in Appendix I.

Table 1: Estimated Existing Peak Surface Water Discharge

Surface Areas	Runoff Coefficient	1 in 10 year peak surface water discharge (l/s)	1 in 30 year peak surface water discharge (l/s)
Hardstanding and Building	0.85	20.8	28.8
Maintained Grasslands	0.2	2.6	3.5
Total		23.4	32.3

4 Proposed development

It is proposed to demolish the existing school building and construct a new building to host music and theatre teaching facilities. The new building will include a basement that will take up a large area of the site and extend beyond the footprint of the building above ground.

The proposed building and external hardstanding areas will encompass 1,410m² of the post development site, the remaining area will be grassed. Therefore, 85% of the site is considered impermeable. Project drawings are included in Appendix F.

5 Surface water drainage strategy

SKC810 and SKC811 in Appendix G show the proposed drainage strategy which is described in further detail in the following sections. The Haringey SUDs proforma provided in Appendix H also provides a summary of the key facts and proposals for the project.

5.1 Strategic principles

The surface water drainage strategy has been developed in line with the following key principles and policies:

- The drainage hierarchy set out in Policy SI 13 of the London Plan 2021;
- Design in accordance with the requirement of the National Planning Policy Framework (NPPF), Planning Policy Guidance (PPG) and BS EN 752 to protect the site from flooding and avoid increase in off-site flood risk;
- The London Sustainable Drainage Proforma, Haringey, London, 2019 (Appendix H);
- Control of surface water runoff at source in line with the principles of the SUDS Manual (CIRIA C753);
- Control of pollution to the water environment in line with the principles of the SUDS Manual (CIRIA C753);
- Contribution to enhancing biodiversity and amenity in accordance with the SUDS Manual (CIRIA C753).

5.2 Disposal and drainage hierarchy

Policy SI 13 of the London Plan states that developments should utilise Sustainable Urban Drainage Systems (SUDS) to manage surface water run-off as close to source as possible and proposes a drainage hierarchy. The following discusses the implementation of the drainage hierarchy, as discussed with the LLFA on 23 January 2020 and more recently on the 4th March 2022

Store rainwater for later use

From a catchment perspective, the perceived benefits of rainwater harvesting are that:

- Firstly, there is some reduction in the peak flows in the system because of the attenuation provided by partially empty storage tanks with a consequent reduction in flooding across the catchment; and
- Secondly, that there is a reduction of stress on water resources in the catchment.

Whilst we fully understand the need to reduce pressure on water resources, research led by the Environment Agency has shown that conventional rainwater harvesting systems consisting of a dedicated in-ground plastic tank, treatment, pumps and associated distribution pipework in residential developments offer questionable whole life sustainability benefits. The study found that in many cases the embodied energy and carbon emissions associated with installation of the system are not offset by the reduction in carbon emissions associated with the reduction in potable water use over the design life of the development.

Furthermore, demand for non-potable water will be relatively small. Rainwater harvesting is therefore not proposed for the development.

Infiltration drainage

As discussed in Section 2.2, infiltration tests have been carried out as part of the site investigation. Given the clayey nature of the ground, no significant infiltration was observed during the tests. Infiltration drainage is therefore not feasible.

Attenuate rainwater in ponds or open water features for gradual release

The proposed building will occupy most of the site, close to the southern boundary and the existing sports pitch to the north. The proposed basement will project beyond the footprint of the building. Open water attenuation features can therefore not be accommodated as part of the development.

Attenuate rainwater by storing in tanks or sealed water features for gradual release

As open water attenuation is not feasible, surface water drainage flows will be attenuated in a below ground attenuation tank (ACO Stormbrixx) and a shallow podium drainage system in external spaces above basement. This will be integrated with green spaces and landscaping above the basement roof slab. This is further discussed in Section 5.5.

Discharge rainwater direct to a watercourse

There are no watercourses in proximity of the site. Discharge to a watercourse is therefore not feasible.

Discharge rainwater to a surface water sewer / drain

Surface water drainage flows will be discharged to the surface sewer along Bishopswood Road, through a new connection. This is an improvement from current, as the drainage surveys have shown that surface water drainage flows are currently discharged to the foul sewer.

Discharge rainwater to a combined sewer

As above, surface water drainage flows will be discharged to the surface water sewer.

5.3 Design event

The proposed surface water drainage system will be designed for:

- No surface water flooding for all events up to 1 in 30 year return period in line with BS EN 752, with a +35% increase in rainfall intensities in line with DEFRA's climate change allowances for peak rainfall in England introduced in May 2022.
- No flooding of the buildings for extreme events up to the 1 in 100 year return period including a 40% allowance for climate change, in line with DEFRA's climate change allowances for peak rainfall in England introduced in May 2022.

5.4 Proposed peak discharge rates

The Mayor's Sustainable Design and Construction Supplementary Planning Guidance defines how the greenfield runoff rate is to be estimated, and also recognises that to avoid blockage the discharge of a drainage outfall should not be restricted to a rate lower than 5l/s. In line with this guidance, it is proposed to limit the surface water discharge to 5l/s/achieving a reduction in peak discharge from existing of approximately 76- 81%. The peak discharge rate has been agreed with the LLFA in a meeting on 23 January 2020 and more recently during meetings on the 4th March 2022.

The surface water will be discharged into the existing TW's public surface water sewer (TWMH 9602) in Bishopswood Road via a new connection.

5.5 Source control and attenuation proposals

The proposed below ground surface water drainage system will be designed for no surface water flooding for all events up to the 1 in 30 year + 35% event. The national Planning Policy Framework (NPPF) also requires that developments contain within their boundary any flooding for all events up to the 1 in 100 year + 40% for climate change, without overflowing onto adjacent land or flooding any of the buildings. As in this case there is no opportunity for controlled surface flooding during extreme events in excess of 1 in 30 year + 35% event, the attenuation storage tank has been sized for the 1 in 100 year +40% event.

A MicroDrainage network model of the drainage system has been developed using FEH data. This includes key pipe runs, storage elements and flow controls. The model has been used to confirm hydraulic performance of the system, and interaction between the different components. Outline attenuation volumes have been calculated and the associated reports are contained within Appendix I. A total of 66m³ will be required. Surface water flows exceeding this event will flood to the road and the sports pitch and will not flood any buildings.

It is proposed for 58m³ of the total volume to be stored within a below ground attenuation tank. Modular ACO Stormbrixx units in an impermeable membrane have been proposed as these units can be accessed and cleared of silt and debris. The attenuation tank will be located between the proposed building and Bishopswood Road.

The intention is for the roof to drain predominantly to the southern side of the building. This will be achieved via the connection of rainwater downpipes to a layer of permavoid modular storage units above basement roof slab. The soft landscaping above the basement roof slab will also drain to the permavoid layer and discharge to the south of the building. The introduction of the permavoid system will reduce the amount of gully/outlet penetrations into the building from ground level and reduce the number of suspended pipework runs within the building. These permavoid modular storage units will provide the remainder of the 7.5m³ storage. The proposed storage arrangement is shown on the drainage strategy in Appendix E.

The sunken garden will need to be pumped via the basement into the surface water drainage system. The pump will be sized to accommodate the 1 in 30 year storm with storage for the 1 in 100 year + 40% storm provided under the decking / suspended floor within the sunken garden.

The land drain along the back of the retaining wall at the southern edge of the pitch will be retained and reinstated where necessary.

5.6 Pollution control

The risk of pollution of the water environment associated with the site is low. The main source of pollution for the site is airborne dust and litter. Surface water runoff will be of suitable quality for discharge to the public sewer without particular treatment. Silt traps at gullies and channel drains outlets will intercept silt at source.

Maintenance requirements for the surface water drainage system and a detailed drainage plan for the site will be included within the Operation and Maintenance Manual.

Two car parking spaces are proposed to the west of the building will be maintained. No loading bays are currently proposed. It is not anticipated hydrocarbon interception will be required, however deep trapped gullies are proposed.

5.7 Biodiversity and amenity

Due to the constrained nature of the site there are limited opportunities for biodiversity and amenity however the green roof, sunken garden and podium areas offer opportunities to enhance biodiversity and provide amenity spaces.

6 Foul water drainage strategy

All foul drainage flows from ground level and above will discharge by gravity to the TW foul sewer on Bishopswood Road (TWMH 9603) via the proposed foul drainage run along the south of the building.

It is proposed to reuse the existing drainage connection to the TW foul sewer. The feasibility of reusing this connection depends on its diameter after lining and its condition and will be confirmed on review of the full results of the CCTV survey.

Foul drainage flows from showers, WCs and plantroom gullies within the basement will be pumped. A package pumping station is proposed with duty / standby pumps for foul flows from the showers and WC's. Two further package pumping stations are proposed for the plant room gully drainage. This has been proposed to prevent smells from the WC's entering the plant rooms as these gullies are not anticipated to be used on a regular basis and are likely to be dry for the majority of the time. An opportunity to reduce the number of pumps is to be reviewed at the next design stage.

The basement slab and substructures will be designed to withstand the groundwater hydrostatic pressure, and therefore groundwater pressure relief is not required. A cavity drainage system is included as part of the waterproofing strategy. This system is to be designed by a specialist with outfalls to dry sumps located at the perimeter of the basement wall. The flow from the cavity system is anticipated to be low, therefore the collection sump is not proposed to be fitted with a permanent pump. Instead the dry sump is to be monitored and emptied via a submersible pump as required. Moisture sensors may be placed within the sumps to allow the sumps to be monitored remotely via the building management system (BMS).

The basement slab will be protected from the effect of clay heave by a compressible void former. To prevent vertical movement of the drainage system below the basement slab, all pipework and chambers will be cast with the slab. Highest strength heave protection will also run below the drainage system.

A raised threshold will be necessary at the top of stairs allowing access from the pitch into the basement, to prevent any potential water ingress.

7 Maintenance

The school will manage all parts of the site drainage, with clear overview of the operation and maintenance of the drainage system and any works carried out by contractors.

It is anticipated that the drainage system will require routine inspection and maintenance to include:

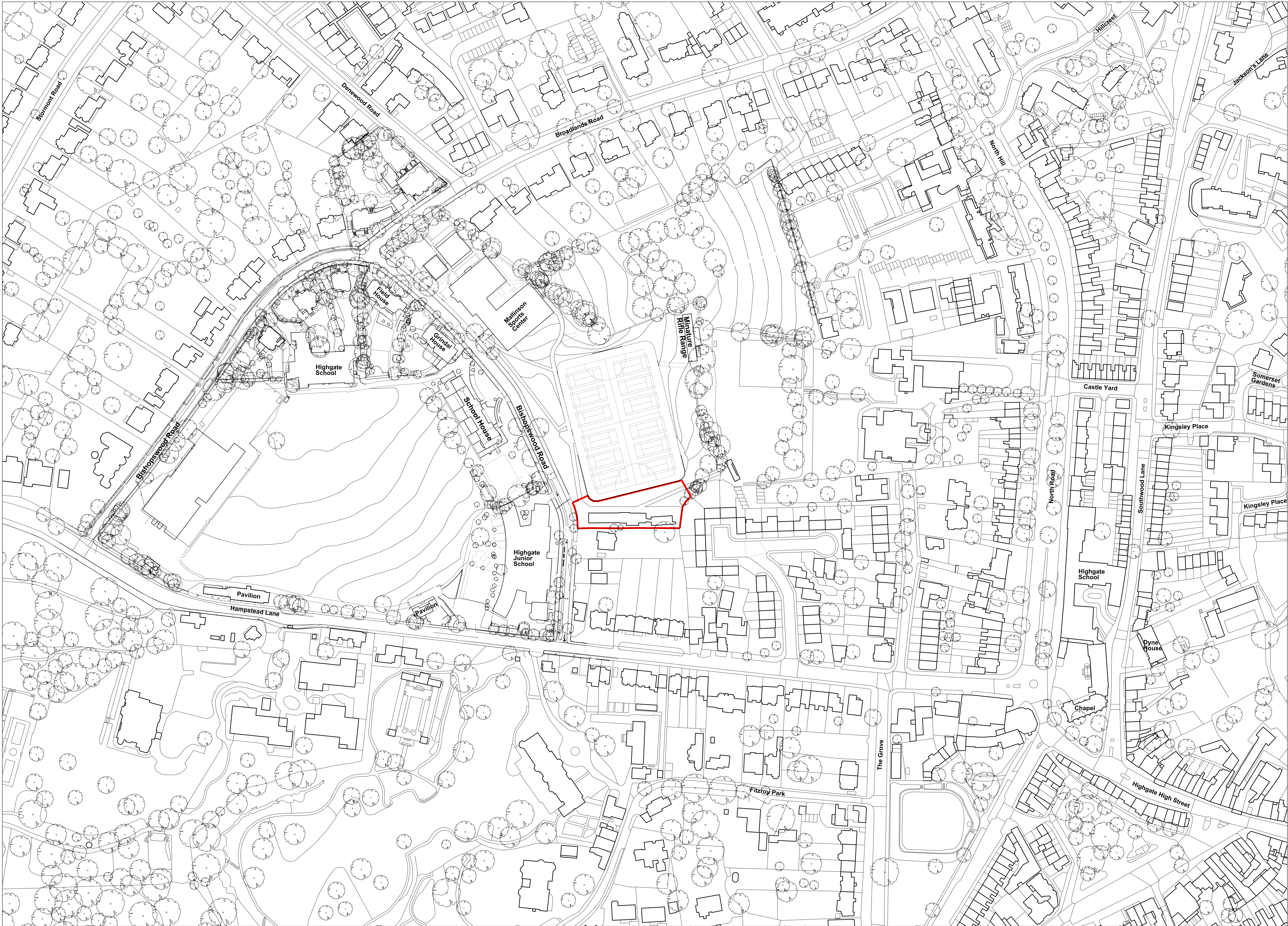
- Regular inspections of channels drains and gullies
- Removal of silts and blockages as required, but at least once a year
- Sweep external surfaces every 12 months

- Regular routine maintenance and testing of the pumping station in accordance with manufacturers recommendations.

Maintenance schedules are included within Appendix J, in line with the recommendations set out in the CIRIA C753 SUDS Manual.

Over the lifetime of the development, it may be necessary to replace the buried geo-cellular crates. These will be located outside of the main access road and the replacement works can be carried out with minimal disruption to the school if planned carefully.

Appendix A – Site Plan & Topo survey



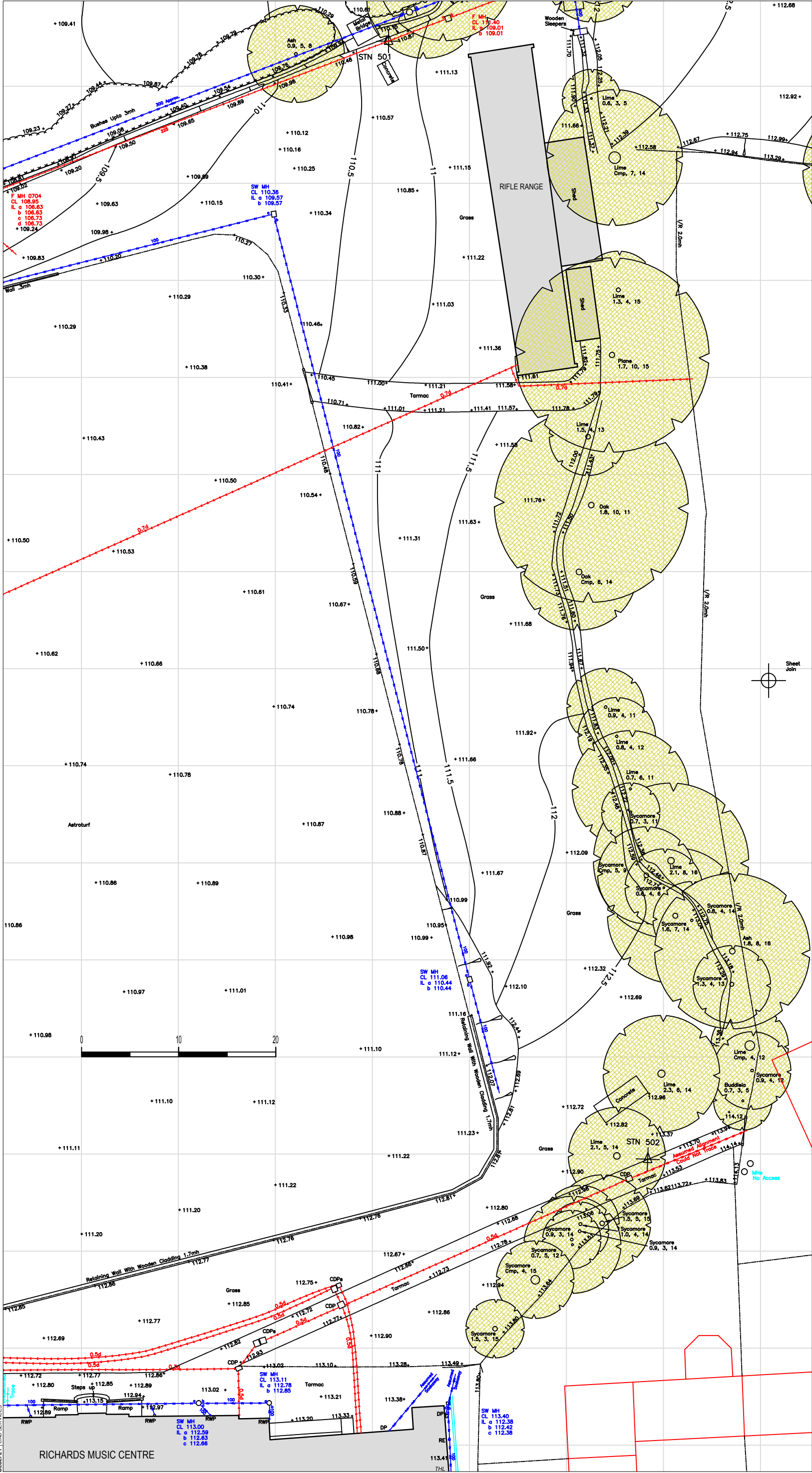
Work Package	Cost Check	Info/Briefing	Tender	Contract	Construction

Date	Rev.	Description

Approved By	Date	Rev.	Description

Project	Highgate School Richards Music Centre
Subject	Existing Contextual Plan
Architects	Hopkins Architects Partnership LLP 27 Broadway Terrace, London, NW1 6LG T: 020 7724 1751 E: mail@hopkins.co.uk

Sort Code	Drawing Number	Rev.
A/HS-RMC	0001	-
Date	19.02.2016	Scale 1:1250 at A1



Notes

HIGHGATE

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Project: **DH OPTION STUDIES**
Client: **HIGHGATE SCHOOL**
Title: **SITE PLAN
RIFLE RANGE**

Job No: 001
Dwg No: HGS/102
Scale: NTS Date: SEPT 2015

DO NOT SCALE from this drawing.
Contractors must verify all dimensions on site before setting
out, commencing work or making drawings.
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Appendix B – EA Flood Map

Flood map for planning

Your reference
427 RMCS

Location (easting/northing)
528022/187600

Created
5 Feb 2020 16:37

Your selected location is in flood zone 1, an area with a low probability of flooding.

This means:

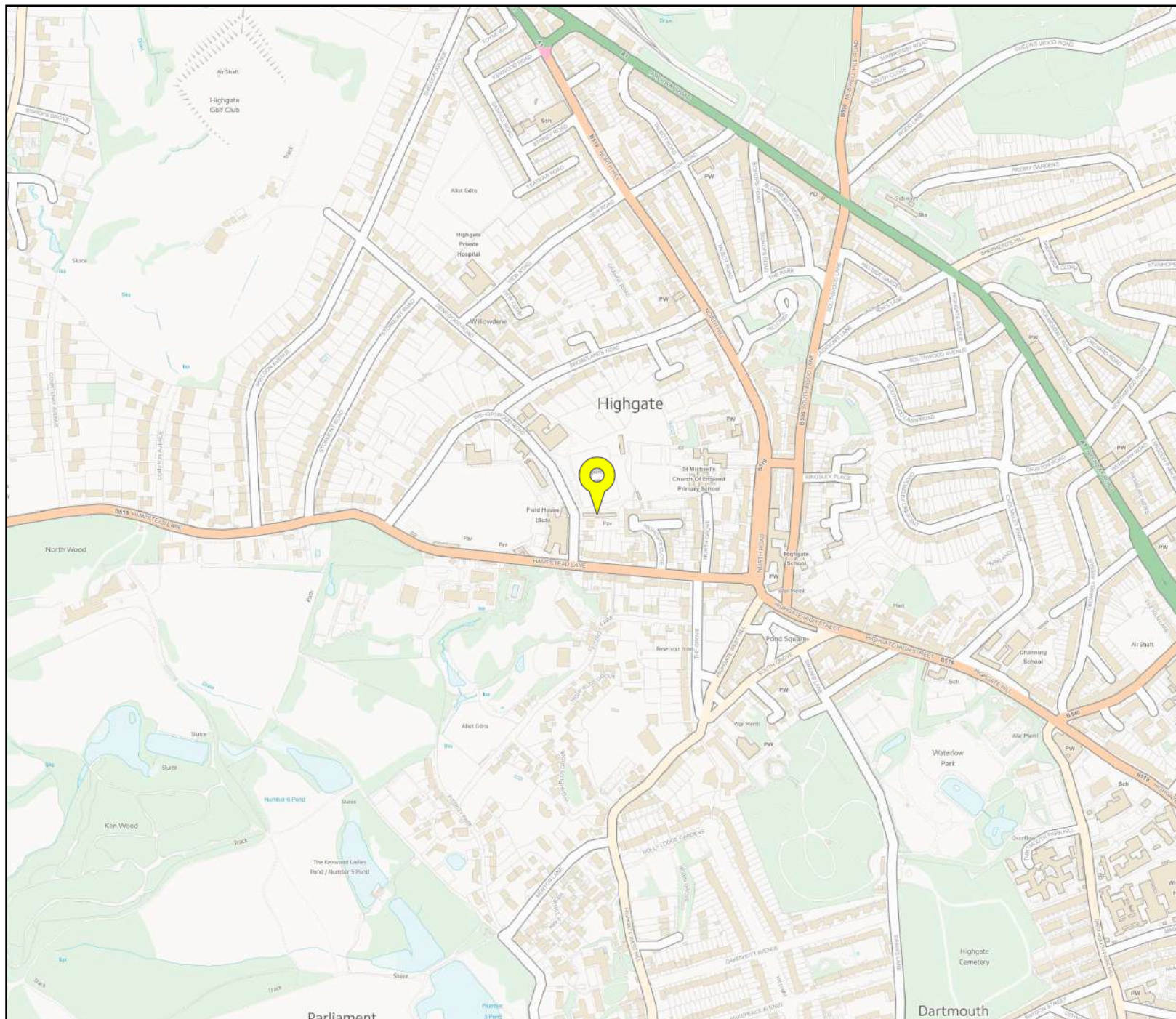
- you don't need to do a flood risk assessment if your development is smaller than 1 hectare and not affected by other sources of flooding
- you may need to do a flood risk assessment if your development is larger than 1 hectare or affected by other sources of flooding or in an area with critical drainage problems

Notes

The flood map for planning shows river and sea flooding data only. It doesn't include other sources of flooding. It is for use in development planning and flood risk assessments.

This information relates to the selected location and is not specific to any property within it. The map is updated regularly and is correct at the time of printing.

The Open Government Licence sets out the terms and conditions for using government data.
<https://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>



Flood map for planning

Your reference
427 RMCS

Location (easting/northing)
528022/187600

Scale
1:10000

Created
5 Feb 2020 16:37

-  Selected point
-  Flood zone 3
-  Flood zone 3: areas benefitting from flood defences
-  Flood zone 2
-  Flood zone 1
-  Flood defence
-  Main river
-  Flood storage area


0 100 200 300m

Appendix C – Ground Investigation Report

SITE INVESTIGATION REPORT

**RICHARDS MUSIC CENTRE, HIGHGATE SCHOOL
BISHOPSWOOD ROAD, LONDON N6 4PR**



Client: **HIGHGATE SCHOOL**
North Road, London
N6 4AY

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Geotechnical specialists: **A-SQUARED STUDIO**
1 Westminster Bridge Rd
London SE1 7XW

SCL Report ref: **9933/JRCB**

Date: **3rd June 2016 (Rev 2)**

SITE INVESTIGATION REPORT

RICHARDS MUSIC CENTRE, HIGHGATE SCHOOL BISHOPSWOOD ROAD, LONDON N6 4PR

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Rev 0	12/05/16	Draft issue for comment (unchecked)	John Bartley BSc, MSc, CGeol, FGS	
Rev 1	16/05/16	Interim issue pending completion of TP2	John Bartley BSc, MSc, CGeol, FGS	
Rev 2	03/06/16	Minor text changes. TP2 cancelled	John Bartley BSc, MSc, CGeol, FGS	Stuart Wagstaff BSc, MSc, CGeol, FGS

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APPENDIX A

Fieldwork, in-situ testing and monitoring

- ✚ Cable percussive borehole records
- ✚ Standard Penetration Test results
- ✚ SPT hammer energy rating certificate
- ✚ Window sample records
- ✚ Trial pit records
- ✚ Trial pit soakage test records
- ✚ Monitoring records (observation pipe and vibrating wire piezometer)

Laboratory test results

- ✚ Index property tests
- ✚ Plasticity charts
- ✚ Unconsolidated undrained triaxial tests
- ✚ Consolidated undrained triaxial tests (K4 Soils Laboratory)
- ✚ Oedometer tests (K4 Soils Laboratory)

Contamination and chemical testing

QTS Environmental Ltd Reports:

- ✚ 16-41198 (03/03/16)
- ✚ 16-41460 (10/03/16)

Ground profiles

- ✚ Plot of SPT 'N' and undrained cohesion versus depth
- ✚ Schematic cross section

Plans & drawings

- ✚ Development scheme drawings
- ✚ Photographs
- ✚ Site Plan
- ✚ Location Plan

APPENDIX B

Envirocheck report (79759257, 12/02/16)

1.0 INTRODUCTION

Consideration is being given to the redevelopment of this site with the construction of a new music centre. In connection with the proposed works, Soil Consultants Ltd (SCL) were commissioned by Expedition Engineering to carry out a site investigation to include the following elements:

-  Desk Study to identify site history and potential contaminative uses
-  Identification of ground sequence, groundwater levels and geotechnical parameters
-  Recommendations for spread/raft/piled foundation design
-  Contamination appraisal, risk assessment and conceptual model

This report describes the investigation undertaken, gives a summary of the ground conditions encountered and then provides recommendations for the design of foundations and retaining walls. An environmental appraisal is then provided together with a site specific risk assessment and conceptual model.

2.0 SITE DESCRIPTION

The existing Richards Music Centre is located within the existing Highgate School campus on the eastern side of Bishopswood Road in Highgate, north London. The centre is a narrow, single-storey building, measuring about 7m x 60m with its centre at approximate NGR 528025E 187600N. To the south of the site is a 3-storey detached house (No 2 Bishopswood Road) and grounds, whilst to the east are the rear gardens of residential properties which front onto Highgate Close. An access road and open green area are present to the north, with an artificially surfaced sports pitch beyond. Bishopswood Road forms the western site boundary.

The ground surface slopes down very gently to the north, from about +113.5mOD on the southern boundary to about +112.75mOD at its northern extent; these levels are shown on the Highgate School drawing 'DH Options Studies' (HGS/101, Sept 15). The artificial pitch to the north is cut into the slope with an RC retaining wall, about 1.7m high delineating it from the site. Numerous mature and semi-mature deciduous trees are present to the south, east and west of the existing building. These include Lime and Sycamore trees which are up to approximately 15m in height.

The current site features are shown on the site plan and photographs which are included in Appendix A and the aerial photograph on the front cover.

3.0 GEO-ENVIRONMENTAL DESK STUDY

3.1 Envirocheck historical map pack and reports

An historical map and environmental database search was commissioned from Envirocheck to ascertain the site history/usage and surrounding land usage. An indication of the gradual development of the site over the years can be gained by a study of the historical maps (shown in Appendix B). The following table contains a summary of the site development obtained from the source maps provided in the Envirocheck historical maps.

Historical development of site and surrounding area		
Map date	The site and immediate surrounding areas	Significant development / features in surrounding area (generally within 250m)
1864-1879	- The site is shown to be an open undeveloped area - The area which includes the site and the slope to the north is delineated into discrete sections; possibly landscaping features or terracing	- General area appears to be residential - The National School is present to the north-east - A cricket ground is present about 50m-100m to the east 'The Parsonage' is present about 100m to the south-east - Several ponds within about 100m/120m radius and what appears to be a ditch draining the fields just to the north, into the ponds - Waterworks about 200m to the south-east
1896-1920	- The site is still undeveloped with no significant changes - Bishopswood Road is now present on the western boundary and Sussex House is identified immediately to the south (now No 2 Bishopswood Road) - In 1915 a small unidentified building is present within the south-eastern part of the site	- Field House and School House are present on the western side of Bishopswood Road - Some excavations/terracing appear to have taken place within the grounds of the National School to the east – presumably this was to provide level playing fields - A pond is identified about 180m to the north-east - The area to the north is identified as a cricket ground on the 1915 map

Historical development of site and surrounding area		
Map date	The site and immediate surrounding areas	Significant development / features in surrounding area (generally within 250m)
1935-present day	The present-day building is now present, identified as 'Pavilions'	- The property immediately to the south is now identified as Mansfield House - The landscaped/levelled area to the north-east is identified as a sports ground, becoming tennis courts from about 1952 (later identified as Highgate Lawn Tennis Club) - Highgate Close is present to the south-east from 1970 onwards

The relevant historical maps are included in Appendix B of this report.

The Envirocheck Report includes information from a database of local activities encompassing a range of subjects related to land use, pollution, and geological/hydrological conditions. A summary of contaminative uses and other environmental issues covered by the desk study within the site and its immediate surroundings (250m unless otherwise stated) is as follows:

AGENCY & HYDROLOGICAL

- Discharge consents: none within 250m. Nearest is 379m SE, trade effluent
- Local authority pollution prevention and controls: petrol filling station, 236m E
- Nearest surface water feature: 253m SW, issues (spring) flowing southwards
- Pollution incidents to controlled waters: none within 250m. Nearest is 364m SW, Cat 2 significant incident (oils)
- Groundwater vulnerability: soils of high leaching potential on site
- Drift deposits: none
- Bedrock aquifer designation: Secondary Aquifer – A
- Flooding: no risks identified
- Detailed river network lines: 253m SW, secondary river ('issues' discussed above)

WASTE

- Local authority landfill coverage: no data

GEOLOGICAL

- ✚ Solid geology: Thames Group
- ✚ BGS estimated/measured soil chemistry: no data for site
- ✚ Ground stability hazards: 'moderate' hazard potential for shrinking swelling clay on site. All other risks are low to negligible
- ✚ Radon potential: no radon protective measures required, <1% homes above action level

INDUSTRIAL LAND USE

- ✚ Contemporary trade directory entries: no entries within 200m. Nearest is 210m SW, hospital (inactive)
- ✚ Fuel station entries: 245m E, open petrol station

SENSITIVE LAND USE

- ✚ Local nature reserves and SSSIs: none within 250m

3.2 Walk-over survey

Our site walkover survey was undertaken on 31st March 2016. The development site (which comprised the Richards Music Centre and immediate surrounding area) was generally found to be in a clean and tidy state, with the exception of some building waste (including scrap plasterboard, metal etc), which was stored at the rear of the building. No fuel tanks or chemical containers were visibly obvious within the vicinity of the site. The immediate surrounding areas (within 250m) which included an artificial sports pitch to the north, residential buildings/gardens to the east and south and Highgate School buildings to the west, were also noted to be in a well-maintained and tidy state, as far as observed.

Overall, we have not identified any particular features (such as fuel tanks), materials (such as chemical containers) or land use within the site or in its immediate vicinity which are likely to give rise to significant contamination risks and we thus have no particular concerns in this regard. Photographs of the site taken during the walkover survey are presented in Appendix A.

4.0 EXPLORATORY WORK

The scope of the investigation was specified by Expedition/A-Squared Studio and the fieldwork was carried out in two phases in February and April 2016. The investigation comprised the following elements:

Cable percussive boreholes

Three cable percussive boreholes as follows:

Hole ID	Coordinates	Ground level	Total depth (below ground level)	Installations and notes
BH1	527997E 187610N	+112.70mOD	20m	 50mm ID pipe installed to 7.00m depth  SPT hammer $E_r = 76\%$
BH2	528028E 187615N	+112.80mOD	30m	 50mm ID pipe installed to 6.50m depth  Vibrating wire piezometers installed at 8.00m, 12.00m and 18.00m depth  SPT hammer $E_r = 73\%$
BH3	528049E 187610N	+112.90mOD	20m	 50mm ID pipe installed to 8.00m depth  SPT hammer $E_r = 73\%$

Sampling and in-situ testing (SPT) were carried out at regular intervals.

Trial pits

A summary of the trial pits is as follows:

Hole ID	Coordinates	Ground level	Depth (below ground level)	Notes
TP1	527995E 187603N	+112.9mOD	1.00m	 Hand excavated  To expose foundation of existing music centre
TP2				 To be completed
TP3	528011E 187613N	+112.85mOD	1.90m	 Machine excavated  To expose retaining wall heel
TP4	528047E 187622N	+112.75mOD	2.00m	 Machine excavated  To expose retaining wall heel
TP5	528024E 187610N	+112.75mOD	2.00m	 Machine excavated  To expose general ground sequence
TPS1	527990E 187603N	+113.0mOD	1.80m	 Soakage test generally in accordance with BRE Digest 365
TPS2	528058E 187613N	+112.90mOD	1.80m	 Soakage test generally in accordance with BRE Digest 365

Window sample boreholes

Three window sample boreholes were completed using hand-held/operated equipment under the supervision of a geotechnical engineer. A summary of the boreholes is as follows:

Hole ID	Coordinates	Ground level	Depth (below ground level)	Notes
WS1	527994E 187597N	+113.2mOD	4.00m	Monitoring pipe installed to base (35mmID)
WS2	528016E 187595N	+113.2mOD	4.00m	Monitoring pipe installed to base (35mmID)
WS3	528038E 187594N	+113.7mOD	4.00m	Monitoring pipe installed to base (35mmID)

Geotechnical laboratory testing

The following geotechnical laboratory testing was completed:

- Natural Moisture Content and index properties tests
- Unconsolidated, undrained triaxial tests
- Oedometer tests (K4 Soils Laboratory)
- Consolidated, undrained (CUP) triaxial compression tests (K4 Soils Laboratory)

The oedometer and CUP tests were scheduled by A-Squared Studio.

Contamination and chemical testing

Selected soil and groundwater samples were delivered to a specialist laboratory (QTS Environmental Ltd) and the following testing was carried out:

- General soil suite - 10no samples
- Waste Acceptance Criterion (WAC) - 2no samples
- Soluble sulphate/pH - 11no samples

The engineering logs of the exploratory holes and the geotechnical laboratory testing results are included in Appendix A. The ground levels at the exploratory locations have been interpolated from the Highgate School drawing HGS/101 (Sept 2015).

5.0 GROUND CONDITIONS

Reference to published BGS data indicates that the site is underlain by the Claygate Member resting upon the London Clay. Beneath variable made ground/superficial soils the investigation encountered an upper layer of essentially brown/grey mottled silty clay overlying dark grey clay silty sandy clay. For the purposes of this discussion we have identified the upper mottled clay layer as the Claygate Member and the underlying darker clay as the London Clay. In fact both of these sub-units are incorporated under the parent unit of the London Clay Formation. This sequence is illustrated on the appended cross section through the cable percussive boreholes.

5.1 Made ground

Either topsoil (300mm to 1000mm thick) or asphalt/concrete hard surfacing (up to 250mm thick) were generally present at the borehole and trial pit positions. The underlying made ground generally comprised brown/orange, light grey/brown, brown or grey silty sandy clay or clayey sand with variable amounts of gravel, brick/concrete fragments, clinker and occasional metal fragments. The clay soils were assessed as being of a firm, locally soft consistency.

Remote from the retaining wall along the northern boundary, the made ground generally extended to depths of <1.00m below ground level. In the vicinity of the wall, significantly greater thicknesses of made ground were present, with a maximum of 2.20m in BH2.

5.2 Superficial clay

Localised deposits of superficial clays were encountered, generally in the window sample boreholes located in the southern part of the site (WS2 and WS3). These deposits comprised soft or firm grey, light brown/grey and brown/orange mottled gravelly clay.

5.3 Claygate Member

This unit comprised variable weathered brown, brown/orange, light grey, dark brown and locally red/brown clay which was generally slightly silty to very silty and locally sandy; occasional silt parting were observed. Where its full thickness was proven, this stratum extended to depths of between 3.90m and 4.50m (ie between about +108mOD to +109mOD).

Plasticity tests indicate that the soils classify as High Plasticity (CH) in the BS5930 scheme, with a 'medium' to 'high' volume change potential in the NHBC scheme. Laboratory triaxial tests and SPT N values indicate the clay to be generally of medium to high strength.

5.4 London Clay

This formation was only encountered in the cable percussive boreholes and was met at depths of between 3.90m and 4.50m (approximately +108mOD to +109mOD). The formation comprised dark grey clay with a variable silt and sand content and with occasional to frequent silt/sand partings and scattered shell fragments. The upper parts may be representative of the unweathered Claygate Member but due to its gradational nature of the boundary is not easily identified. Below about 21.50m depth (BH1) the clay became dark greyish brown in colour with a lower silt/sand content

In-situ SPT and laboratory triaxial tests indicate the clay to be locally medium strength in its upper levels (BH1), becoming high strength then very high strength with depth. Index property testing indicated an intermediate to high plasticity classification using the BS scheme. This formation was present to the full 30m depth investigated.

5.5 Groundwater

During the drilling of the boreholes, slow groundwater inflows were recorded at various depths within the London Clay, the shallowest being at about 5m depth. A minor seepage occurred within made ground in TP4, resulting in a small pocket of accumulated water at the base of the pit. In the soakage test, TPS2, the water level rose slightly due to a slow inflow.

Observation pipes (35mm or 50mm ID) were installed in all boreholes to depths of between 4.00m and 7.00m, with response zones from 1.00m depth and the base of the pipe. Monitoring visits were carried out on three occasions and these indicated highly variable water levels, ranging between 0.61m and 2.41m depth. This range in water levels probably reflects the variability in silt/sand content in the predominantly clay soils and thus a variability in the permeability. The silt/sand partings within the clay, particularly below about 4m/5m depth will almost certainly be fully charged with groundwater with a relatively high horizontal permeability.

Vibrating wire piezometers were installed within BH2 at 8.00m, 12.00m and 18.00m depth below ground level. Monitoring of the piezometers was carried out by ITM Monitoring on three occasions (including the initial installation readings) on 17th February, 2nd March and 10th March 2016; the results are included in Appendix A. The piezometric levels on the latest visit varied between +109.97mOD and +110.45mOD, equivalent to between 2.35m and 2.83m depth below ground level. This relatively small range in piezometric levels suggests a probable hydrostatic distribution with hydraulic continuity from the surface to the deepest installation.

5.6 Environmental observations

No visual or olfactory evidence of significant contamination was observed in the exploratory holes.

5.7 Foundation trial pits

A summary of the exposed foundations is as follows:

Ref	Location	Observations
TP1	NW corner of existing building	 Concrete foundation at 0.80m depth  Supported by natural firm clay
TP2	Northern central part of existing building	 Cancelled
TP3	Retaining wall	 Upper surface of heel at 1.90m depth  Unable to establish base/depth of heel due to concrete obstructions
TP4	Retaining wall	 Upper surface of heel at 1.90m depth  Unable to establish base/depth of heel

6.0 GEOTECHNICAL ASSESSMENT

The proposed development scheme involves the demolition of the existing music centre and construction of a new 2-storey building to accommodate classrooms, theatre, library and offices. The current proposals envisage a single level basement at about 4m depth which will accommodate further classrooms, a rifle range, offices and plant areas. We understand that an alternative scheme which incorporates a 2-level basement may also be considered.

Expedition advise that the columns will be arranged on a grid of approximately 8m x 7m, and that loads of approximately 2750kN and 1800kN (DL+LL) are anticipated for internal and perimeter columns respectively.

The investigation has indicated that beneath a generally small thickness of made ground, the natural Claygate Member is present overlying the London Clay. Larger thicknesses of made ground were present near to the RC retaining wall along the northern boundary. Groundwater was measured at shallow depths in the monitoring installations, locally at <1m below ground level as shown on the appended cross section through the cable-percussion boreholes. It is perhaps not surprising that shallow groundwater conditions predominate when considering the evidence from old maps that there were a number of ponds nearby and the area to the north was drained by a ditch into ponds. This general area of relatively high ground also drains southwards (issues about 250m SW) into the Highgate Ponds.

For construction of the proposed basement we consider that an embedded retaining wall would present the best solution. For the single basement level option, consideration could possibly be given to the construction of a new RC basement wall in sequential open excavation. However, there would be significant attendant problems with this approach and these are discussed below. For a 2-level basement, we consider that an embedded wall will almost certainly be required.

Foundations for the new structure will depend upon the structural loads and configuration. In our opinion, piled foundations will present the optimum type. The individual column loads are considered to be too high for individual pad foundations, although we understand that consideration is also being given to the use of an RC raft basement level.

6.1 Retaining wall and basement excavation

The basement excavation will encounter made ground, localised superficial clay, clay of the Claygate Member and the London Clay. Groundwater was generally not observed at shallow levels when undertaking the boreholes and trial pits, but these were of relatively short duration with the inflows clearly taking some time to develop; subsequent monitoring of the borehole installations measured shallow standing levels at between 0.61m and 2.41m depth.

As discussed above, an embedded retaining structure such as a secant bored pile or steel sheet pile wall is considered to be the optimum type. A properly designed and dimensioned wall would provide an effective cut-off to groundwater and ensure stability of the excavation.

Consideration could possibly be given to the use of an RC panel wall, constructed in open excavation but this would depend crucially on the potential groundwater inflow and stability. Such a structure would need to be constructed sequentially with temporary support probably being necessary. Little groundwater was observed during the actual execution of the boreholes and trial pits, at least above 5m depth, and if short term inflows are very slow then there may be some merit in this type of construction. However, the influence of groundwater would clearly be critical in determining the feasibility of this approach. Whilst the soils are generally cohesive, those at basement level contain sand/silt horizons and some degree of groundwater inflow would be expected. In order to assess the viability of this approach, we would recommend advance trial excavations to the full basement depth by an experienced groundworks contractor and that these are left open for a reasonable period; this would allow an assessment of the groundwater conditions and the potential stability of the excavations.

Careful selection of design parameters, both temporary and long term will be needed to ensure overall stability of the new basement wall, incorporating allowances for factors such as the presence of high groundwater and the probability of soil softening. Deflection of the wall is unlikely to be critical expect in the vicinity of No 2 Bishopswood Road and the residential building to the east. The key to controlling ground movements outside the excavation will be to adopt a well-designed, robust arrangement of temporary bracings/props during construction. Of course, in the permanent condition, lateral support will be provided by the new basement and ground floor slabs.

The following table of coefficients may be used for the preliminary design of the basement retaining wall:

Stratum	Bulk density [Mg/m ³]	Effective cohesion, c' [kN/m ²]	Effective friction angle, ϕ' [degrees]
Made ground	1.80	0	22
Superficial clay	1.80	0	23
Claygate Member	2.00	0	22
London Clay			
<5m below basement slab	2.00	0	21
>5m below basement slab	2.00	5	21

The above preliminary parameters may be regarded as being 'moderately-conservative' estimates which in our experience are appropriate for these strata. Effective stress testing has been undertaken as part of this investigation (scheduled by A-Squared Studio) and the results may be used by a specialist designer to inform their own assessment of appropriate parameters.

The wall designer should use the parameters to derive the active and passive earth pressure coefficients, K_a and K_p . The determination of appropriate earth pressure coefficients, together with factors such as the pattern of earth pressure distribution, will depend upon the type/geometry of the wall and the overall design approach. Piled walls may of course also be used to provide vertical load capacity if required subject to the necessary allowance being made for interaction effects.

It is noted that a significant number of trees are present along the southern and western boundaries. The clay soils will be shrinkable and due consideration will need to be given to potential shrink/swell effects on the retaining wall. These could include either the incorporation of a compressible layer if appropriate or modification of the design parameters.

A specialist contractor should be consulted to confirm the most appropriate type of wall and to provide the final wall design.

6.2 Piled foundations

Piled foundations would transfer the structural loads to the London Clay at depth. For the ground and groundwater conditions encountered, with frequent seepages/inflows within the London Clay, we consider that Continuous-flight Auger-injected piles (CFA) are likely to be the most appropriate type. The following table of coefficients may be used for the preliminary design of CFA piles and, based upon the measured strength profile.

Shaft adhesion

Stratum	Depth	Undrained cohesion (from strength profile)	Ultimate unit shaft adhesion ' q_s '
All soils above basement level	Above say 5m depth (allow for pile cap)	N/A	Ignore
London Clay	Below 5m depth (about +108mOD)	Increases linearly from 70kPa at a rate of 8kPa/m	Increases linearly from 35kPa at a rate of 4kPa/m (incorporates $\alpha = 0.50$)

Notes:

- Unit shaft adhesion ' q_s ' = $\alpha \times c_u$ (where $\alpha = 0.50$ and c_u is the undrained cohesion from the design line)
- The α value of 0.5 is based upon 102mm diameter triaxial tests and this should not be varied
- The average shaft adhesion over the pile length should be limited to 110kN/m²
- The maximum value for unit shaft adhesion should be limited to 140kN/m²

End bearing

Stratum	Depth/level	Undrained cohesion (from strength profile)	Ultimate unit base resistance 'q _b '
London Clay	Below 15m depth (about +98mOD)	Increases linearly from 150kPa at a rate of 8kPa/m	Increases linearly from 1,350kPa at a rate of 72kPa/m (incorporates N _c = 9)

Notes:

- a) Unit base resistance in clay 'q_b' = N_c x c_u (where N_c = 9 and c_u is the equivalent undrained cohesion from the design line)

An overall Factor of Safety of 2.6 should be appropriate when applied to these ultimate parameters, in accordance with LDSA guidelines. As a preliminary guide to the use of the coefficients, we have calculated the capacities of single piles with a range of diameters terminating at various depths.

Pile diameter (mm)	Pile toe depth – note c (mbgl)	Pile toe level – note c (mOD)	Working load (kN)
300	15	+98	235
	20	+93	400
	25	+88	600
450	15	+98	380
	20	+93	635
	25	+88	940
600	15	+98	545
	20	+93	895
	25	+88	1315

Notes:

- a) Working load is calculated using F_{shaft} and F_{base} = 2.6
b) Concrete stress should be considered in the final design
c) Relative to assumed PPL at +113mOD
d) Ignores the contribution of all soils to 5m depth

The above examples are not recommendations for pile diameter/length but are intended to illustrate the use of the shaft and base parameters.

Eurocode 7 adopts a different approach, applying partial factors to the ultimate pile capacity. The pile resistance is calculated using the above parameters in accordance with EC7 (BS EN 1997-1:2004 and UK National Annex) for the ultimate limit state GEO Design Approach 1, Combinations 1 and 2. The following partial factors, as recommended in the UK National Annex, are applied:

- a] Model Factor, γ_{Rd} = 1.4 (Combinations 1 and 2)
b] Factor on shaft resistance, γ_s = 1.6 (Combination 2)
c] Factor on base resistance, γ_b = 2.0 (Combination 2)

The design engineer must ensure that the correct comparisons are made between the Design Actions and Design Resistances and that SLS checks are made.

A specialist piling contractor should be consulted to confirm the most appropriate piling technique and to provide the final pile design.

6.3 Raft foundation at basement level

Either the Claygate Member or the London Clay will be exposed at the proposed basement level. In their undisturbed state, these are expected to be relatively competent strata capable of supporting moderate structural loads. It must be noted however that these strata will be highly sensitive in the presence of groundwater with an appreciable risk of softening; this is discussed further below.

If the excavation can be carried out successfully without leading to softening of the foundation soils then consideration could be given to the use of an RC raft foundation to support the new building. No loadings have been provided but we would expect the new building to generate a UDL over the probable raft footprint of approximately 40kPa, which would be well within the capabilities of the natural soils. However, the feasibility of a raft will of course need to be verified and this will depend upon the structural arrangements of the new columns and the distribution/concentration of the loads. Due consideration would need to be given to potential soil heave and hydrostatic pressures and these are discussed further in Section 6.4 of this report. The depth of such foundations would be beyond the expected zone of influence of the nearby trees and no special precautions would be required in this respect.

The soils at formation level will be highly susceptible to softening and are likely to rapidly lose strength and become almost unworkable in the presence of significant groundwater. If a water-tight, deeply embedded retaining wall is adopted the risk would be lower although good construction techniques, such as the immediate placing of a blinding layer would still be required. It may simply be possible to undertake local deepening if softened material is present, to ensure that the foundations are supported by the stiff natural clay. This emphasises the need for full depth trial excavations, as recommended in the previous section, to allow an assessment of the likely response of the stress-relieved soils, the influence of groundwater and appropriate water control measures. Of course, such trial excavations could indicate that this approach is not practical and a piled foundation solution would then certainly be required throughout.

6.4 Basement excavation and soil heave

The proposed works will result in the removal of approximately 4m of soil for the single level basement. When taking into account the existing building, this could be equivalent to an unloading of approximately 100kPa (assume a 20kPa UDL for the building), potentially resulting in short and long term heave in the London Clay. Factors such as the length of the construction programme, the restraining effects of the retaining wall piles and the basement slab/raft stiffness will generally determine the amount of heave which could occur.

The basement slab could either be designed as a suspended structure, incorporating a void to accommodate potential heave, or as a ground-bearing slab designed to resist potential heave forces. A raft foundation

may result in a net unloading and potential ground movements would need to be assessed for this option. We understand that a ground movement analysis is to be carried out by A-Squared Studio to address soil heave in relation to basement slab or raft design and the potential differential movements which could occur if a mixed pile/raft solution is adopted.

It will be necessary to consider potential uplift of the slab due to potential hydrostatic pressures and in this respect the guidelines incorporated in BS8102:2009 should be followed. We recommend that a water level at say 1m depth is adopted for design. This would result in minimum uplift pressures of about 30kPa for the single level basement.

6.5 Foundation concrete

Low concentrations of soluble sulphates (2:1 soil/water extract) were measured in selected soil samples with near neutral pH values. The results fall into Site Design Class DS-1 of Table C2 given in BRE Special Digest 1 (2005) and with a 'mobile' ground water classification, this would result in buried concrete being designed in accordance with ACEC Site Class AC-1. However, the results suggest that pyrite is probably present with a significant number of samples (40% of those tested) containing oxidisable sulphides >0.3%. With the proposed excavation into the London Clay, we consider that there is a theoretical risk of oxidation occurring and therefore, as recommended by the BRE digest, determination of the characteristic value of Total Potential Sulphate (TPS) has been carried out. Using all of the results, this procedure results in a more onerous classification of ACEC Site Class AC-4. This classification should be used for concrete which could be exposed to disturbed ground which might be vulnerable to oxidation, for example any slab, raft or pile caps constructed at basement level.

7.0 ENVIRONMENTAL ASSESSMENT

This appraisal adopts the current UK practice which uses the Source-Pathway-Receptor methodology to assess contamination risks. For a site to be designated as contaminated a plausible linkage between any identified sources and receptors must be identified, ie whether significant pollution linkages (SPLs) are present. In considering the potential for contamination to cause a significant effect, the extent and nature of the potential source are assessed and pathways/receptors identified; without an SPL there is theoretically no risk to the receptors from contamination. The assessed risks to the various potential receptors are summarised in the tabulated Conceptual Site Model which forms Section 7.6 of this report.

7.1 Environmental setting and context

The Envirocheck report indicates a Bedrock Aquifer Designation of 'Secondary A'. No groundwater abstraction points or source protection zones are identified within the search buffer. The site is assessed as being of **low** Environmental Sensitivity.

7.2 Potential contamination sources (on-site and off-site)

The desk study has not identified any significant potential contamination sources within the site or its immediate surroundings. Some ground workings were identified to the east of the site but these appear to be associated with a levelling exercise to provide a sports area. We assess there to be a **low** risk of potential contaminative sources which could affect the site.

7.3 Contamination testing

In order to identify whether known or unknown sources within (and outside) the site have caused contamination, we have carried out testing on a series of soil and groundwater samples. The desk study has indicated that the main risk to the site and potential receptors is likely to be only the limited thickness of made ground present. Testing for a general range of contaminants was therefore initially undertaken.

The results were assessed where relevant against the DEFRA Soil Guideline Values (SGV) and the LQM/CIEH Generic Assessment Criteria (GAC) for Human Health Risk Assessment in which LQM/CIEH have derived additional SGVs from the current CLEA Model (2nd Edition, 2009). There are currently no published SGV's or GAC's for Extractable/Total Petroleum Hydrocarbons and the results were compared with the frequently used EA remedial target of 1,000mg/kg. The SGV for lead contamination has been withdrawn but Category 4 Screening Levels (C4SLs) recently introduced by DEFRA can be useful values for comparison with recorded results. C4SLs have also been useful for comparison with several other contaminants.

The contamination testing was carried out specifically for the purpose of providing a general guidance evaluation for the proposed development. Reference should be made to the foreword to the appended contamination test results in order to fully understand the context in which this discussion should be viewed.

There are no specific published guidelines for school use and we therefore assessed the results against the criteria for residential development.

Using these criteria the following results are of note:

-  **Lead:** one of the samples exhibited an elevated Lead concentration (2,950mg/kg) in relation to the DEFRA Cat 4 threshold of 310mg/kg
-  **Petroleum hydrocarbons:** generally low in all samples
-  **Polycyclic Aromatic Hydrocarbons:** generally low in all samples
-  **Asbestos:** loose fibres (crocidolite) detected in one sample of made ground

The results of the testing suggest that there is no widespread contamination present at the borehole positions. However, a localised high lead concentration has been measured and asbestos was identified in one sample. It should be noted of course that there may of course be pockets of undetected contamination between exploratory points. The implications of the contamination results are discussed below.

7.4 Disposal of excavated soils

A rigorous hazard assessment of the results was not within the scope of our investigation, but our preliminary conclusion from the contamination testing and WAC testing is that the made ground will probably classify as either 'inert' or 'non-hazardous industrial' waste with an 'inert' classification for natural soils. The presence of a localised elevated concentration of lead and the presence of asbestos will affect the classification for some of the soils and additional testing is likely to be required during excavation to confirm the disposal classification. Early consultations must be made with appropriate waste facilities or regulators to confirm the requirements for off-site disposal and any additional testing which may be required.

7.5 Ground gas

No significant ground gas risk was identified by the desk study and no degradable soils were observed during the investigation. Gas monitoring was undertaken and the results are included in Appendix A. The concentrations of methane, carbon monoxide and hydrogen sulphide were very low to negligible and we consider that the risk with respect to these gases is relatively low. However, the concentration on carbon dioxide was locally elevated with concentrations of >5% in a number of instances.

Whilst 100% of the made ground is likely to be removed from within the building footprint during basement excavation, there will be a residual risk of lateral gas migration into the basement void. In view of the proposed usage, ie theatre, offices and classrooms, we consider that there will be some risk to the end-user. We therefore consider that it would be advisable to incorporate gas protection measures into the basement wall structure to mitigate this risk. On the basis of the monitoring carried out to date, we consider that Characteristic Situation 2 should be adopted (as described in CIRIA C665 "Assessing risks posed by hazardous ground gases to buildings", 2007) and appropriate protection measures designed. Further monitoring should be carried out and we would recommend that at least three additional visits are made. The risk level should be revised if required following additional monitoring.

7.6 Risk Assessment and Conceptual Model

Taking into account the above discussion, the assessed risks to potential receptors are summarised as follows:

Source/ hazard	Pathway	Receptor	Mitigation measures/explanation	Assessed Risk level
Contaminated soil: on-site and off-site sources	Ingestion/contact	End user and construction workers	The desk study has identified no significant potential contamination sources within the site or its vicinity Whilst a localised elevated concentration of lead was measured, together with one occurrence of fibrous asbestos, the whole of the made ground, which is likely to be the only probable source of contamination, will be removed during basement excavation. Therefore there will be no SPL and no risk to the end-user Appropriate PPE must be worn by construction workers and the site H&S manual should specifically address the potential localised presence of asbestos and lead	LOW
Contaminated soil: on-site sources	Migration of contaminated ground water and/or surface run-off through contaminated fill into aquifer	Aquifer and surface water	A Secondary-A aquifer designation applies to the 'bedrock' No surface/groundwater abstraction points or source protection zones were identified The desk study has identified no significant potential contamination sources within the site or its vicinity Whilst a localised elevated concentration of lead was measured, together with one occurrence of fibrous asbestos, the whole of the made ground, which is likely to be the only probable source of contamination, will be removed during basement excavation. Therefore there will be no SPL and no risk to the surface or groundwater	LOW

In conclusion, based upon the information reviewed and the results of the investigation, our assessment is that the residual risks to potential receptors should be **LOW** provided appropriate remedial measures are adopted. It is self-evident that there may be zones of contamination within the site which were not encountered in our boreholes. A careful watching brief should be kept during construction and if obvious or suspected contamination is encountered this should be dealt with prescriptively; a suitable contingency should be in place in this regard.



GENERAL INFORMATION, LIMITATIONS AND EXCEPTIONS

Unless otherwise stated, our Report should be construed as being a Ground Investigation Report (GIR) as defined in BS EN1997-2. Our Report is not intended to be and should not be viewed or treated as a Geotechnical Design Report (GDR) as defined in EN1997-2. Any 'design' recommendations which are provided are for guidance only and are intended to allow the designer to assess the results and implications of our investigation/testing and to permit preliminary design of relevant elements of the proposed scheme.

The methods of investigation used have been chosen taking into account the constraints of the site including but not limited to access and space limitations. Where it has not been possible to reasonably use an EC7 compliant investigation technique we have adopted a practical technique to obtain indicative soil parameters and any interpretation is based upon our engineering experience and relevant published information.

The Report is issued on the condition that Soil Consultants Ltd will under no circumstances be liable for any loss arising directly or indirectly from ground conditions between the exploratory points which differ from those identified during our investigation. In addition Soil Consultants Ltd will not be liable for any loss arising directly or indirectly from any opinion given on the possible configuration of strata both between the exploratory points and/or below the maximum depth of the investigation; such opinions, where given, are for guidance only and no liability can be accepted as to their accuracy. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in using this Report.

Comments made relating to ground-water or ground-gas are based upon observations made during our investigation unless otherwise stated. Ground-water and ground-gas conditions may vary with time from those reported due to factors such as seasonal effects, atmospheric effects and and/or tidal conditions. We recommend that if monitoring installations have been included as part of our investigation, continued monitoring should be carried out to maximise the information gained.

Specific geotechnical features/hazards such as (but not limited to) areas of root-related desiccation and dissolution features in chalk/soluble rock can exist in discrete localised areas - there can be no certainty that any or all of such features/hazards have been located, sampled or identified. Where a risk is identified the designer should provide appropriate contingencies to mitigate the risk through additional exploratory work and/or an engineered solution.

Where a specific risk of ground dissolution features has been identified in our Report (anything above a 'low' risk rating), reference should be made to the local building control to establish whether there are any specific local requirements for foundation design and appropriate allowances should be incorporated into the design. If such a risk assessment was not within the scope of our investigation and where it is deemed that the ground sequence may give rise to such a risk (for example near-surface chalk strata) it is recommended that an appropriate assessment should be undertaken prior to design of foundations.

Where spread foundations are used, we recommend that all excavations are inspected and approved by suitably experienced personnel; appropriate inspection records should be kept. This should also apply to any structures which are in direct contact with the soil where the soil could have a detrimental effect on performance or integrity of the structure.

Ground contamination often exists in small discrete areas - there can be no certainty that any or all such areas have been located, sampled or identified.

The findings and opinions conveyed in this Report may be based on information from a variety of sources such as previous desk studies, investigations or chemical analyses. Soil Consultants Limited cannot and does not provide any guarantee as to the authenticity, accuracy or reliability of such information from third parties; such information has not been independently verified unless stated in our Report.

Our Report is written in the context of an agreed scope of work between Soil Consultants Ltd and the Client and should not be used in any different context. In light of additional information becoming available, improved practices and changes in legislation, amendment or re-interpretation of the assessment or the Report in part or in whole may be necessary after its original publication.

Unless otherwise stated our investigation does not include an arboricultural survey, asbestos survey, ecological survey or flood risk assessment and these should be deemed to be outside the scope of our investigation.

(Rev_1_08_03_2013)

APPENDIX A

Fieldwork, in-situ testing and monitoring

-  Cable percussive borehole records
-  Standard Penetration Test results
-  SPT hammer energy rating certificate
-  Window sample records
-  Trial pit records
-  Trial pit soakage test records
-  Monitoring records (observation pipe and vibrating wire piezometer)

FOREWORD FOR CABLE PERCUSSIVE DRILLING - GUIDANCE NOTES

GENERAL

The Borehole Records are compiled from the driller's description of the strata encountered, an examination of the samples by our Geotechnical Engineer and the results of in-situ and laboratory tests. Based on this data, the report presents an opinion on the configuration of strata within the site. However, such reasonable assumptions are given for guidance only and no liability can be accepted for changes in conditions not revealed by the boreholes.

BORING METHODS

The Cable Percussion technique of boring is normally employed and allows the ground conditions to be reasonably well established. However, some disturbance of the ground is inevitable, particularly some "softening" of the upper zone of clay immediately beneath a granular soil. The presence of thin layers of different soils within a stratum may not always be detected.

GROUND WATER

The depth at which ground water was struck is entered on the Borehole Records. However, this observation may not indicate the true water level at that period. Due to the speed of boring and the relatively small diameter of the borehole, natural ground water may be present at a depth slightly higher than the water strike. Moreover, ground water levels are subject to variations caused by changes in the local drainage conditions and by seasonal effects. When a moderate inflow of water does take place, boring is suspended for at least 10 minutes to enable a more accurate short-term water level to be achieved. An estimate of the rate of inflow is also given. This is a relative term and serves only as a guide to the probable flow of water into an excavation.

Further observations of the water level made during the progress of the borehole are shown including end of shift and overnight readings and the depth at which water was sealed off by the borehole casing, if applicable.

Whilst drilling through granular soils, it is usually necessary to introduce water into the borehole to permit their extraction. When additional water has been used a remark is made on the Borehole Record and the implications are discussed in the text.

SAMPLES

Undisturbed samples of the predominantly cohesive soils are obtained using a 100mm diameter open-drive sampler. In granular soils, disturbed bulk samples are taken and placed in polythene bags. Small jar samples are taken at frequent intervals in all soils for subsequent visual examination. Where ground water is encountered in sufficient quantity, a sample of the ground water is also taken.

IN-SITU STANDARD PENETRATION TESTS

This test is performed in accordance with the procedure given in B.S.1377:1990. The individual blow count record for each test is given on a separate table. The 'N' value is normally the number of blows to achieve a penetration of 0.3m following a seating distance of 0.15m and is quoted at the mid-depth of the test zone. However if a change of stratum occurs within the test zone then a revised 'N' value is calculated to assess one layer in particular. In hard strata full penetration may not be obtained. In such cases the suffix + indicates that the result has been extrapolated from the limited penetration achieved. Where ground water has affected the measured values, the resultant 'N' values have been placed in brackets since it is unlikely to represent the true in-situ density of the soil.

Highgate School - Richards Music Centre							Borehole No: BH1		
Site & Location: Bishopswood Road, London N6 4PR									
Client: Highgate School					Coordinates: 527997E, 187610N		Sheet 1 of 2		
Engineer: Expedition/A-Squared Studio					Ground Level: +112.70mOD		Report No: 9933/JRCB		
Progress & Observations	Samples & Tests		Field Test Results	Strata		Legend	Strata Descriptions	Backfill / Installation	
	Type	Depth (m)		Depth (m)	Level (m)				
BH commenced: 17/02/16 BH/casing dia: 150mm	B	0.50					Turf over dark brown slightly sandy TOPSOIL with occasional brick and flint gravel		
Hand excavated inspection pit to 1.20m	D	1.10		1.00	111.70		MADE GROUND: orange/brown, light grey/brown and brown mottled clay with occasional flint gravel and brick		1
	U	1.20		1.45	111.25				
	D	1.70					Firm brown/orange and light grey mottled slightly silty CLAY, locally very silty		2
Chiselling on claystone: 2.90m and 3.05m (15 mins)	SPT/S	2.20	N=10				...below 2.20m becoming orangish brown, locally mottled light grey		
	D	2.20	N60=13						
	U	3.20							3
Groundwater inflow at 5.00m - rose to 4.90m (20 mins) - sealed at 5.50m	D	3.70							
	SPT/S	4.20	N=10				...at 4.20m becoming dark grey slightly sandy clay		4
	D	4.20	N60=13	4.50	108.20		Firm becoming stiff dark grey slightly sandy CLAY with frequent pockets and partings of fine light grey sand. Locally silty		5
Groundwater inflow at 6.50m - rose to 6.30m (20 mins) - sealed at 7.20m	D	5.20							
	U	5.70							6
	D	6.20							
Groundwater inflow at 8.75m - rose to 8.60m (20 mins) - sealed at 9.20m	D	6.70							
	SPT/S	7.20	N=19						7
	D	7.20	N60=24						
	D	8.20							8
	U	8.70							
	D	9.20							9
	D	9.70							
				10.00	102.70		Continued on next sheet		10
Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub SPT/S = split spoon SPT/C = solid cone HV = Hand Vane [kPa] PP = Pocket Penetrometer [kg/cm²] PID = Photo Ionisation Detector [ppmv] * = full SPT penetration not achieved - see summary sheet								Borehole type: Cable Percussion	
Remarks: a) Monitoring pipe (50mm ID) installed to 7.00m								Borehole No: BH1	

Highgate School - Richards Music Centre							Borehole No: BH1		
Site & Location: Bishopswood Road, London N6 4PR									
Client: Highgate School					Coordinates: 527997E, 187610N		Sheet 2 of 2		
Engineer: Expedition/A-Squared Studio					Ground Level: +112.70mOD		Report No: 9933/JRCB		
Progress & Observations	Samples & Tests		Field Test Results	Strata		Legend	Strata Descriptions	Backfill / Installation	
	Type	Depth (m)		Depth (m)	Level (m)				
Groundwater inflow at 13.00m - rose to 12.80m (20 mins) - sealed at 13.50m BH cased to 13.50m	SPT/S D	10.20 10.20	N=22 N60=28	12.50	100.20		Stiff becoming very stiff dark grey slightly sandy CLAY with frequent pockets and partings of fine light grey sand		
	D	11.20							
	U	11.70							
	D	12.20							
	D	12.70							Very stiff dark grey slightly sandy CLAY with frequent partings of fine light grey sand. Locally silty
	SPT/S D	13.20 13.20	N=27 N60=34						
	D	14.20							
	U	14.70							
	D	15.20							
	D	15.70							
SPT/S D	16.20 16.20	N=31 N60=39		<u>...below 15.70m with rare shell fragments</u>					
D	17.20								
U	17.70								
D	18.20								
Chiselling on claystone: 17.30m and 17.50m (15 mins)	D	18.70							
	SPT/S D	19.55 19.55	N=34 N60=43						
BH complete: 17/02/16 (dry)				20.00	92.70		End of borehole at 20.00m		
Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub SPT/S = split spoon SPT/C = solid cone HV = Hand Vane [kPa] PP = Pocket Penetrometer [kg/cm²] PID = Photo Ionisation Detector [ppmv] * = full SPT penetration not achieved - see summary sheet								Borehole type: Cable Percussion	
Remarks: a) Monitoring pipe (50mm ID) installed to 7.00m								Borehole No: BH1	

Highgate School - Richards Music Centre Site & Location: Bishopswood Road, London N6 4PR							Borehole No: BH2	
Client: Highgate School					Coordinates: 528028E, 187615N		Sheet 1 of 3	
Engineer: Expedition/A-Squared Studio					Ground Level: +112.80mOD		Report No: 9933/JRCB	
Progress & Observations	Samples & Tests		Field Test Results	Strata		Legend	Strata Descriptions	Backfill / Installation
	Type	Depth (m)		Depth (m)	Level (m)			
BH commenced: 15 Feb 2016 BH/casing dia: 150mm Hand excavated inspection pit to 1.20m	D	0.40					Turf over dark brown slightly sandy TOPSOIL with occasional brick of flint and gravel	
	D	0.70		0.70	112.10		MADE GROUND: brown/orange, light brown, grey and dark brown mottled clay with occasional gravel of flint and brick	
	D	1.00		1.00	111.80		MADE GROUND: brown and grey mottled clay with frequent subangular cobbles of brick and concrete	1
	SPT/S B	1.20 1.20	N=7 N ₆₀ =9					
	SPT/S B	2.00 2.00	N=7 N ₆₀ =9	2.20	110.60		Firm to stiff brown and brown/orange slightly silty CLAY with frequent veins of light grey clay and occasional silt partings. Locally silty	2
	U	3.00						3
	D	3.45						
	SPT/S D	4.00 4.00	N=12 N ₆₀ =15	4.30	108.50		Stiff dark grey slightly sandy CLAY with frequent pockets and partings of fine light grey sand. Locally silty and sandy	4
	D	4.60						5
	U	5.00						
Groundwater inflow at 5.60m - rose to 5.40m (20 mins) - sealed at 7.50m	D	5.45						6
	D	6.00					...at 6.0m locally with pockets of bluish grey clay and occasional decayed wood fragments	
	SPT/S D	6.50 6.50	N=22 N ₆₀ =27					7
	D	7.50						
	SPT/S D	8.00 8.00	N=24 N ₆₀ =29					8
Groundwater inflow at 8.00m, - rose to 7.80m; (20 mins) - sealed at 10.10m	D	9.00						9
	U	9.50						
	D	9.95 10.00		10.00	102.80			10
Continued on next sheet								
Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub SPT/S = split spoon SPT/C = solid cone HV = Hand Vane [kPa] PP = Pocket Penetrometer [kg/cm²] PID = Photo Ionisation Detector [ppmv] * = full SPT penetration not achieved - see summary sheet							Borehole type: Cable Percussion	
Remarks: a) Monitoring pipe (50mm ID) installed to 6.50m b) Vibrating wire piezometers installed at 8m, 12m and 18m depth							Borehole No: BH2	

Highgate School - Richards Music Centre							Borehole No: BH2					
Site & Location: Bishopswood Road, London N6 4PR												
Client: Highgate School					Coordinates: 528028E, 187615N		Sheet 3 of 3					
Engineer: Expedition/A-Squared Studio					Ground Level: +112.80mOD		Report No: 9933/JRCB					
Progress & Observations	Samples & Tests		Field Test Results	Strata		Legend	Strata Descriptions	Backfill / Installation				
	Type	Depth (m)		Depth (m)	Level (m)							
BH cased to 23.50m	D	20.45	N=35 N ₆₀ =43	21.50	91.30		Very stiff dark grey silty slightly sandy CLAY with frequent partings of light grey fine sand. Locally very silty with occasional shell fragments					
	D	21.00					21					
	SPT/S	21.50					N=38 N ₆₀ =46		24.50	25	Very stiff dark greyish brown fissured CLAY, locally slightly silty. Occasional shell fragments	22
	D	21.50										
	D	22.50										
	U	23.00	23									
	D	23.45		24								
	D	24.00										
	SPT/S	24.50	N=41 N ₆₀ =50		27.50		28		Very stiff dark greyish brown fissured CLAY, locally slightly silty. Occasional shell fragments	25		
	D	24.50										
	D	25.50		26								
	U	26.00	27									
	D	26.45		28								
	D	27.00										
	SPT/S	27.50	29									
D	27.50											
D	28.50	29										
BH completed: 16 Feb 2016 BH dry upon completion	U	29.00	30.00	82.80		...at 25.50m locally slightly silty	30					
	D	29.45				...below 26.45m with rare shell fragments						
	D	30.00				...at 28.50m locally slightly silty						
End of borehole at 30.00m												
Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub SPT/S = split spoon SPT/C = solid cone HV = Hand Vane [kPa] PP = Pocket Penetrometer [kg/cm ²] PID = Photo Ionisation Detector [ppmv] * = full SPT penetration not achieved - see summary sheet												
Remarks: a) Monitoring pipe (50mm ID) installed to 6.50m b) Vibrating wire piezometers installed at 8m, 12m and 18m depth												
Borehole type: Cable Percussion Borehole No: BH2												

Highgate School - Richards Music Centre Site & Location: Bishopswood Road, London N6 4PR							Borehole No: BH3	
Client: Highgate School					Coordinates: 528049E, 187610N		Sheet 1 of 2	
Engineer: Expedition/A-Squared Studio					Ground Level: +112.90mOD		Report No: 9933/JRCB	
Progress & Observations	Samples & Tests		Field Test Results	Strata		Legend	Strata Descriptions	Backfill / Installation
	Type	Depth (m)		Depth (m)	Level (m)			
BH commenced: 17 Feb 2016 BH/casing dia: 150mm Hand excavated inspection pit to 1.20m	B	0.40		0.40	112.50		MADE GROUND: Turf over dark brown, brown/orange and light grey/brown clay with occasional gravel of brick and flint	
	U	1.20					Firm brown, brown/orange and light grey mottled slightly silty CLAY. Occasional silt partings	
	D	1.65						
	SPT/S	2.00	N=8				...below 2.0m becoming orangish brown with frequent bluish grey gleying	
Groundwater inflow at 5.10m: - rose to 5.00m (20 mins) - sealed at 6.00m	D	2.00	N ₆₀ =10					
	U	3.00						
	D	3.50						
	SPT/S	3.90	N=10	3.90	109.00		Firm becoming stiff dark grey slightly sandy CLAY with frequent pockets and partings of light grey fine sand. Locally silty	
	D	4.00	N ₆₀ =12					
	U	5.00						
	D	5.45						
	D	6.00						
Groundwater inflow at 7.40m: - rose to 7.20m (20 mins) - sealed at 8.00m	SPT/S	6.50	N=18					
	D	6.50	N ₆₀ =22					
	U	8.00						
	D	8.45					...at 8.45m locally very sandy clay to clayey sand	
	D	9.00						
	SPT/S	9.50	N=19					
	D	9.50	N ₆₀ =23					
				10.00	102.90		Continued on next sheet	
Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub SPT/S = split spoon SPT/C = solid cone HV = Hand Vane [kPa] PP = Pocket Penetrometer [kg/cm ²] PID = Photo Ionisation Detector [ppmv] * = full SPT penetration not achieved - see summary sheet								Borehole type: Cable Percussion
Remarks: a) Monitoring pipe (50mm ID) installed to 7.00m								Borehole No: BH3

Highgate School - Richards Music Centre							Borehole No: BH3	
Site & Location: Bishopswood Road, London N6 4PR								
Client: Highgate School				Coordinates: 528049E, 187610N			Sheet 2 of 2	
Engineer: Expedition/A-Squared Studio				Ground Level: +112.90mOD			Report No: 9933/JRCB	
Progress & Observations	Samples & Tests		Field Test Results	Strata		Legend	Strata Descriptions	Backfill / Installation
	Type	Depth (m)		Depth (m)	Level (m)			
Groundwater strike at 10.20m; rising to 10.00m; sealed out at 10.50m End of shift 17 Feb 2016 BH depth: 12.0m BH dry Start of shift 18 Feb 2016 Groundwater depth: 2.10m Groundwater seepage at 14.80m BH completed: 18 Feb 2016 BH dry upon completion	D	10.50	N=23 N60=28			Stiff dark grey slightly sandy CLAY with frequent pockets and partings of light grey fine sand. Locally very silty		11
	U	11.00						
	D	11.45						
	D	12.00						
	SPT/S	12.50						
	D	12.50						
	D	13.50						
	U	14.00						
	D	14.45						
	D	15.00						
	SPT/S	15.50	N=27 N60=33	15.00	97.90	Very stiff dark grey silty slightly sandy CLAY with frequent partings of light grey fine sand. Locally very silty and sandy		15
	D	15.50						
	D	16.50						
	U	17.00						
	D	17.45						
	D	18.00						
	SPT/S	18.50						
	D	18.50						
	U	19.50						
	D	20.00						
End of borehole at 20.00m							20	
Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub SPT/S = split spoon SPT/C = solid cone HV = Hand Vane [kPa] PP = Pocket Penetrometer [kg/cm²] PID = Photo Ionisation Detector [ppmv] * = full SPT penetration not achieved - see summary sheet								
Remarks: a) Monitoring pipe (50mm ID) installed to 7.00m								
Borehole type: Cable Percussion Borehole No: BH3								

Site & Location	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Report No:	9933 / JRCB
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STANDARD PENETRATION TEST SUMMARY

BH ID	Depth [m]	Test type	'N' value and blow-counts [Seating blows/Test blows]	N ₆₀	N ₆₀ - ext	Casing depth [m]	Water depth [m]	Remarks
BH1	2.20	S	N = 10 :1 1/ 2 2 3 3	11		1.50	DRY	
BH1	4.20	S	N = 10 :1 2/ 2 2 3 3	11		1.50	DRY	
BH1	7.20	S	N = 19 :1 2/ 4 4 5 6	21		7.20	DRY	
BH1	10.20	S	N = 22 :2 3/ 4 5 6 7	24		9.20	DRY	
BH1	13.20	S	N = 27 :3 3/ 5 7 7 8	29		9.20	13.00	
BH1	16.20	S	N = 31 :4 5/ 6 8 8 9	34		13.50	DRY	
BH1	19.55	S	N = 34 :5 5/ 7 8 9 10	37		13.50	DRY	
BH2	1.20	S	N = 7 :1 2/ 2 2 2 1	9		0.00	DRY	
BH2	2.00	S	N = 7 :1 1/ 1 3 2 1	9		2.00	DRY	
BH2	4.00	S	N = 12 :2 2/ 3 3 3 3	15		3.00	DRY	
BH2	6.50	S	N = 22 :3 4/ 5 5 5 7	27		6.00	6.30	
BH2	8.00	S	N = 24 :3 4/ 5 5 6 8	29		7.50	7.80	
BH2	11.00	S	N = 26 :4 4/ 6 6 7 7	32		10.50	10.80	
BH2	12.50	S	N = 28 :4 4/ 6 7 7 8	34		12.00	12.20	
BH2	15.50	S	N = 33 :4 5/ 7 8 8 10	40		15.00	15.30	
BH2	18.50	S	N = 31 :5 5/ 7 8 8 8	38		18.00	18.10	
BH2	21.50	S	N = 35 :6 6/ 8 8 8 11	43		21.00	21.30	
BH2	24.50	S	N = 38 :6 6/ 8 9 9 12	46		24.00	DRY	
BH2	27.50	S	N = 41 :7 8/ 9 10 10 12	50		27.00	DRY	
BH3	2.00	S	N = 8 :1 1/ 2 2 2 2	10		1.50	DRY	
BH3	4.00	S	N = 10 :1 2/ 2 2 3 3	12		3.00	DRY	
BH3	6.50	S	N = 18 :2 3/ 4 4 5 5	22		6.00	DRY	
BH3	9.50	S	N = 19 :3 3/ 4 5 5 5	23		9.00	DRY	
BH3	12.50	S	N = 23 :3 4/ 5 6 5 7	28		12.00	DRY	
BH3	15.50	S	N = 27 :4 5/ 6 6 7 8	33		12.00	15.40	
BH3	18.50	S	N = 30 :4 5/ 7 7 7 9	37		12.00	18.40	

Standard Penetration Test : BS EN ISO 22476:2005 Part 3

Hammer Energy Ratio, Er = 76% (BH1) and 73% (BHs 2 and 3)

* where full penetration not achieved, the reported N₆₀ is based on maximum uncorrected blow-counts of 50

** extrapolated N₆₀ value where full penetration not achieved - this is indicative only and should be used with caution

[SPT Sheet 1 of 1]



Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

Dynamic sampling uk ltd
6-8 victory parkway
victory road
Derby
DE24 8ZF

Hammer Ref: CTJ 1.A
Test Date: 26/01/2015
Report Date:
File Name: CTJ 1.A.spt
Test Operator: TP

Instrumented Rod Data

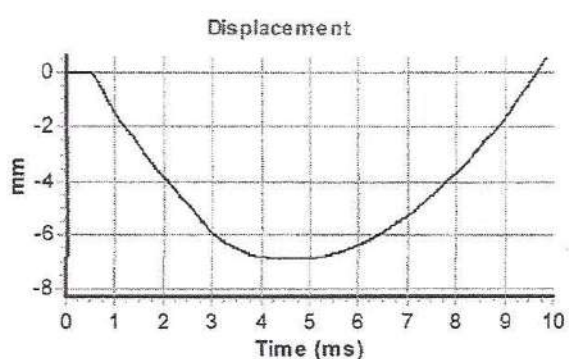
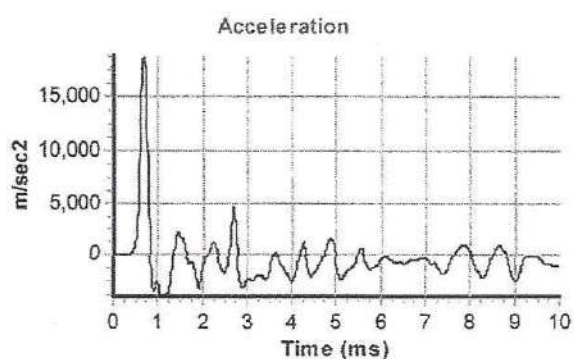
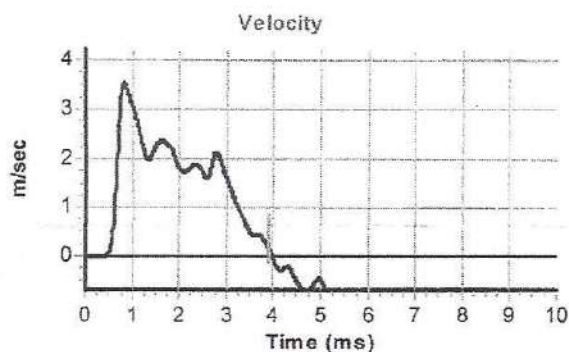
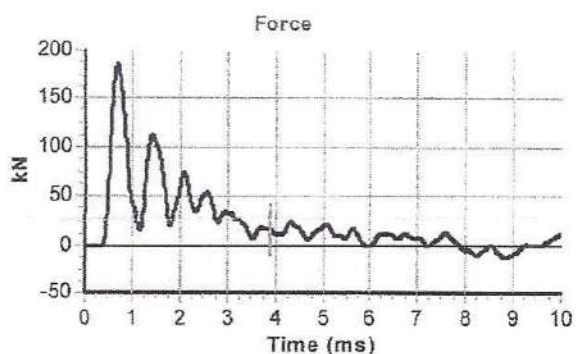
Diameter d_r (mm): 54
Wall Thickness t_r (mm): 6.9
Assumed Modulus E_a (GPa): 208
Accelerometer No.1: 6455
Accelerometer No.2: 6457

Hammer Information

Hammer Mass m (kg): 63.5
Falling Height h (mm): 760
String Length L (m): 15.0

Comments / Location

Hammer tested at Dynamic samplings yard.



Calculations

Area of Rod A (mm^2): 1021
Theoretical Energy E_{theor} (J): 473
Measured Energy E_{meas} (J): 361

Energy Ratio E_r (%): **76**

Signed: A.parker
Title: Manager

The recommended calibration interval is 12 months

SPT Calibration Report

Hammer Energy Measurement Report

Type of Hammer SPT HAMMER
 Client T BEDFORD
 Test No EQU1249
 Test Depth (m) 21.05
 Date of Test 14 April 2015
 Valid until 13 April 2016
 Hammer ID TB02

Mass of the hammer $m = 63.5\text{kg}$
 Falling height $h = 0.76\text{m}$
 $E_{\text{theor}} = m \times g \times h = 473\text{J}$

Characteristics of the instrumented rod

Diameter $d_r = 0.052\text{ m}$
 Length of the instrumented rod 0.558 m
 Area $A = 11.61\text{ cm}^2$
 Modulus $E_a = 206843\text{ MPa}$

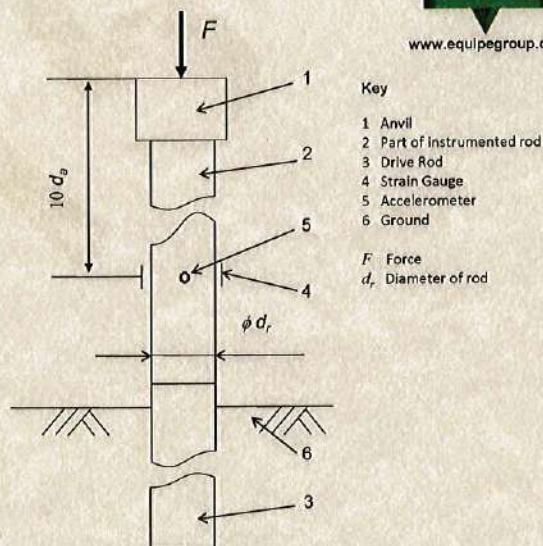
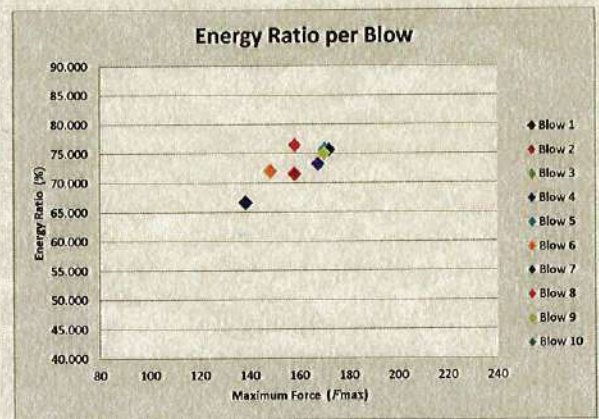
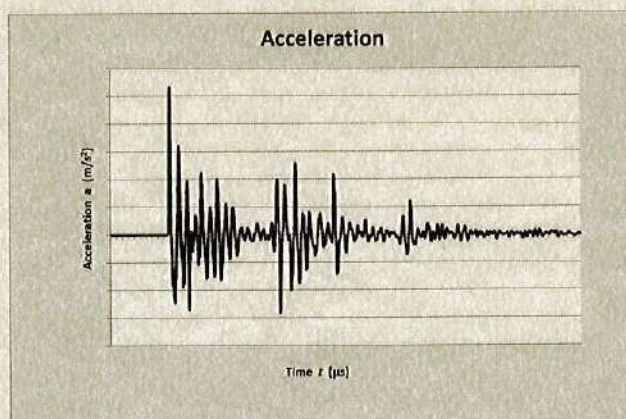
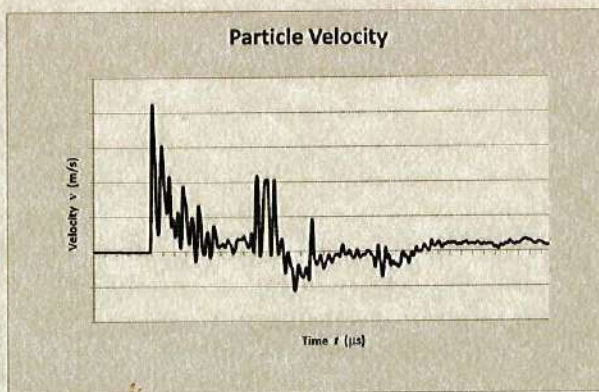
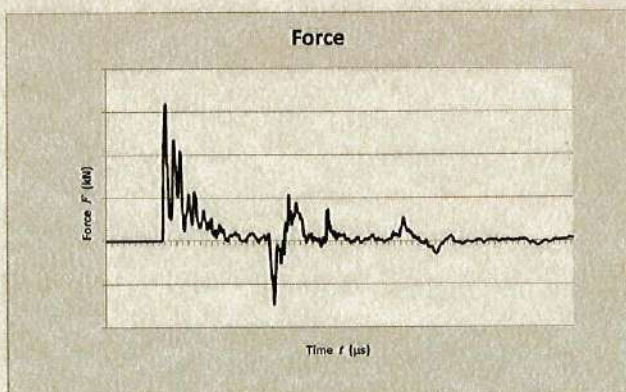


Fig. B.1 and B.2 BS EN ISO 22476-3 : 2005 + A1 : 2011



Observations:

1. Heavily oiled hammer.

$E_{\text{meas}} = 0.345\text{ kN-m}$

$E_{\text{theor}} = 0.473\text{ kN-m}$

$$\text{Energy Ratio} = \frac{E_{\text{meas}}}{E_{\text{theor}}} = 73.01\%$$

Equipe SPT Analyzer Operators: MH

Prepared by:

Epies

Checked by:

H. Spies

Date

15/04/2015

Highgate School - Richards Music Centre							Borehole No: WS1	
Site & Location: Bishopswood Road, London N6 4PR								
Client: Highgate School				Coordinates: 527994E, 187597N		Sheet 1 of 1		
Engineer: Expedition/A-Squared Studio				Ground Level: +113.20mOD		Report No: 9933/JRCB		
Progress & Observations	Samples & Tests		Field Test Results	Strata		Legend	Strata Descriptions	Backfill / Installation
	Type	Depth (m)		Depth (m)	Level (m)			
BH carried out: 19/02/16							MADE GROUND: concrete [100mm] over dark brown slightly gravelly clayey sand. Gravel is fine to coarse brick and flint	
BH dia: 90mm from GL to 1.0m; reducing with depth	E	0.50					...below 0.50m; becoming brown to light brown	
				0.90	112.30			
	D	1.00					Firm brown/orange, brown and light grey mottled CLAY with occasional rounded, fine to coarse flint gravel. Live roots to 2.00m	1
	E	1.00						
	HV	1.30	66					
	HV	1.50	60					
	D	1.50						
	HV	1.70	62					
	HV	1.90	54					
	E	2.00						2
	HV	2.10	78				...at 2.10m; locally stiff	
	D	2.10						
	HV	2.30	74					
	D	2.50						
	HV	2.80	66					
	HV	3.00	60				...below 3.0m; with frequent partings of brown/orange sand	3
	E	3.00						
	D	3.10						
	HV	3.20	64					
	HV	3.40	70					
	D	3.50						
	HV	3.60	90	3.60	109.60		Stiff dark brown/grey, mottled red/brown, slightly sandy CLAY	
	HV	3.80	90					
BH dry upon completion	E	4.00		4.00	109.20		End of borehole at 4.00m	4
								5
Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub SPT/S = split spoon SPT/C = solid cone HV = Hand Vane [kPa] PP = Pocket Penetrometer [kg/cm²] PID = Photo Ionisation Detector [ppmv] * = full SPT penetration not achieved - see summary sheet								Borehole type: Window Sample
Remarks: 35mm ID standpipe installed to 4.0m								Borehole No: WS1

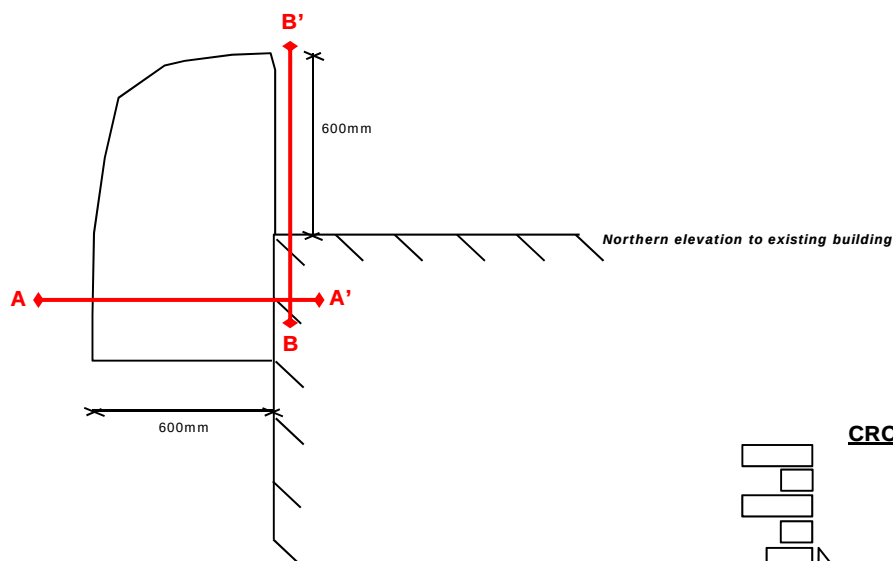
Highgate School - Richards Music Centre Site & Location: Bishopswood Road, London N6 4PR							Borehole No: WS2	
Client: Highgate School					Coordinates: 528016E, 187595N		Sheet 1 of 1	
Engineer: Expedition/A-Squared Studio					Ground Level: +113.20mOD		Report No: 9933/JRCB	
Progress & Observations	Samples & Tests		Field Test Results	Strata		Legend	Strata Descriptions	Backfill / Installation
	Type	Depth (m)		Depth (m)	Level (m)			
BH carried out: 19/02/16 BH dia: 90mm from GL to 1.0m; reducing with depth				0.30	112.90		Dark brown slightly gravelly TOPSOIL with frequent roots. Gravel is fine to coarse flint	
	E	0.50					Soft, becoming firm, grey, light brown/grey and orange/brown mottled gravelly CLAY. Gravel is subangular to rounded, fine to coarse flint	
	E	1.00		1.00	112.20		Firm light brown and blue/grey mottled CLAY	1
	D	1.00						
	HV	1.20	30					
	HV	1.50	42				Firm brown/orange, mottled light grey, CLAY <i>...between 2.0m and 2.30m; locally very sandy clay/very clayey sand</i>	
	HV	1.70	42					
	HV	1.90	80	1.90	111.30			
	E	2.00						2
	HV	2.10	75					
	D	2.10						
	HV	2.30	110	2.30	110.90		Stiff brown, mottled light grey, CLAY <i>...below 3.0m; with frequent partings of brown/orange sand</i>	
	HV	2.50	85					
	D	2.50						
	HV	2.80	75					
	HV	3.00	80				Stiff dark brown/grey, mottled red/brown, CLAY	3
	E	3.00						
	HV	3.20	92					
	D	3.20						
	HV	3.40	120					
	D	3.50		3.50	109.70			
	HV	3.60	130				End of borehole at 4.00m	
	HV	3.80	130					
	E	4.00		4.00	109.20			4
BH dry upon completion								
								5
Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub SPT/S = split spoon SPT/C = solid cone HV = Hand Vane [kPa] PP = Pocket Penetrometer [kg/cm²] PID = Photo Ionisation Detector [ppmv] * = full SPT penetration not achieved - see summary sheet							Borehole type: Window Sample	
Remarks: 35mm ID standpipe installed to 4.0m							Borehole No: WS2	

Highgate School - Richards Music Centre Site & Location: Bishopswood Road, London N6 4PR							Borehole No: WS3	
Client: Highgate School					Coordinates: 528038E, 187594N		Sheet 1 of 1	
Engineer: Expedition/A-Squared Studio					Ground Level: +113.70mOD		Report No: 9933/JRCB	
Progress & Observations	Samples & Tests		Field Test Results	Strata		Legend	Strata Descriptions	Backfill / Installation
	Type	Depth (m)		Depth (m)	Level (m)			
BH carried out: 19/02/16 BH dia: 90mm from GL to 1.0m; reducing with depth	E	0.30		0.30	113.40		MADE GROUND: dark red/brown clayey very sandy gravel. Gravel is fine to coarse clinker/slag and occasional flint	
	HV	0.50	20	0.50	113.20		MADE GROUND: dark grey/brown slightly gravelly clay. Gravel is fine to coarse flint, and occasional brick and ceramic fragments	
	D	0.60					Soft light brown/grey and orange/brown mottled slightly sandy CLAY with occasional subangular to rounded, fine to medium flint gravel	
	HV	0.70	24					
	HV	0.90	30					
	D	1.00						
	HV	1.10	38					
	HV	1.30	42	1.30	112.40		Stiff dark brown/grey and orange/brown mottled CLAY	
	HV	1.50	46					
	HV	1.70	54					
	HV	1.90	60					
	E	2.00						
	D	2.00						
	HV	2.10	60					
	HV	2.30	90					
	HV	2.50	88					
	D	2.50						
	HV	2.70	92					
	HV	2.90	80					
	D	3.00						
	E	3.00						
	HV	3.30	80					
	HV	3.50	72				...at 3.40m; pocket of light brown sandy clay	
	D	3.50					...between 3.50m and 3.60m; pocket of grey/brown sandy clay	
	HV	3.70	110					
	HV	3.90	104					
	E	4.00		4.00	109.70		End of borehole at 4.00m	
BH dry upon completion								
Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub SPT/S = split spoon SPT/C = solid cone HV = Hand Vane [kPa] PP = Pocket Penetrometer [kg/cm²] PID = Photo Ionisation Detector [ppmv] * = full SPT penetration not achieved - see summary sheet							Borehole type: Window Sample	
Remarks: 35mm ID standpipe installed to 4.0m							Borehole No: WS3	

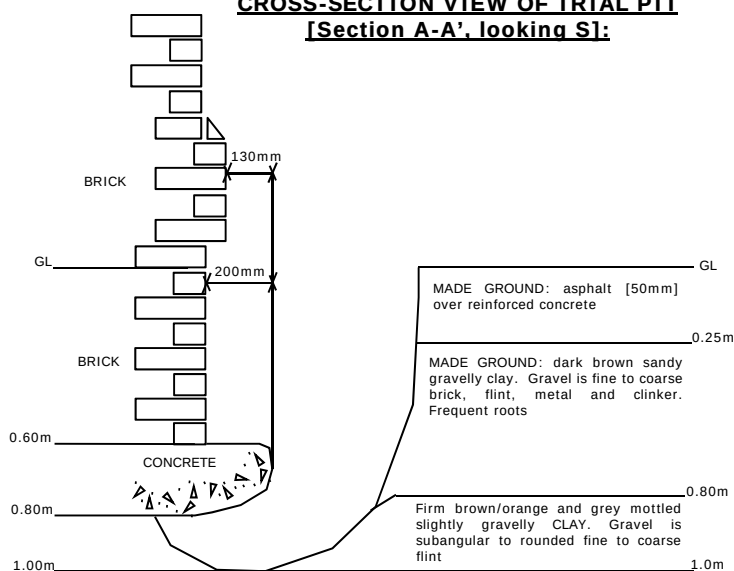
Site & Location:	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Trial Pit No: TP1 [1 of 2]
Client:	Highgate School	Report No: 9933 / JRCB
Engineer:	Expedition / A-Squared Studio	

Coords: 527995E, 187603N. GL = +112.9mOD

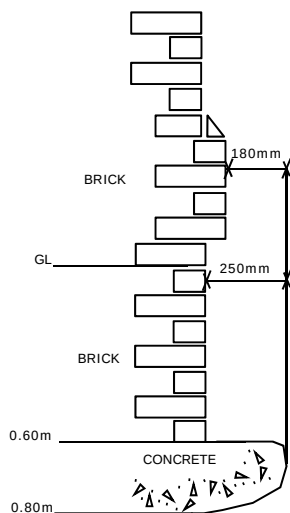
PLAN OF TRIAL PIT



CROSS-SECTION VIEW OF TRIAL PIT [Section A-A', looking S]:



CROSS-SECTION VIEW OF TRIAL PIT [Section B-B', looking W]:



See Section A-A' for ground sequence

D = small disturbed sample, B = bulk sample, HV = hand shear vane test [kPa], pp = pocket penetrometer [kg/cm²]

Date:	12 th April 2016	Groundwater details	Samples
Equipment:	Hand excavated	• Dry	D @ 0.50m D @ 1.00m
Stability:	Stable		
Remarks:	Coords: 527995E, 187603N		Logged by: JW

Site & Location	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Trial Pit No: TP1 [2 of 2]
Client:	Highgate School	Report No: 9933 / JRCB
Engineer:	Expedition / A-Squared Studio	

PHOTOGRAPHS OF TRIAL PIT:

Coords: 527995E, 187603N. GL = +112.9mOD



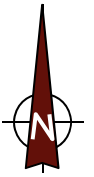
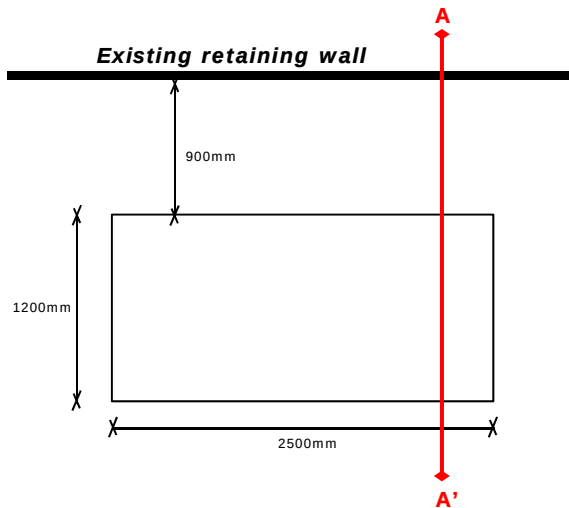
D = small disturbed sample, B = bulk sample, HV = hand shear vane test [kPa], pp = pocket penetrometer [kg/cm²]

Date:	12 th April 2016	Groundwater details	Samples
Equipment:	Hand excavated	• Dry	D @ 0.50m D @ 1.00m
Stability:	Stable		
Remarks:			Logged by: JW

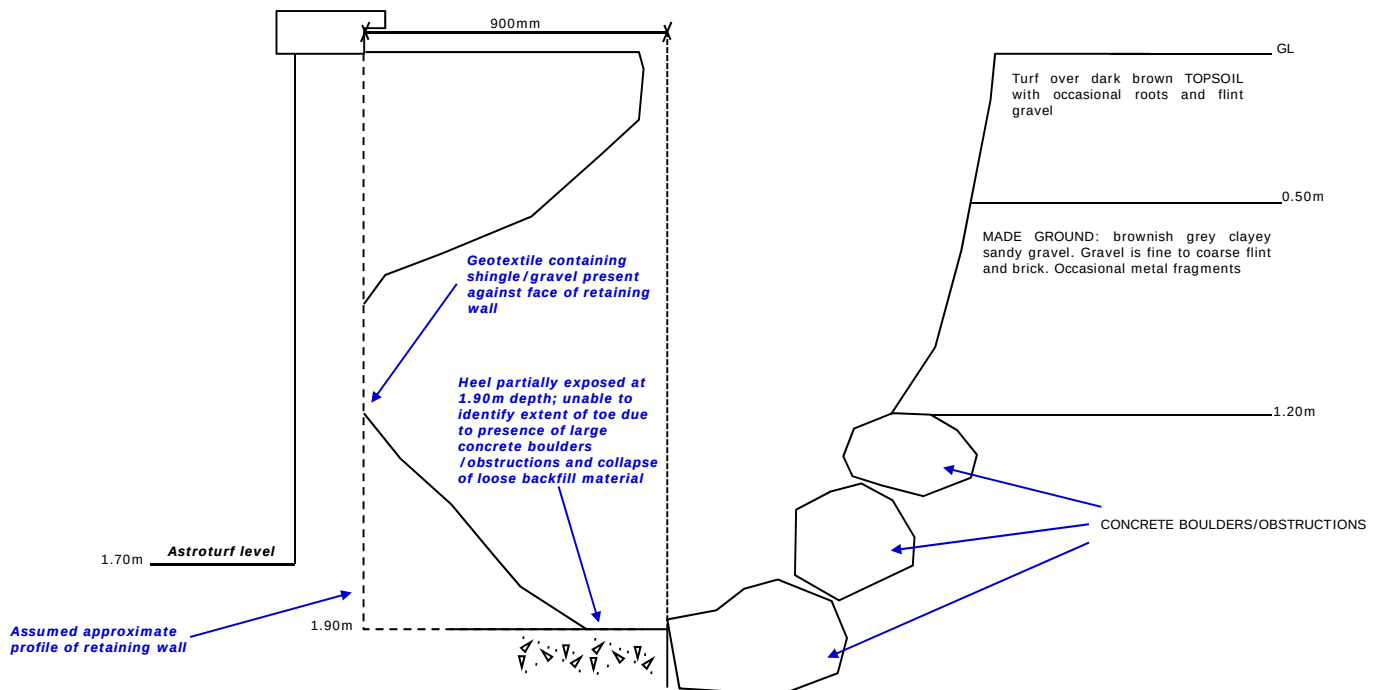
Site & Location	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Trial Pit No: TP3 [1 of 2]
Client:	Highgate School	Report No: 9933 / JRCB
Engineer:	Expedition / A-Squared Studio	

Coords: 528011E, 187613N. GL = +112.85mOD

PLAN OF TRIAL PIT



CROSS-SECTION VIEW OF TRIAL PIT [Section A-A', looking E]:



D = small disturbed sample, B = bulk sample, HV = hand shear vane test [kPa], pp = pocket penetrometer [kg/cm²]

Date:	12 th April 2016	Groundwater details	Samples
Equipment:	Hand excavated	• Dry	
Stability:	Unstable		
Remarks:			Logged by: JW

Site & Location	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Trial Pit No: TP3 [2 of 2]
Client:	Highgate School	Report No: 9933 / JRCB
Engineer:	Expedition / A-Squared Studio	

Coords: 528011E, 187613N. GL = +112.85mOD

PHOTOGRAPHS OF TRIAL PIT:



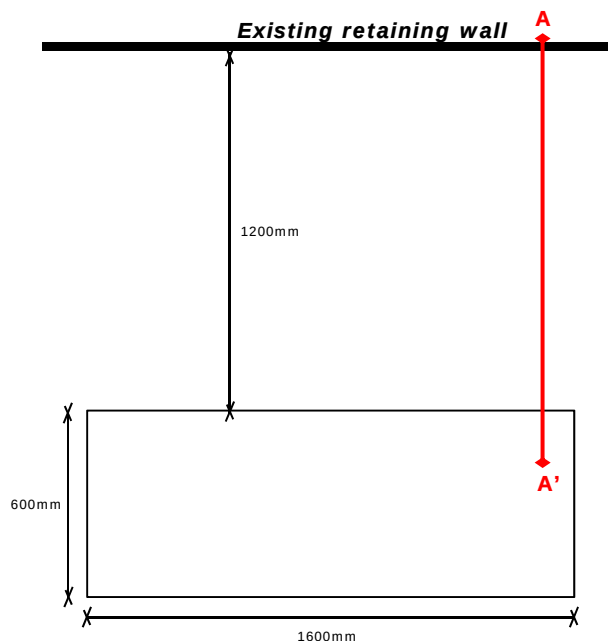
D = small disturbed sample, B = bulk sample, HV = hand shear vane test [kPa], pp = pocket penetrometer [kg/cm²]

Date:	12 th April 2016	Groundwater details	Samples
Equipment:	Hand excavated	• Dry	D @ 0.50m D @ 1.00m
Stability:	Stable		
Remarks:			Logged by: JW

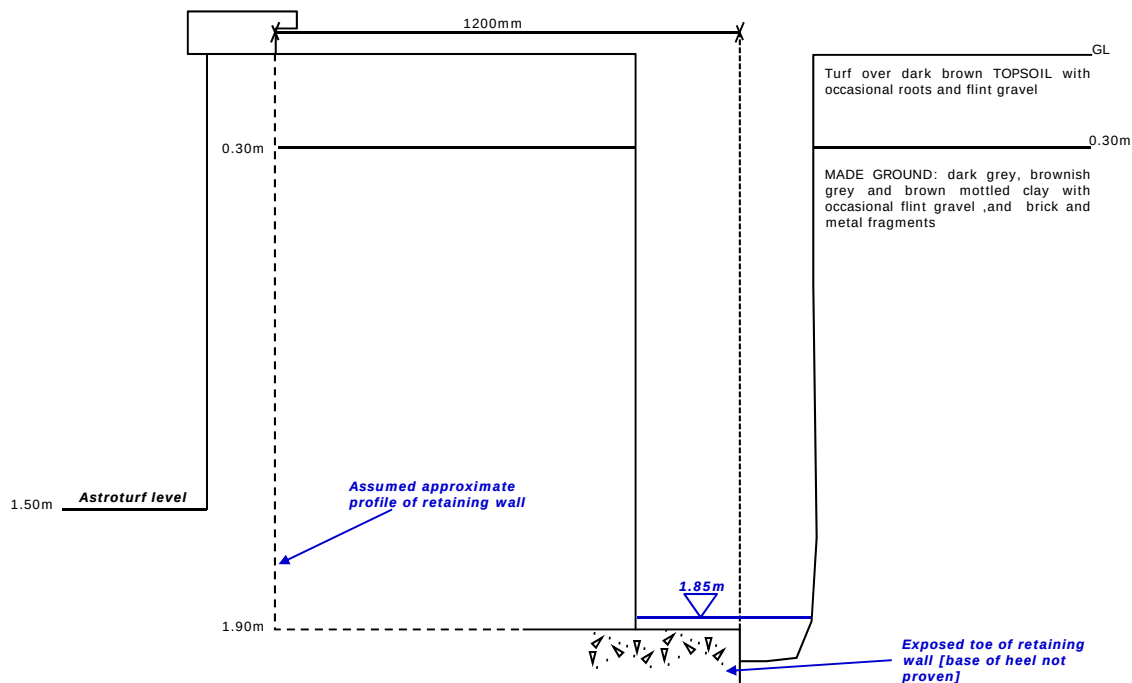
Site & Location	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Trial Pit No: TP4 [1 of 2]
Client:	Highgate School	Report No: 9933 / JRCB
Engineer:	Expedition / A-Squared Studio	

Coords: 528024E, 187622N. GL = +112.75mOD

PLAN OF TRIAL PIT



CROSS-SECTION VIEW OF TRIAL PIT
[Section A-A', looking E]:



D = small disturbed sample, B = bulk sample, HV = hand shear vane test [kPa], pp = pocket penetrometer [kg/cm²]

Date:	12 th April 2016	Groundwater details	Samples
Equipment:	Hand excavated	Seepage within made ground; standing at about 1.85m upon completion	
Stability:	Stable		
Remarks:			Logged by: JW

Site & Location	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Trial Pit No: TP4 [2 of 2]
Client:	Highgate School	Report No: 9933 / JRCB
Engineer:	Expedition / A-Squared Studio	

Coords: 528024E, 187622N. GL = +112.75mOD

PHOTOGRAPHS OF TRIAL PIT:



D = small disturbed sample, B = bulk sample, HV = hand shear vane test [kPa], pp = pocket penetrometer [kg/cm²]

Date:	12 th April 2016	Groundwater details	Samples
Equipment:	Hand excavated	• Dry	D @ 0.50m D @ 1.00m
Stability:	Stable		
Remarks:			Logged by: JW

Site & Location	Highgate School, Richards Music Centre Highgate School, London N6 4PR	Trial Pit No: TP5
Client Engineer	Highgate School Expedition / A-Squared Studio	Report No: 9933 / JRCB

		Coords: 528024E, 187610N		GL: +112.75mOD	
Depth (m)	Strata Description	Samples / Tests			
		Depth (m)	Type	Results	
GL to 0.80	Turf over dark brown TOPSOIL with occasional flint and brick gravel. Occasional roots to 0.10m				
0.80m to 2.0m	Firm light grey and brown/orange brown slightly sandy CLAY	0.90	D		
		2.00	D		
Date of Excavation		12/04/2016		Groundwater	
Equipment		Mini-excavator		Dry	
Stability		Stable		Logged by	
				JW	
		Checked by		JRCB	
Remarks					

Key: D = Disturbed B = Bulk V = Hand Shear Vane Test (kN/m²) PP = Pocket Penetrometer (kg/cm²)



Site & Location	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Report No: 9933 / JRCB
SOAKAGE TEST RESULTS		

Trial Pit No: **TPS1** Depth: **1.85** Test No: **1** (Coords: 527990E, 187603N)

Dimensions:

Width = **0.5** m
 Length = **1.70** m
 Diameter = m
 Casing depth = **0.00** m

 Perimeter = 4.400 m
 Base area = 0.850 m²

Date: 13 April 2016

Ground sequence

GL - 0.35m MADE GROUND: asphalt (50mm) over concrete over orange/brown sand

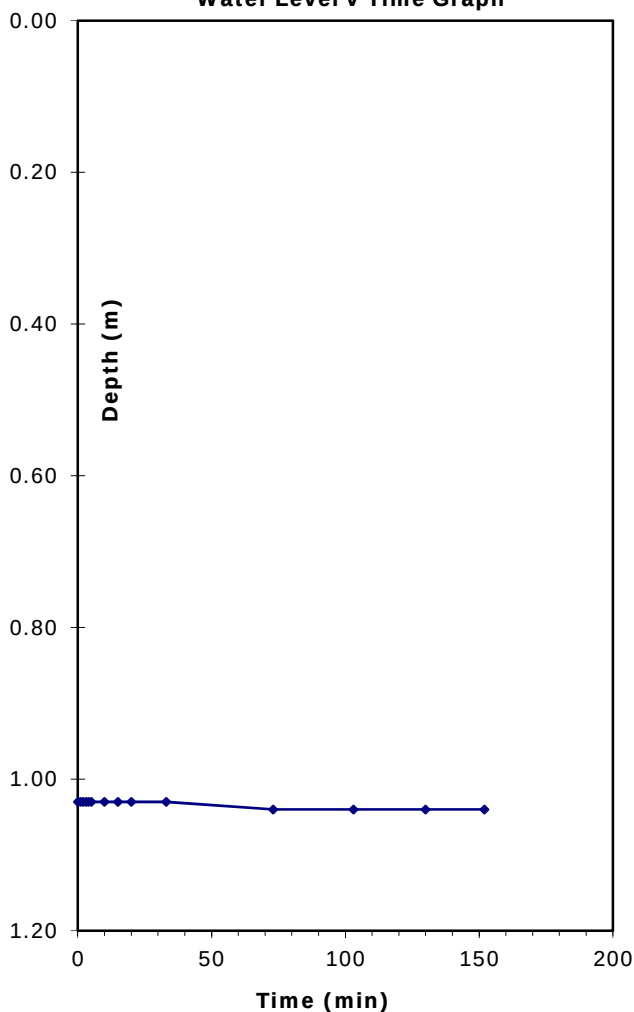
 0.35 - 0.80m MADE GROUND: dark brown slightly gravelly clay with frequent roots. Gravel is brick, flint and clinker

 0.80 - 1.80m Firm brown, orange/brown and light grey mottled slightly gravelly CLAY. Gravel is fine to coarse flint

Readings measured from **0.00** m above ground level (+113.0mOD)

No	Mins	Depth m	Depth mbgl
1	0	1.03	1.03
2	1	1.03	1.03
3	2	1.03	1.03
4	3	1.03	1.03
5	4	1.03	1.03
6	5	1.03	1.03
7	10	1.03	1.03
8	15	1.03	1.03
9	20	1.03	1.03
10	33	1.03	1.03
11	73	1.04	1.04
12	103	1.04	1.04
13	130	1.04	1.04
14	152	1.04	1.04
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			

Water Level v Time Graph



Water Level (m) Time (sec)

WL 1 [top]		
WL 2 [bottom]		

Vol change = m³ V
 Soakage area = m² A
 Time = sec T

Soakage Rate **m / sec** **NO SIGNIFICANT DRAINAGE**

Soakage Rate is calculated using two selected water levels
 and is based on BRE Digest 365: 2003 Soakaway Design

Site & Location	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Report No: 9933 / JRCB
SOAKAGE TEST RESULTS		

Trial Pit No: **TPS2** Depth: **1.80** Test No: **1** (Coords: 528058E, 187613N)

Date: 12 April 2016

Dimensions:

Width = **0.4** m
Length = **1.60** m
Diameter = m
Casing depth = **0.00** m

Perimeter = 4.000 m
Base area = 0.640 m²

Ground sequence

GL - 0.30m Turf over dark brown TOPSOIL

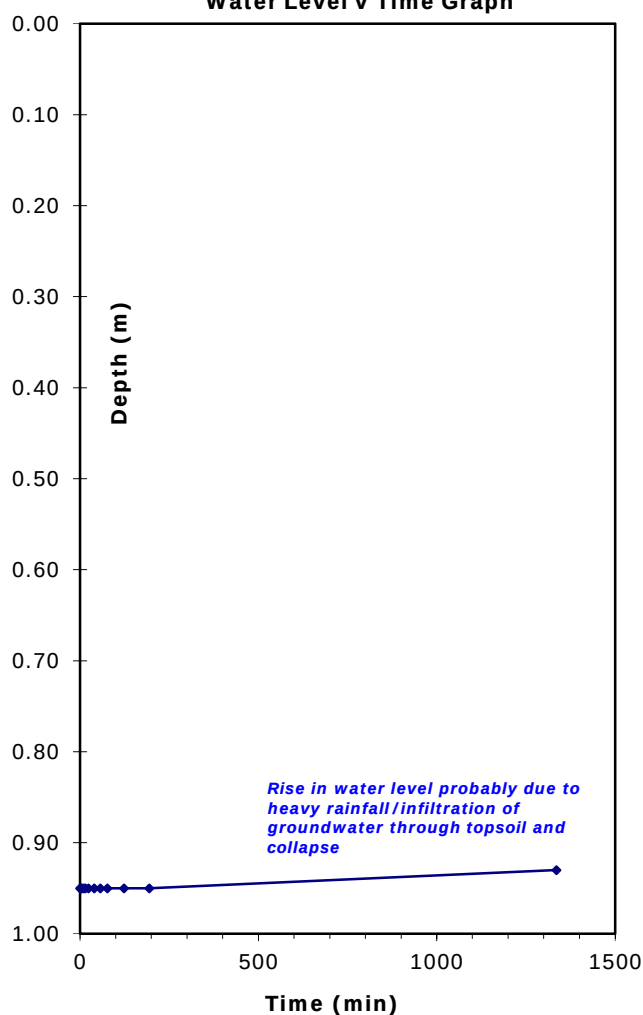
0.30 - 1.00m MADE GROUND: light brown and grey/ brown, slightly silty sand with occasional roots and brick cobbles

1.00 - 1.80m Firm brown, mottled grey, slightly silty CLAY

Readings measured from **0.00** m above ground level (+112.9mOD)

No	Mins	Depth m	Depth mbgl
1	0	0.95	0.95
2	1	0.95	0.95
3	2	0.95	0.95
4	3	0.95	0.95
5	5	0.95	0.95
6	10	0.95	0.95
7	15	0.95	0.95
8	24	0.95	0.95
9	40	0.95	0.95
10	57	0.95	0.95
11	77	0.95	0.95
12	123	0.95	0.95
13	194	0.95	0.95
14	1336	0.93	0.93
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			

Water Level v Time Graph



Water Level (m) Time (sec)

WL 1 [top]		#N/A	#N/A
WL 2 [bottom]		#N/A	#N/A

Vol change = #N/A m³ V
Soakage area = #N/A m² A
Time = #N/A sec T

Soakage Rate #N/A m/sec NO SIGNIFICANT DRAINAGE - LEVEL ROSE

Soakage Rate is calculated using two selected water levels and is based on BRE Digest 365: 2003 Soakaway Design

Site & Location:	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Ref: 9933 / JRCB
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Results of groundwater/gas monitoring

Date:	01 Mar 16	11 Mar 16	
Time [24hr]:	09:30	09:50	
Barometric pressure:			
a) Trend [24hrs]:	Falling	Rising	
b) At start [mB]:	1000	1027	
c) At end [mB]:	1000	1028	
Recorded by:	BM	JW	
Surface ground conditions:	Wet	Damp	
Weather conditions:	Heavy rain	Hazy	
Ambient air temp [°C]:	10	3	

Monitoring equipment

Instrument: GA2000 Plus MC08/0126/00
Calibration check details: Within monitor tolerance
Next calibration date: 20 Jul 16

Notes:

- 1] Barometric pressure trend and ambient air temperature is recorded from Wunderground.com website on the day of the monitoring visit
- 2] Calibration check is performed at start of monitoring against ambient air and also periodically with a 5% CH₄, 5% CO₂ and 6% O₂ gas mixture
- 3] CH₄ = methane; CO₂ = carbon dioxide; CO = carbon monoxide; O₂ = oxygen; H₂S = hydrogen sulphide

Results

Date	Time [24hr]	Borehole	GW Depth	Depth to Base	CH ₄ [%]		CO ₂ [%]		O ₂ [%]		Highest [ppm]		Emission Rate	Relative Pressure	VOC [ppm]
			[m]	[m]	Max	Steady	Max	Steady	Min	Steady	CO	H ₂ S	[l/hr]	[mb]	
01/03/2016	10:21	BH1	2.41	6.60	0.0	0.0	3.1	3.1	17.0	17.0	0	0	0.00	0.00	
	10:03	BH2	2.00	5.10	0.0	0.0	1.7	1.7	18.5	18.5	0	0	0.00	0.00	
	09:45	BH3	2.12	7.95	0.0	0.0	5.4	5.4	19.3	19.3	0	0	0.00	0.00	
	10:42	WS2	1.56	4.00	0.1	0.1	0.4	0.4	11.1	11.1	0	0	0.00	0.00	
	11:02	WS3	0.61	3.45	0.0	0.0	4.1	4.1	18.7	18.7	0	0	0.00	0.00	
11/03/2016	10:20	BH1	2.45	6.60	0.1	0.1	4.4	4.4	16.7	16.7	0	0	0.00	-3.00	
	10:30	BH2	1.97	5.10	0.1	0.1	2.2	2.2	18.1	18.1	0	0	0.00	0.01	
	10:40	BH3	2.12	7.90	0.1	0.1	3.1	2.2	20.2	20.2	0	0	0.00	-2.00	
	09:50	WS1	2.38	3.95	0.0	0.0	4.1	4.1	19.5	19.5	0	0	0.00	-2.75	
	10:00	WS2	NR	3.95	0.0	0.0	0.2	0.1	20.3	20.7	0	0	0.00	-0.66	
	10:10	WS3	0.75	3.45	0.1	0.1	4.7	4.7	18.7	18.7	0	0	2.20	7.55	

Site & Location:	Highgate School - Richards Music Centre Bishopswood Road, London N6 4PR	Ref: 9933 / JRCB
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Results of groundwater / gas monitoring

Date:	23 Mar 16		
Time [24hr]:	09:00		
Barometric pressure:			
a) Trend [24hrs]:	Steady		
b) At start [mB]:	1006		
c) At end [mB]:	1006		
Recorded by:	BM		
Surface ground conditions:	Dry		
Weather conditions:	Overcast		
Ambient air temp [°C]:	9		

Monitoring equipment

Instrument: GA2000 Plus MC08/0126/00
Calibration check details: Within monitor tolerance
Next calibration date: 20 Jul 16

Notes:

- 1] Barometric pressure trend and ambient air temperature is recorded from Wunderground.com website on the day of the monitoring visit
- 2] Calibration check is performed at start of monitoring against ambient air and also periodically with a 5% CH₄, 5% CO₂ and 6% O₂ gas mixture
- 3] CH₄ = methane; CO₂ = carbon dioxide; CO = carbon monoxide; O₂ = oxygen; H₂S = hydrogen sulphide

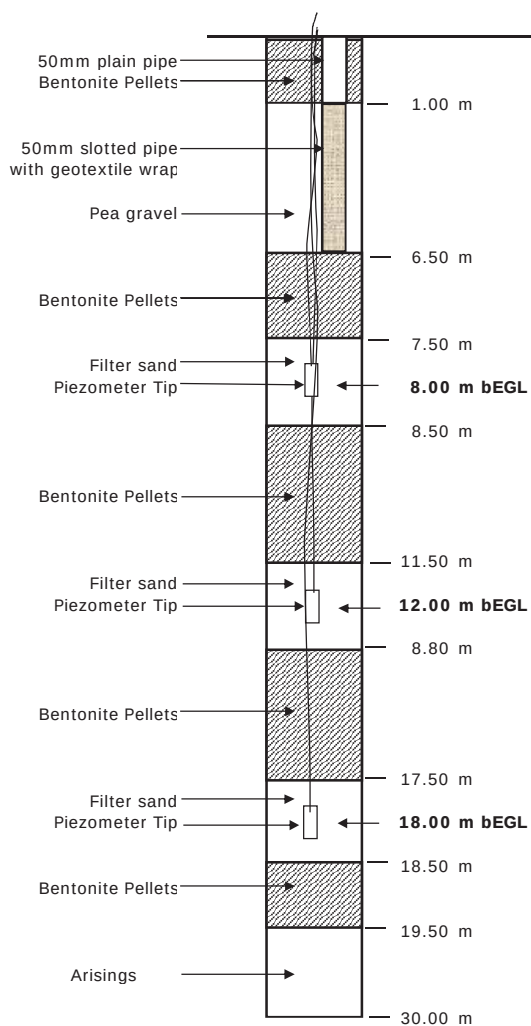
Results

Date	Time [24hr]	Borehole	GW Depth	Depth to Base	CH ₄ [%]		CO ₂ [%]		O ₂ [%]		Highest [ppm]		Emission Rate	Relative Pressure	VOC [ppm]
			[m]	[m]	Max	Steady	Max	Steady	Min	Steady	CO	H ₂ S	[l/hr]	[mb]	
23/03/2016	09:38	BH1	2.41	6.53	0.2	0.2	5.2	5.2	15.8	15.8	0	0	0.00	0.00	
	09:31	BH2	2.00	4.85	0.2	0.2	6.6	2.1	17.7	17.7	0	0	0.00	0.00	
	19:24	BH3	2.10	7.90	0.2	0.2	6.8	6.8	18.5	18.9	0	0	0.00	0.01	
	09:00	WS1	2.48	3.95	0.1	0.1	4.4	4.4	18.1	18.1	0	0	0.00	0.00	
	09:10	WS2	1.62	3.95	0.2	0.2	4.1	0.1	18.6	20.8	0	0	0.00	0.00	
	09:16	WS3	0.64	3.45	0.2	0.2	4.4	4.4	18.2	18.2	0	0	0.00	0.01	

Site : **Highgate School**

Vibrating Wire Piezometer Installation Details

Borehole No. Bh 2
 Location Richard's Music Centre
 528034 E 187616 N
 Date Installed 17/02/16



E.G.L. = 112.8 mAOD

2C
 Serial No.: 54215
 Linear Gauge Constant (mH2O): 0.01558446
 Base reading (Linear): 6601.5
 Colour code: Orange
 Initial reading 5.52 mH2O, 10.0 degC

2B
 Serial No.: 54216
 Linear Gauge Constant (mH2O): 0.01717880
 Base reading (Linear): 5983.8
 Colour code: Red
 Initial reading 9.01 mH2O, 10.7 degC

2A
 Serial No.: 54217
 Linear Gauge Constant (mH2O): 0.01496617
 Base reading (Linear): 6033.1
 Colour code: Brown
 Initial reading 14.44 mH2O, 11.8 degC

Not to Scale

Highgate School - Richards Music Centre Vibrating Wire Piezometer Readings Engineering Data

Piezo Ref	2A	2B	2C
Installation Depth (mbEGL)	18.00	12.00	8.00
Logger Channel	2A	2B	2C
Serial No.	54217	54216	54215
Linear gauge factor (mH ₂ O)	0.01496617	0.01717880	0.01558446
Base Hz ² /1000	6033.1	5983.8	6601.5

1st reading immediately after installaton

[illegible]

Highgate School - Richards Music Centre Vibrating Wire Piezometer Readings Reduced Data

Piezo Ref	2A	2B	2C
EGL at installation (mAOD)	112.800	112.800	112.800
Installation Depth (mAOD)	94.80	100.80	104.80
Logger Channel	2A	2B	2C

[illegible]

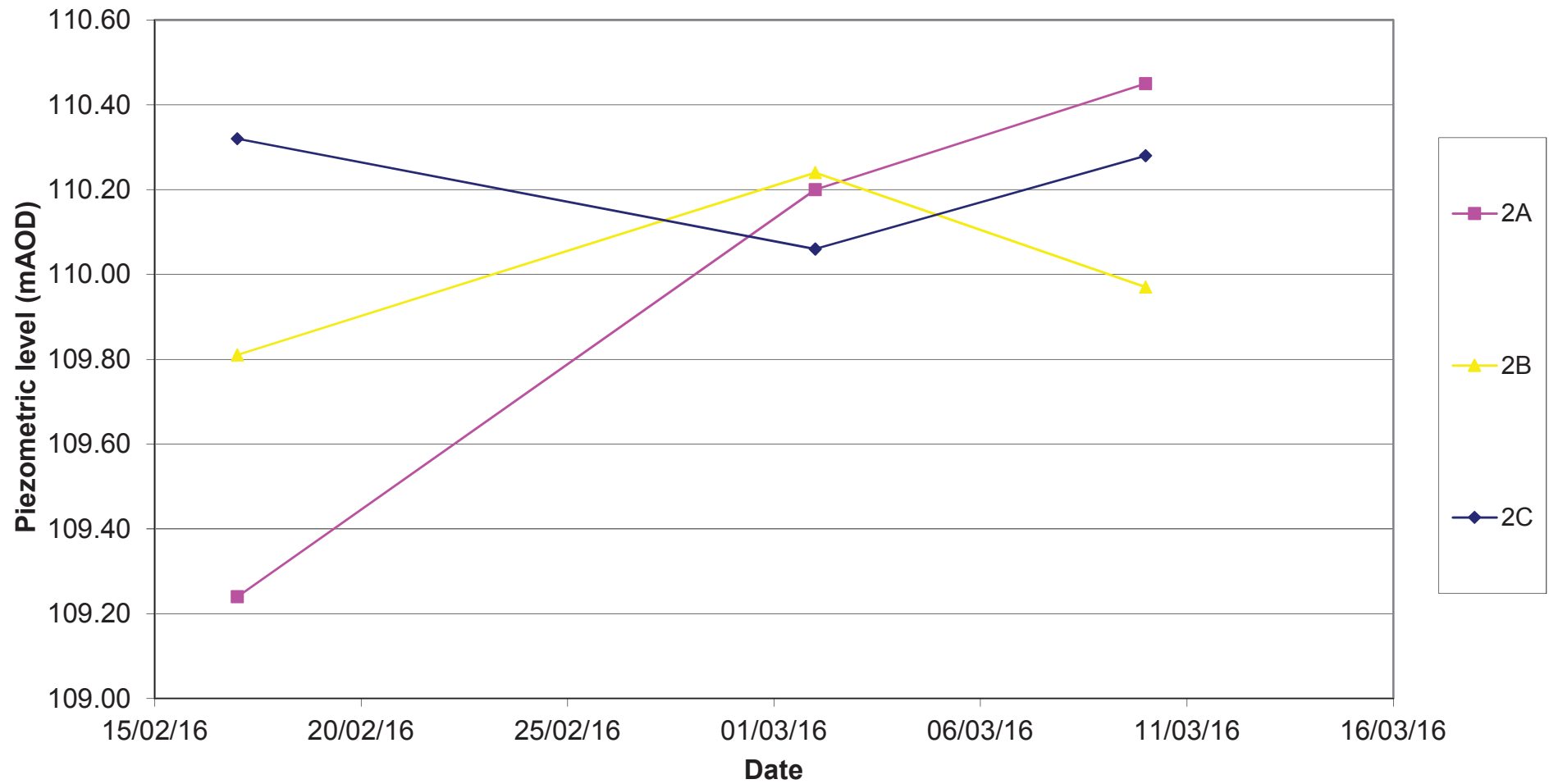
112.8

2.35

2.83

2.52

**Highgate School
BH2 Piezometers. Reduced Data**



Technical Services Timesheet



SWO 1463

Site	HIGHGATE SCHOOL	Client	SOIL CONSULTANTS LTD		
Date	WEDNESDAY 17/02/16	Shift (Day/Night)	D	Site Contact	JOHN BARTLEY
Summary Of Work		Materials Used			
Mobilised to site		3N° VW piezometers with 23, 17 = 11m of cable			
Installed 3N° VW piezometers in B/H 2					
at 18, 12 and 8m bEGL					
		Equipment Used			
		VWNOTE VWN582			
		Hire Plant			
		Verbal instructions issued			
		Standing Time/Obstructed access/Breakdowns etc, reasons			
Staff on Site: S. MORTON					
Signed for Client		Signed for ITM			
Print Name	S. WILLIAMS	Print Name	S. MORTON		

Calculation of Engineering units from frequency-based units.

The mathematical relationship between the frequency of vibration of a tensioned wire and the force applying the tension, is an approximate straight line relationship between the square of the measured frequency and the applied force.

Engineering units of measurement maybe derived from the frequency-based units measured by vibrating wire readouts, in 3 traditional ways:-

From 'Period' units ($t \times 10^7$) and from 'Linear' ($f^2/1000$) units using two methods: a simple Linear equation or a Polynomial equation.

Calculation using 'Period' units.

The following formula is used for readings in 'Period' units.

$$E = K (10^7/P0^2 - 10^7/P1^2)$$

Where,

E is the Pressure in resultant Engineering units,

K is the Period Gauge Factor for units of calibration (from the calibration sheet)

P0 is the installation Period 'base' or 'zero' reading

P1 is the current Period reading.

This method of calculation is used by the Soil Instruments Vibrating Wire loggers' (models RO-1-VW-1 or 2 and with serial numbers starting VL or TVL) internal processors', for calculating and displaying directly on the loggers' LCD screen, the required Engineering based units.

The loggers' require 'Period' base or zero reading units for entering into their channel tables, to calculate and display correctly the required engineering units.

If an Engineering-based unit is required other than the units of calibration, then the correct K factor will have to be calculated using the standard relationship between Engineering units.

For example, if the units of calculation required were in mH₂O and the calibration units were kPa, we can find out that 1kPa is equal to 0.1022mH₂O, so we would derive the K factor for mH₂O by multiplying the K factor for kPa by 0.1022.

Please see conversion factors in the user manual or www.soil.co.uk

Calculation using Linear units.

The following formula is used for readings in 'Linear' units.

$$E = G (R0 - R1)$$

Where,

E is the resultant Engineering unit,

G the linear Gauge factor for the units of calibration (from the calibration sheet)

R0 is the installation Linear 'base' or 'zero' reading

R1 is the current Linear reading.

Again the Linear gauge factor for units other than the units of calibration would need to be calculated using the same principles as stated in the last paragraph of the 'Period unit' section.

VIBRATING WIRE INSTRUMENTS CALIBRATION CERTIFICATE

Instrument Type : W9 Vibrating Wire Piezometer	Serial No. : 054215
Instrument Range : 0.00 to 300.0 kPa	Calibration Date : 12/01/2016
Gauge Factors in kPa	Ambient Temperature : 22°C
Period Gauge Factor (K): 1524.6350000	Barometric Pressure : 994 mbar
Linear Gauge Factor (G): (kPa/digit)0.1524600	Calibration Technician : Wayne Diprose
Polynomial Gauge Factor A: -0.000000195038300	Calibration Equipment:
Polynomial Gauge Factor B: -0.1502697000	Mensor APC 600
Polynomial Gauge Factor C**: 1001.473000	AVW200 Data Logger
	Regression Zero : 6608.6

Applied (kPa)	Reading (Period)	Reading F ² /1000	Calculated (Linear)	Error %FS (Linear)	Linear Increment	Calculated (Polynomial)	Error %FS (Polynomial)
0.00	3890.2	6607.9	0.100	0.03	0.0	-0.010	0.00
30.00	3949.1	6412.1	29.953	-0.02	-195.8	29.910	-0.03
60.00	4011.2	6215.0	60.003	0.00	-197.1	60.014	0.00
90.00	4076.5	6017.6	90.100	0.03	-197.4	90.148	0.05
120.00	4144.5	5821.8	119.952	-0.02	-195.8	120.023	0.01
150.00	4216.4	5624.9	149.972	-0.01	-196.9	150.051	0.02
180.00	4291.9	5428.8	179.871	-0.04	-196.1	179.941	-0.02
210.00	4371.9	5232.0	209.875	-0.04	-196.8	209.924	-0.03
240.00	4456.6	5035.0	239.911	-0.03	-197.0	239.921	-0.03
270.00	4546.7	4837.4	270.038	0.01	-197.6	269.995	0.00
300.00	4642.6	4639.6	300.195	0.07	-197.8	300.084	0.03

Formulae: Linear* $E = G(R0 - R1)$
Polynomial** $E = AR1^2 + BR1 + C$

* The zero reading should be established on site by the user on installation.

** The site value of C must be calculated using the formula $C = -(AR0^2 + BR0)$

The instrument detailed hereon has, as applicable, been tested and calibrated in accordance with procedures, which are part of our ISO 9001:2008 Quality Management System, and unless otherwise indicated, performs within $\pm 0.10\%$ (Polynomial) as specified. Thus, the instrument conforms in all respects to our relevant specifications and drawings.

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VIBRATING WIRE INSTRUMENTS CALIBRATION CERTIFICATE

Instrument Type	: W9 Vibrating Wire Piezometer	Serial No.	: 054216
Instrument Range	: 0.00 to 300.0 kPa	Calibration Date	: 12/01/2016
<u>Gauge Factors in kPa</u>		Ambient Temperature	: 22°C
Period Gauge Factor (K):	1680.9370000	Barometric Pressure	: 994 mbar
Linear Gauge Factor (G):	(kPa/digit)0.1680900	Calibration Technician	: Wayne Diprose
Polynomial Gauge Factor A:	-0.000000224473000	<u>Calibration Equipment:</u>	
Polynomial Gauge Factor B:	-0.1657994000	Mensor APC 600	
Polynomial Gauge Factor C**:	1003.318000	AVW200 Data Logger	
		Regression Zero	: 6003.3

Applied (kPa)	Reading (Period)	Reading F ² /1000	Calculated (Linear)	Error %FS (Linear)	Linear Increment	Calculated (Polynomial)	Error %FS (Polynomial)
0.00	4081.7	6002.4	0.141	0.05	0.0	0.036	0.01
30.00	4143.4	5824.8	29.995	0.00	-177.6	29.953	-0.02
60.00	4208.4	5646.4	59.983	-0.01	-178.4	59.991	0.00
90.00	4276.4	5468.1	89.954	-0.02	-178.3	89.998	0.00
120.00	4348.0	5289.6	119.958	-0.01	-178.5	120.024	0.01
150.00	4423.2	5111.3	149.930	-0.02	-178.3	150.003	0.00
180.00	4502.5	4932.8	179.934	-0.02	-178.5	180.000	0.00
210.00	4586.2	4754.3	209.939	-0.02	-178.5	209.984	-0.01
240.00	4675.0	4575.5	239.994	0.00	-178.8	240.003	0.00
270.00	4769.2	4396.6	270.066	0.02	-178.9	270.025	0.01
300.00	4869.1	4218.0	300.088	0.03	-178.6	299.982	-0.01

Formulae: Linear* $E = G(R0 - R1)$
Polynomial** $E = AR1^2 + BR1 + C$

* The zero reading should be established on site by the user on installation.

** The site value of C must be calculated using the formula $C = -(AR0^2 + BR0)$

The instrument detailed hereon has, as applicable, been tested and calibrated in accordance with procedures, which are part of our ISO 9001:2008 Quality Management System, and unless otherwise indicated, performs within $\pm 0.10\%$ (Polynomial) as specified. Thus, the instrument conforms in all respects to our relevant specifications and drawings.

Certified:  Line MANAGER

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TN22 1QL United Kingdom

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Soil Instruments Ltd. Registered in England. Number: 07960087. Registered Office: 34 Bell Lane, Uckfield, East Sussex, TN22 1QL, UK

VIBRATING WIRE INSTRUMENTS CALIBRATION CERTIFICATE

Instrument Type : W9 Vibrating Wire Piezometer	Serial No. : 054217
Instrument Range : 0.00 to 300.0 kPa	Calibration Date : 12/01/2016
Gauge Factors in kPa	Ambient Temperature : 22°C
Period Gauge Factor (K): 1464.3860000	Barometric Pressure : 994 mbar
Linear Gauge Factor (G): (kPa/digit)0.1464400	Calibration Technician : Wayne Diprose
Polynomial Gauge Factor A: -0.000000991063900	Calibration Equipment:
Polynomial Gauge Factor B: -0.1364796000	Mensor APC 600
Polynomial Gauge Factor C**: 861.649000	AVW200 Data Logger
	Regression Zero : 6052.0

Applied (kPa)	Reading (Period)	Reading F ² /1000	Calculated (Linear)	Error %FS (Linear)	Linear Increment	Calculated (Polynomial)	Error %FS (Polynomial)
0.00	4066.3	6048.0	0.589	0.20	0.0	-0.031	-0.01
30.00	4136.1	5845.5	30.243	0.08	-202.5	29.993	0.00
60.00	4209.9	5642.2	60.014	0.00	-203.3	60.054	0.02
90.00	4287.8	5439.1	89.756	-0.08	-203.1	90.003	0.00
120.00	4370.6	5235.0	119.644	-0.12	-204.1	120.018	0.01
150.00	4458.6	5030.5	149.591	-0.14	-204.5	150.009	0.00
180.00	4552.3	4825.5	179.611	-0.13	-205.0	179.989	0.00
210.00	4652.3	4620.3	209.660	-0.11	-205.2	209.916	-0.03
240.00	4760.2	4413.2	239.987	0.00	-207.1	240.035	0.01
270.00	4875.7	4206.6	270.242	0.08	-206.6	269.997	0.00
300.00	5000.6	3999.0	300.643	0.21	-207.6	300.018	0.01

Formulae: Linear* $E = G(R_0 - R_1)$
Polynomial** $E = AR_1^2 + BR_1 + C$

* The zero reading should be established on site by the user on installation.

** The site value of C must be calculated using the formula $C = -(AR_0^2 + BR_0)$

The instrument detailed hereon has, as applicable, been tested and calibrated in accordance with procedures, which are part of our ISO 9001:2008 Quality Management System, and unless otherwise indicated, performs within $\pm 0.10\%$ (Polynomial) as specified. Thus, the instrument conforms in all respects to our relevant specifications and drawings.

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APPENDIX A

Laboratory test results

- ✚ Index property tests
- ✚ Plasticity charts
- ✚ Unconsolidated undrained triaxial tests
- ✚ Consolidated undrained triaxial tests (K4 Soils Laboratory)
- ✚ Oedometer tests (K4 Soils Laboratory)