Report No 2008/92

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Report on Ground Investigation

at Site of

Proposed IRM Extension and Workshop Development

at

Manchester Metropolitan University

Manchester

August 2008

Sub Soil Surveys Ltd.
Manchester

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1 INTRODUCTION AND OBJECT

1.1 This report been prepared at the request of Scott Hughes Design at the site of a proposed IRM extension and new workshop development at the John Dalton Building, Manchester Metropolitan University, Chester Street. Manchester.

1.2 The IRM extension site lies on the northern elevation of the John Dalton Tower to the south of Chester Street, with the new workshop development located on land to the south of the John Dalton Central building to the north of the (elevated) Mancunian Way. The John Dalton complex is located to the west of Oxford Road within Manchester city centre at approximate National Grid Reference SJ 841 972. The site is outlined on the appended site plan.

1.3 At the time of the investigation the IRM extension site was an area of concrete hardstanding adjacent to the eastern elevation of the seven storey John Dalton Tower and northern elevation of a two storey section of the John Dalton Central building. The proposed new workshop site was a grassed area with a relatively small two storey (existing workshop) structure on the western half of the site. There was a slight slope down to the NNW on both sites. On the proposed workshop site a retaining structure was present along the southern and western edges of the site consisting of stone gabions and soil, retaining higher land to the south west and south east. A slightly mounded area was located along the southern edge of this site. Two metal items (possibly of decorative purpose) were present on the north eastern corner of the site, consisting of a large wheel/cog and an engine. There was also evidence (trunk remains) that a number of large mature trees had once been present on the site. A 'venting unit' was present on the eastern elevation of the existing structure. Underground services were observed crossing the site and a number of services are known to be present in the area from service records supplied by our client. A 'power plant service unit' was located on the western elevation of the John Dalton East building directly to the east of the site. Support columns for the elevated Mancunian Way were located to the south of the site. Slight cracking was observed on masonry on the western elevation of the John Dalton West building to the west of both sites.

1.4 It is proposed to demolish the existing workshop structure to the south of John Dalton Central and construct a new two storey steel framed workshop (approx. 570m^2 plan

area) and to construct a two storey steel framed extension onto the existing John Dalton Tower. Further details of development layout, foundation loadings and design have not been made available at this time.

1.5 The object of the investigation was to sink a series of boreholes and to

a) report on the type, thickness and variability of the soil strata proved underlying the site

b) establish groundwater conditions

c) determine the maximum safe bearing capacities of the various soil strata

d) carry out some testing for chemical contamination at the borehole positions

e) carry out monitoring for potentially hazardous ground gases in wells established in some boreholes and

f) comment on the findings.

2 SITE GEOLOGY

2.1 The site is situated in an area where the geological succession is estimated to bc as follows:

i)	Firm, stiff and very stiff CLAY with sandy zones, variable gravel content, cobbles & boulders and possibly with zones or lenses of SILT, SAND and GRAVEL	- Glacial Deposits
ii)	Red silty SANDSTONE	- Sherwood Sandstone
iii)	Reddish brown MUDSTONE with lenses of gypsum	- Manchester Marl
iv)	Reddish brown silty SANDSTONE	- Collyhurst Sandstone
v)	SANDSTONES and MUDSTONES with coal seams	- Coal Measures

2.2 From the geological mapping the site is indicated to overlie an area of Glacial Clay deposits bordered by Glacial Sand and Gravels to the south and Fluvio-Glacial Sands and Gravels to the north.

Boreholes in the surrounding area indicate drift deposits between 8.5-25ft (2.6-7.6m) in thickness.

The NW-SE trending West Manchester Fault is indicated on the geological mapping to outcrop at rockhead to the east of the site, this fault is an extension of the Irwell Valley Fault (mapped in coal workings >2km north west of the site). The faults in this area are not typically considered to be (excessively) active and are not a source of tectonic risk however a fault may occur as a 'smash zone' of weaker material which may affect pile foundation installation.

2.3 The Sherwood Sandstone have been used as a source of water in the past. It is therefore possible that old well(s) may be present on the site and these may impede construction progress or present a hazard.

2.4 A previous investigation by this company has been carried out on the John Dalton site in the immediate vicinity of the current investigation sites. The proved strata succession in the previous investigation can be summarised as Made Ground up to

3.5m thick onto an 1.4->1.5m thick impersistent soft, firm and very stiff Clay underlain by a medium dense and dense Glacial Sand below 1.3-2.0m bgl onto stiff and very stiff Glacial Clays proved below 2.0-3.5m bgl.

3 GEOCHEMICAL RISK ASSESSMENT

3.1 The assessment of old maps of the area was beyond the scope of this investigation, however, a historical assessment during a previous investigation of the site by this company indicated that the site has been developed from at least 1848 by terraced properties and streets. The majority of the site underwent clearance by the 1965 mapping, with the current university structures present to the north of the Mancunian Way by the 1970 mapping. The site is recorded to be crossed by sewers along the line of the old roadways, with other old underground services also present across the site.

3.2 The consideration of asbestos or radioactive materials being present on the site lies outside the scope of this investigation although any materials suspected of containing such materials during any physical investigation or groundwork on the site would be subjected to appropriate analysis/appraisal.

3.3 The following potential sources of geochemical contamination have been identified by this investigation :

Sources of potential Geocontamination	
On Site	Off Site
• Former terraced properties and associated underground infrastructure: Material placed during construction works (services, old foundations, possible basements, etc.) - Potential Contaminants: Metals, PAH and Oils	• Possible leaching of mobile contaminants that may have been spilt, dumped or leaked - Potential Contaminants: Metals, PAH and Oils
Possible ground gas formation/migration from underlying Made Ground	Possible ground gas formation/migration from surrounding infilled/levelled land

3.4 The contamination which we have identified from the site history and knowledge of the area as being of greatest concern are Metals, Sulphates, pH, Polyaromatic Hydrocarbons (PAH) and Oils (Petroleum Hydrocarbons). Analysis would include speciated PAH and banded TPH suites. As noted above Asbestos lies outside the scope of our work.

3.5 The Potential Receptors of the various contaminants are :

1	Present site users and construction personnel
2	End users of the site
3	Controlled Waters
4	Groundwater and underlying major Aquifer
5	Flora and Fauna
6	Building Structure/Services

3.6 In order for there to be a risk to a potential receptor from the identified sources of potential geocontamination there has to be a pathway linking them. We present below a table of possible pathways which also indicates their likelihood of occurrence :

Geocontamination Source	Pathway	Receptor - from Table 6.5					
		1	2	3	4	5	6
Made Ground / Soil	Ingestion	L	P	NA	NA	P	NA
	Skin/Direct Contact	L	L	NA	NA	P	P
	Inhalation of Dust	L	L	NA	NA	L	NA
	Services	L	P	P	P	P	P
	Surface Water	L	P	NA	L	L	L
Groundwater	Ingestion	P	U	NA	NA	P	L
	Skin/Direct Contact	P	P	P	NA	L	L
Ground Gas	Migration	L	L	NA	NA	P	L

Key to pathways : L - Likely P - Possible U - Unlikely NA - Not Applicable

3.7 We present below a further table which develops conceptual ground model implicit in the above pathways table and assesses the risk presented by each of the links to the potential receptors :

Source	Pathway	Receptor	Probability	Consequence	Risk	Action for further assessment
Contaminated Soil/ groundwater	Ingestion of soil and inhalation of dust and vapours	Construction personnel	Likely	Medium	Moderate	Measure Soil contamination and feed results to contractor/designer for his risk assessment
Contaminated Soil/ groundwater	Ingestion of soil and inhalation of dust and vapours	End users of site	Likely	Medium	Moderate	Measure Soil contamination. undertake remediation as required to mitigate risk
Contaminated Soil/ Groundwater via services	Via service pipes	End users Structures	Low	Medium	Moderate /Low	Measure soil contamination Ensure good construction

Contaminated soil/ groundwater	Downward Migration	Groundwater & Major Aquifer	Likely	Medium	Moderate	Measure Soil Contamination
Ground Gas - Methane and Carbon Dioxide	Migration leading to build up in structures	Construction personnel End Users	Likely	Severe	High	On site Ground Gas Monitoring leading to appropriate gas exclusion measures
Contaminated Soil	Ingestion of soil and inhalation of dust and vapours	Flora/Fauna	Low	Medium	Moderate /Low	Measure Soil Contamination
Contaminated Groundwater	Ingestion	Flora/Fauna	Low	Mild	Low	No Action needed
Contaminated Soil/Ground water	Direct Contact	Buildings	Likely	Medium	Moderate	Measure Soil Contamination Ensure adequate waterproofing/construction

Key to risk terms:	
Severe	Acute risks to human health Catastrophic damage to buildings/property (e.g. by explosion) Major pollution of controlled waters (watercourses or groundwater)
Medium	Chronic (long-term) risk to human health Pollution of sensitive controlled waters Significant effects on sensitive ecosystems or species
Mild	Pollution of non-sensitive waters Significant damage to buildings or structures PPE requirement to reduce health risk
Minor	Damage to non-sensitive ecosystems or species Minor damage to buildings or structures
High Likelihood	Pollutant linkage may be present, and risk is almost certain to occur in the long term, or there is evidence of harm to the receptor
Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term
Low Likelihood	Pollutant linkage may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so
Unlikely	Pollutant linkage may be present but the circumstances under which harm would occur are improbable

3.8 The CLEA methodology has derived Soil Guideline Values (SGV's) for three 'standard' exposure scenarios; Residential Development with plant uptake and allotments; Residential Development without plant uptake and Commercial/Industrial Development. Where an SGV has not been published we will use Generic Assessment Criteria (GAC) published by LQM. These GAC have been produced to CLEA methodology using appropriately reviewed toxicological data using the CLEA UK model. We are of the opinion that the 'Commercial/Industrial Development' scenario should be used for the proposed site developments.

We also note that a major revision to the UK system of contaminated land assessment was issued on 13 August 2008. The implications of this have not been fully assessed, however, in the interim we will refer to the previously published SGV's/GAC's as noted above.

4 SITE INVESTIGATION AND SOIL PROFILE

4.1 Three light cable percussion boreholes (1-3) were sunk to depths of between 12.05 and 12.15m below ground level (m bgl), two windowless sampler boreholes (WS1&2) were sunk to a depth of 5.0m bgl and two trial pits (TP1&2) were hand excavated to depths of 0.7 and 1.2m bgl at the locations indicated on the enclosed site plan (Fig 2). The borehole logs are detailed in Appendix A, soil sections are plotted in Fig 1 and photographs of the windowless sampler borehole runs (WS1&2) are included in Appendix C.

4.2 From these results it can be seen that the soil strata vary between the boreholes but can be approximated as follows:-

Soil Profile

Description of stratum	Depth to top of stratum (m)	Thickness of stratum (m)	Remarks
Tarmac onto concrete, stone, bitmac, brick and concrete fragments and ash Topsoil onto sand, stone, brick fragments, soft/firm clay, ash, fine roots Soft/firm grey organic clay with occasional ash and brick fragments (at base of BH3)	0	0.80 - 3.50 & >1.2	Made Ground - Thickness not proven in TP's 1 & 2
Loose brown SAND AND GRAVEL	1.3	0-1.2	Sand and Gravel - Only proved in BH1
Very soft to soft/firm dark grey and grey/brown organic CLAY with a little gravel, sand and gravel lenses, cobbles and peat layers -'organic' odour (BH1 & 3)	2.50-3.50	0 - 2.05	Organic Clay - Only proven in BH1 & 3
Soft/firm becoming firm/stiff and stiff light grey/brown mottled silty sandy CLAY with some gravel, sand lenses, coal fragments and grey fissures	0.80 - 1.30	0 - 0.80	Clay - Only proven in WS1 & 2

Loose and medium dense brown SAND AND GRAVEL with cobbles, clayey zones, sand lenses and occasional firm to stiff clay lenses - very stiff sandy clay lens (WS1)	1.40 - 2.10	0 - 2.10	Sand and Gravel - Only proven in WS1 & 2
Stiff and very stiff brown silty sandy CLAY with a little gravel, sand and gravel lenses, coal fragments, cobbles and occasional laminated zones - sand lens in WS1 - 'organic' lenses and odour (BH1)	2.60 - 4.55	0.60 - 6.05 & >1.7	Glacial Clay Zone 1 - Proved in all boreholes - Thickness not proven in WS2
Firm/stiff to stiff brown silty sandy CLAY with a little gravel, cobbles, coal fragments - occasional laminated zones (BH2)	4.60 - 7.0	0 - 3.85 & >0.40	Glacial Clay Zone 2 - Proved in WS1, BH1 & BH2 - Thickness not proven in WS2
Very stiff brown very sandy CLAY with a little gravel and coal fragments / Brown claybound SAND	9.0 - 10.05	1.35 - 2.50	Glacial Clay Zone 3 - Proved in BH1-3
Hard brown very sandy CLAY with a little gravel/ Very dense reddish brown claybound SAND with clay lenses - possible weak weathered upper zone of bedrock	11.40 - 11.50	-	Clay/Sand - Proved in BH1-3

4.3 Although the maximum proved thickness of Made Ground was 3.50m in borehole 3, thicker zones may be present below the site, between and away from the borehole positions (e.g. old foundations, basements, service excavations, etc.).

4.4 The Sand and Gravel proved at 1.3-2.5m bgl in BH1 may be a Made Ground deposit or possibly an Alluvial deposit overlying the organic clay. The organic clay proved within the Made Ground of BH3 may be disturbed upper zone of the underlying natural Organic Clay deposit.

4.5 The hard sandy Clay/very dense Sand proved at the base of the boreholes 1-3 could possibly be the weathered upper zone of the bedrock. If bedrock the standard penetration test results place it within a 'weak' bedrock deposit strength.

4.6 The trial pits proved the footings of the adjacent John Dalton building at 0.55m bgl in TP2 and the footing was not encountered within the 1.2m bgl depth of TP1.

4.7 There could be greater variation in the depths to and thicknesses of the various strata between and away from the borehole positions than indicated by the above table or the enclosed diagrammatic soil section (Fig. 1).

5 GROUNDWATER AND EXCAVATIONS

5.1 Groundwater observations are detailed in the borehole logs and tabulated below:

Groundwater Observations

BH	Depth on striking groundwater (m bgl)	Level after 20 mins (m bgl)	Estimated seepage	Stratum in which observed	Highest recorded water level (m bgl)
BH1	None	-	-	Organic Clay	3.91 in standpipe
BH2	None	-	-	-	-
BH3	None	-	-	Made Ground	2.16 in standpipe
WS1	None	-	-	-	-
WS2	None	-	-	Sand and Gravel	3.05 in standpipe
TP1 & 2	None	-	-	-	-

5.2 These observations indicate that during the investigation period there was a groundwater table present below the site at about 2.1-3.9m bgl associated with the Made Ground, Organic Clay and Sand and Gravel Deposits. Higher water levels particularly in the Made Ground should be expected during and after periods of wet weather with correspondingly lower levels during protracted dry spells.

5.3 Groundwater control may well be required in excavations to be taken below any water table in order to prevent the onset of 'running' conditions or the 'piping' and 'heaving' of the base of excavations. Any system of groundwater control to be adopted at this site should be designed and operated so as to prevent the loss of 'fines' from the surrounding ground thereby causing a loss of support and attendant settlement to the ground and any nearby structures, etc.

5.4 It would be advisable to provide adequate lateral support for the vertical sides of all deep excavations at this site. In particular, consideration should be given in the design and construction of any deep excavations to the relatively low strength of the Organic Clay proved in some of the boreholes. Particular note should be made of the need to maintain adequate lateral support to the adjacent structures, the Mancunian Way, etc.

5.5 If a cast in-situ concrete piling system is to be adopted at this site care should be taken in the design and placing of the mix to prevent the groundwater from leaching out the grout from the mix and/or causing a 'necking' of the piles.

6 CHEMICAL TESTING AND APPRAISAL

6.1 We have initially undertaken chemical testing on seven samples of Made Ground and upper natural ground strata obtained from varying shallow depths within the boreholes and trial pits. From the appended results it may be seen that the following concentrations were measured:

Summary of Chemical Test Results

Contaminant/ Parameter	Concentration (mg/kg except pH)		DEFRA/ EA Generic SGV	Comments
	Min.	Max.	Comm/ Industr	
Arsenic	7	23	500	Low concentrations
Cadmium	<1	2	1,400	Low concentrations
Chromium (total)	14	210	5,000	Low concentrations
Copper	9	130	45,700~	Low concentrations ~GAC from LQM
Lead	15	400	750	Low concentrations
Mercury	<1	1	480	Low concentrations
Nickel	19	26	5,000	Low concentrations
Selenium	<3	<3	8,000	Low concentrations
Zinc	84	330	188,000~	Low concentrations ~GAC from LQM
pH	7.3	8.7	-	
Polycyclic Aromatic Hydrocarbons (PAH)	0.12	430	-	
Benzo(a) Pyrene	0.02	24	29.7~	Low concentrations ~GAC from LQM
Dibenzo (ah) Anthracene	<0.01	2.9	29.7~	Low concentrations ~GAC from LQM
Fluorene	<0.01	9.5	59,000~	Low concentrations ~GAC from LQM
Naphthalene	<0.01	6.3	290~	Low concentrations ~GAC from LQM
Total Petroleum Hydrocarbons (TPH)	14	1,249		
C8-C10	<1	<1	65.9~	Low concentrations ~GAC from LQM
C10-C12	<1	2	625~	Low concentrations ~GAC from LQM
C12-C16	<1	47	12200~	Low concentrations ~GAC from LQM

C16-C21	<1	320	9190~	Low concentrations ~GAC from LQM
C21-C35	14	880	9250~	Low concentrations ~GAC from LQM

6.2 The tests have been carried out on 'spot' samples hence higher (or lower) concentrations of contaminants may well be present below the site between and away from the borehole positions.

6.3 The results of the above contamination testing indicates that below the site of the proposed development, levels below commercial/industrial end use SGV and GAC values have been measured in the samples tested. The sample from BH3 at 0.6m bgl returned elevated (relative to the other boreholes) levels of TPH and PAH, although no 'oily' material/odour was observed within this sample.

6.4 We are of the opinion that due to the measured levels of contamination that have been generally proven and the proposed end use that a remediation exercise will not be required on the site. The material may generally safely remain in place below structures and hardstanding where contact with the soils by the end users may sensibly be considered to be unlikely. If the development is to include areas where soils may be exposed (for example landscaped areas) remediation may be required to prevent human contact (potential receptors) with the contaminated Made Ground soils (the source). Should the proposed development be changed to include a more sensitive end use, this advice would need to be reappraised.

6.5 As part of the development work to be undertaken on the site a careful inspection of all excavations should be undertaken and any materials which may be suspected to contain higher levels of or different contaminants (in particular oils or other hydrocarbons) than those reported in this investigation should be subject to further relevant testing and appraisal. Any imported material (i.e. for landscaped areas, etc.) should be demonstrated to be 'clean' by appropriate contamination testing (ideally undertaken before importation and placement).

6.6 Construction personnel should be adequately protected from contact with the contaminated soils by the use of normal construction hygiene precautions (e.g. suitable protective clothing, gloves, no smoking or eating, etc.) and dust minimisation

measures should be adopted to minimise risks to construction personnel and the general public.

6.7 Disposal of soil from the site will probably attract a premium, however reference should be made to the relevant tip operators and waste disposal authority regarding this issue. More detailed testing may be needed to fully classify the waste and achieve the most economic disposal route.

6.8 Sulphate and pH tests were carried out on samples of the soil and the results are appended and summarised below:

Soil	
Sulphate Concentration	= <0.1 g/l SO_4 in 2:1 water/soil extract
pH	= 7.3 - 8.7

6.9 From these results it can be seen that relatively low sulphate concentrations have been proved in the samples tested indicating that there should not be any deterioration due to sulphate attack of good quality dense concrete made from Ordinary Portland Cement. See BRE Digest Special Digest 1 (2001) for further details.

7 GROUND GAS MONITORING

7.1 Three standpipes were installed in boreholes 1, 3 & WS2 with the response zone details presented on the borehole logs. The standpipes were fitted with gas taps and have been monitored on two occasions to date for the presence of Methane, Carbon Dioxide and Oxygen using a Gas Data LMS Xi instrument. Subsequent to the gas readings being obtained, the gas taps were briefly removed to allow measurement of the groundwater level in the standpipe reported in Section 5.1 and then replaced to allow the standpipe atmosphere to equilibrate prior to the succeeding monitoring visit.

7.2 The results of the ground gas monitoring to date are appended. From these results it may be seen that trace Methane levels of up to 0.3% by volume were recorded within the standpipes. Carbon Dioxide concentrations up to 1.4% by volume and depleted Oxygen concentrations were also measured. Combined with the gas flow readings these results give a Gas Screening Value (GSV) of 0.02 l/hr, these initial readings place the site within Characteristic Situation 1 (CS1) of CIRIA document C665 which is very low risk. Further ground gas monitoring visits are to be undertaken and will be reported in due course, along with our final advice for ground gas exclusion measures.

8 SOIL TESTS AND BEARING CAPACITIES

8.1 The following in-situ and laboratory tests were carried out in order to provide the required data for estimating the maximum safe bearing capacities of the various deposits:

i) Undrained Triaxial Compression tests carried out on 38mm diameter relatively 'undisturbed' samples. Detailed results are tabulated in Appendix Bi) and undrained shear strength (Cu) values are plotted in Fig 1.

ii) Standard Penetration Tests carried out in the boreholes. Detailed results are tabulated in the borehole logs (Appendix 'A') and "N" values (blows per 300mm) are plotted in Fig 1.

iii) Hand penetrometer tests carried out on disturbed and undisturbed samples.

From the above it may be seen that:

8.2 Made Ground

Standard Penetration Tests undertaken in this deposit returned results of:

N = 2 - 31 blows for 300 mm penetration

indicating very 'loose' and variable ground conditions

8.3 Sand and Gravel (BH1)

This deposit was proved to be in a loose and medium dense state of packing with Standard Penetration Test results of:

N = 9 & 10 blows for 300 mm penetration

8.4 Organic Clay

This deposit was proved to be of a very soft to soft/firm consistency with measured undrained shear strength values of:

$Cu = 26\ kN/m^2$

and Standard Penetration Tests carried out in this deposit gave results of

N = 5 - 14 blows for 300 mm penetration

8.5 Glacial Clay Zone 1

This deposit was proved to be of a stiff to very stiff consistency with measured undrained shear strength values of:

$$Cu = 106 - 127 \text{ kN/m}^2$$

and a Standard Penetration Tests carried out in this deposit gave a result of

$$N = 17 \text{ blows for } 300 \text{ mm penetration}$$

We estimate the maximum safe bearing capacity of the stiff to very stiff clay to be about

$$300 \text{ kN/m}^2 \text{ (pile foundations)}$$

which may have to be reduced in practice to avoid overstressing underlying weaker deposits

8.6 Glacial Clay Zone 2

This deposit was proved to be of a firm/stiff to stiff consistency with measured undrained shear strength values of:

$$Cu = 82 - 142 \text{ kN/m}^2$$

We estimate the maximum safe bearing capacity of the stiff to very stiff clay to be about

$$240 \text{ kN/m}^2 \text{ (pile foundations)}$$

8.7 Glacial Clay Zone 3

This deposit was proved to be of a very stiff consistency with measured undrained shear strength values of:

$$Cu = 231 \text{ kN/m}^2$$

8.8 Clay/Sand

This deposit was proved to be of a hard/very dense consistency with Standard Penetration Tests carried out in this deposit giving results of:

$$N = 106 - 123 \text{ blows for } 300 \text{ mm penetration}$$

We estimate, therefore, that piles driven to a 'set' in this deposit should develop maximum safe end bearing values of at least

$$1{,}500 \text{ (Driven Piles)}$$

For bored piles the maximum safe end bearing capacity will depend on the degree of disturbance produced at the base of the pile by the boring and concreting. It could be about 750 kN/m^2 or more for piles founded on a relatively undisturbed dense sand

base, but could tend to zero for piles founded on a very loose and soft clayey base. It is, therefore, advisable to check the actual end bearing capacity for a particular type of bored pile by at least two pile loading tests. Alternatively the piling contractor could give adequate proof from his experience on similar soils that he can obtain the required end bearing capacity and working loads for his piles

8.9 It should be noted that the maximum safe bearing capacities are nett values. The gross maximum safe bearing capacities can be obtained by adding the pressure at formation level of the soil surrounding the footing to the nett values.

$$\text{i.e. MSBC (gross)} = \text{MSBC (nett)} + \frac{\gamma D}{102}\ \text{kN/m}^2$$

where

D = depth of soil surrounding footing (m)

γ = average density of soil strata above formation level (kg/m^3)

9 COMMENTS

9.1 It is proposed to demolish the existing workshop structure to the south of John Dalton Central and construct a new two storey steel framed workshop (approx. 570m^2 plan area) and to construct a two storey steel framed extension onto the existing John Dalton Tower. Further details of development layout, foundation loadings and design have not been made available at this time.

9.2 Made Ground up to 3.50m thick was proved in the boreholes although thicker zones may be present elsewhere (e.g. old foundations, deep service excavations, basements, etc.). The Made Ground was underlain by a 0.6-0.8m thick impersistent soft/firm to firm/stiff Clay in WS1 and WS2, with a 1.2-2.1m thick loose to medium dense Sand and Gravel deposit was proved from 1.3-2.1m bgl in WS1, WS2 and BH1 and a 0.5-2.05m thick very soft to soft/firm Organic Clay proved in BH1&3. A 0.6-4.4m thick stiff to very stiff Glacial Clay was proved in all boreholes at 2.6-4.55m bgl underlain by a firm/stiff to stiff Glacial Clay at 4.6-7.0 in BH1-3 and a very stiff Glacial Clay proved below 9.0-10.05m bgl. A hard/very dense Clay/claybound Sand was proved below 11.4-11.5m bgl.

9.3 We are of the opinion that the Made Ground, soft/firm Clay and Organic Clay are unsuitable for the support of major structures due to the risks of excessive total and differential settlements developing. We are of the opinion that in view of the proved thickness of Made Ground below some parts of the site, the former development over most of the site and the restricted nature of the site within a working university environment (including the proximity to live services) that the use of piled foundations will present the most suitable and economic foundation. The proposed developments may, therefore, be supported on piled foundations established into the firm/stiff to very stiff Glacial Clay Zones 1 and 2 and designed on the maximum safe bearing capacities given in Section 8.

The working loads for the piles may be estimated from the maximum safe end bearing capacities given in Section 8 and the following skin friction values.

ALLOWABLE SKIN FRICTION

Stratum	Allowable Skin Friction kN/m^2	
	Bored Piles	Driven Piles
Stiff and very stiff Glacial Clay Zone 1	23	35
Firm/stiff to stiff Glacial Clay Zone 2	20	30

These values are based on the assumptions that with bored piles the boring and concreting will produce a 50% reduction in shear strength whilst for driven piles the driving and concreting will produce at 25% reduction. A maximum skin friction of 40 kN/m^2 has also been assumed.

These skin friction values may have to be modified ie., increased or decreased when the type of pile and method of construction and concreting etc., are known.

It should also be noted that the above skin friction values are based on mean factors of safety approximately 2.5. Higher skin friction values are, therefore, possible if the structural consultant and client is prepared to accept lower factors of safety for certain structures.

The final working loads for the piles should be confirmed by at least two pile loading tests are alternatively the piling contractor should give adequate proof from his experience on similar soils that he can obtain the required working loads. Either bored or driven piles may be adopted however with driven piles the specialist piling contractor should confirm that with his particular system there will be no excessive vibration or vibration induced settlements which may affect surrounding structures.

9.4 It should be appreciated that differential movements will tend to develop between existing and proposed structures. Provision for such movement (settlement joints, etc.) should be incorporated to remove the risk of structural damage to either the existing or new structures.

9.5 Chemical testing of sampled soils from varying depths within the Made Ground revealed low concentrations of contaminants in the samples which dictate that remediation of the site will not be necessary (see section 6). Initial ground gas monitoring visits have also been undertaken, the initial results are discussed in section 7, with further monitoring results and comments to follow.

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Claire L Capes
Engineering Geologist

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Eur Ing R H Shires

REFERENCES

BS 5930 : 1999 : Code of practice for site investigation. British Standards Institution

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SUB SOIL *Surveys Ltd* MANCHESTER M29 7LD 0942 883565

Ground Level | Site Reference 2008/92 | Borehole No. 1 | 1 of 2

Boring Method: Light Cable Percussion | CASING: 150mm to depth of 9.0m | Site: MMU, Manchester | Client: Scott Hughes Design

Date	Depth of Casing Below G.L.	Water Level Morning & Evening	Depth of Strata Below G.L.	Description of Strata (all depths given in metres)	Inst. Details	No & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
21.07.08				Topsoil, clay, brick fragments, stone, sand, fine roots						
			0.30	(MADE GROUND)		1D	0.20			
				Crushed concrete and stone						
			0.60	(MADE GROUND)						
				Sand, stone, clay and brick fragments (MADE GROUND)		2D	1.00			
						3X	1.35	1.65	10	
			1.30	Loose brown claybound SAND with some gravel and firm to stiff sandy clay lenses		4X	1.95	2.25	9	
			2.50	Soft to soft/firm grey brown organic CLAY with a little gravel - 'organic' odour		5X	2.65	2.95	5	
						6D	3.00			
						7U	3.50	3.95		
						8D	4.05			
						9X	4.25	4.55	14	
21.07.08 22.07.08	4.0		4.55	Stiff brown sandy CLAY with a little gravel and organic lenses - slight 'organic' odour		10U	4.70	5.15		
			5.15	Firm/stiff to stiff brown silty sandy CLAY with a little gravel, cobbles and coal fragments		11D	5.25			
						12U	5.50	5.95		
						13D	6.05			
						14U	6.50	6.95		
						15D	7.05			
						16U	7.50	7.95		
			8.00							

Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during boring depths below ground level

depth observed	after 5 mins.	after 10 mins.	after 15 mins.	after 20 mins.	Estimated Seepage	Depth of Casing when sealed N.S. - Not Sealed
None						

Water Added to Assist Boring at:

Water level in Cased/Uncased Borehole on Completion depth below ground level

Date	Water Level	Depth of Casing

REMARKS

Standpipe inserted to 4.5m, gravel response zone 1.0-4.5m bgl
Time spent excavating by hand - 1 hrs.

SUB SOIL *Surveys Ltd* MANCHESTER M29 7LD 0942 883565

Ground Level | Site Reference 2008/92 | Borehole No. 1 | 2 of 2

Boring Method: Light Cable Percussion

CASING: 150mm to depth of 9.0m

Site: MMU, Manchester

Client: Scott Hughes Design

Date	Depth of Casing Below G.L.	Water Level Morning & Evening	Depth of Strata Below G.L.	Description of Strata (all depths given in metres)	Inst. Details	No. & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
				Firm/stiff to stiff brown silty sandy CLAY with a little gravel, cobbles and coal fragments		17D	8.05			
						18U	8.50	8.95		
			9.00	Very stiff brown silty sandy CLAY with a little gravel and coal fragments		19D	9.05			
						20U	9.50	9.95		
						21D	10.05			
						22U	10.50	10.95		
						23D	11.05			
			11.50	Hard brown very sandy CLAY with a little gravel/very dense brown claybound SAND - possibly weak weathered upper zone of bedrock		24U	11.50	11.70		NR
						25X	11.85	12.15	106	
22.07.08	9.0		12.15							

Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during boring depths below ground level

depth observed	after 5 mins.	after 10 mins.	after 15 mins.	after 20 mins.	Estimated Seepage	Depth of Casing when sealed N.S. - Not Sealed

Water level in Cased/Uncased Borehole on Completion depth below ground level

Date	Water Level	Depth of Casing

Water Added to Assist Boring at:

REMARKS

SUB SOIL *Surveys Ltd*
MANCHESTER
M29 7LD
0942 883565

Ground Level

Site Reference 2008/92

Borehole No. 2

Boring Method: Light Cable Percussion

CASING: 150mm to depth of 10.0m

Site: MMU, Manchester

Client: Scott Hughes Design

Date	Depth of Casing Below G.L.	Water Level Morning & Evening	Depth of Strata Below G.L.	Description of Strata (all depths given in metres)	Reduced Level	No & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
18.07.08			0.20	Topsoil, clay, stone, concrete, brick fragments, ash and fine roots (MADE GROUND)		1D	0.20			
				Brown sandy clay, brick fragments, stone and ash (MADE GROUND)		2D	1.00			
						3X	1.35	1.65	11	
						4X	1.95	2.25	31	NR
						5D	2.30			
			2.60			6X	2.65	2.95	17	
				Stiff to very stiff brown silty sandy CLAY with a little gravel, coal fragments, silty sand lenses and cobbles		7U	3.20	3.65		
						8D	3.75			
18.07.08 21.07.08	4.0	Dry	4.0							
						9U	4.40	4.85		
						10D	4.95			
						11U	5.50	5.95		
						12D	6.05			
						13U	6.50	6.95		
			7.00							
				Firm/stiff brown sandy CLAY with a little gravel		14D	7.05			
						15U	7.50	7.95		
			8.00							

Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during boring depths below ground level

depth observed	after 5 mins.	after 10 mins.	after 15 mins.	after 20 mins.	Estimated Seepage	Depth of Casing when sealed N.S. - Not Sealed
None						

Water level in Cased/Uncased Borehole on Completion depth below ground level

Date	Water Level	Depth of Casing

Water Added to Assist Boring at:

REMARKS

18.7.2008 Locating services 2 hours
Time spent excavating by hand - 2 hrs.
Time Spent Re-instating: (30 mins)

SUB SOIL *Surveys Ltd*

MANCHESTER
M29 7LD
0942 883565

Ground Level

Site Reference 2008/92

Borehole No 2

Boring Method: Light Cable Percussion

CASING: 150mm to depth of 10.0m

Site: MMU, Manchester

Client: Scott Hughes Design

Date	Depth of Casing Below G.L.	Water Level Morning & Evening	Depth of Strata Below G.L.	Description of Strata (all depths given in metres)	Reduced Level	No & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
				Firm/stiff to stiff brown silty sandy CLAY with a little gravel and occasional laminated zones		16D	8.05			
						17U	8.50	8.95		
						18D	9.05			
						19U	9.50	9.95		
			10.00	Very stiff brown very sandy CLAY with a little gravel/brown claybound SAND		20D	10.05			
						21U	10.50	10.95		
						22D	11.05			
			11.40	Very dense reddish brown claybound SAND with a little gravel and cobbles - possible weak weathered upper zone of bedrock		23D 24X	11.40 11.75	12.05	117	
21.07.08	10.0		12.05							

Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during boring depths below ground level

depth observed	after 5 mins.	after 10 mins.	after 15 mins.	after 20 mins.	Estimated Seepage	Depth of Casing when sealed N.S. - Not Sealed

Water level in Cased/Uncased Borehole on Completion depth below ground level

Date	Water Level	Depth of Casing

Water Added to Assist Boring at:

REMARKS

SUB SOIL *Surveys Ltd*

MANCHESTER
M29 7LD
0942 883565

Ground Level

Site Reference 2008/92

Borehole No 3

Boring Method: Light Cable Percussion

CASING: 150mm to depth of 9.0m

Site: MMU, Manchester

Client: Scott Hughes Design

Date	Depth of Casing Below G.L.	Water Level Morning & Evening	Depth of Strata Below G.L.	Description of Strata (all depths given in metres)	Inst Details	No. & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
23.07.08			0.10	Tarmac						
			0.25	Concrete						
				Roadstone (MADE GROUND)						
			0.60	Soft/firm clay, ash, bitmac, stone, brick fragments (MADE GROUND)		1D	0.60			
						2D	1.00			
						3X	1.55	1.85	4	NR
						4D	2.00			
						5X	2.15	2.45	2	
			2.50	Soft/firm grey organic clay with occasional ash and brick fragments (MADE GROUND)						
				- 'organic' odour		6X	2.95	3.25	6	
			3.50	Very soft to soft dark grey and grey organic CLAY with sand and gravel lenses, cobbles and peat layers		7U	3.50	3.95		
			4.00	- 'organic' odour						
				Stiff brown sandy CLAY with a little gravel and coal fragments		8D	4.05			
						9U	4.50	4.95		
						10D	5.05			
						11U	5.50	5.95		
						12D	6.05			
						13U	6.50	6.95		
						14D	7.05			
						15U	7.50	7.95		
			8.00							

Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during boring depths below ground level

depth observed	after 5 mins.	after 10 mins.	after 15 mins	after 20 mins.	Estimated Seepage	Depth of Casing when sealed N.S. - Not Sealed
None						

Water Added to Assist Boring at.

Water level in Cased/Uncased Borehole on Completion depth below ground level

Date	Water Level	Depth of Casing

REMARKS

Standpipe inserted to 4.5m, gravel response zone 1.0-4.5m bgl
Breaking out - 45 minutes
Time spent chiselling - 1.5 hrs. Time spent excavating by hand - 1.75 hrs.

SUB SOIL *Surveys Ltd* MANCHESTER M29 7LD 0942 883565

Ground Level

Site Reference 2008/92

Borehole No. 3

Boring Method: Light Cable Percussion

CASING: 150mm to depth of 9.0m

Site: MMU, Manchester

Client: Scott Hughes Design

Date	Depth of Casing Below G.L.	Water Level Morning & Evening	Depth of Strata Below G.L.	Description of Strata (all depths given in metres)	Inst Details	No. & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
				Stiff to very stiff brown sandy and silty CLAY with a little gravel, occasional laminated zones, coal fragments, cobbles		16D	8.05			
						17U	8.50	8.95		
						18D	9.05			
						19U	9.50	9.95		
23.07.08 24.07.08	9.0		10.05	Very stiff brown very sandy CLAY with a little gravel/Brown claybound SAND		20D	10.05			
						21U	10.50	10.95		
						22D	11.05			
			11.40	Reddish brown claybound SAND with clay lenses and a little gravel - possibly weak weathered upper zone of bedrock		23D 24X	11.40 11.75	12.05	123	
24.07.08	9.0		12.05							

Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during boring depths below ground level

depth observed	after 5 mins.	after 10 mins.	after 15 mins.	after 20 mins.	Estimated Seepage	Depth of Casing when sealed N.S. - Not Sealed

Water level in Cased/Uncased Borehole on Completion depth below ground level

Date	Water Level	Depth of Casing

Water Added to Assist Boring at:

REMARKS

SUB SOIL *Surveys Ltd* MANCHESTER M29 7LD 0942 883565

Ground Level | Site Reference 2008/92 | Borehole No **WS1** | 1 of 1

Boring Method: Window Sampler | CASING: 100mm to depth of 2.0m | Site: MMU, Manchester | Client: Scott Hughes Design

Date	Depth of Casing Below G.L	Water Level Morning & Evening	Depth of Strata Below G.L	Description of Strata (all depths given in metres)	Reduced Level	No. & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
23.07.08				Topsoil onto sand, stone, brick fragments, clay, ash (MADE GROUND)		1D	0.20			
						2D	0.50			
			0.80	Stiff light brown/grey mottled silty sandy CLAY with some gravel and sand lenses		3D	1.00			
						4R	1.20	2.00		
			1.40	Brown SAND AND GRAVEL with cobbles and occasional clay lenses						
						5R	2.00	3.00		
			2.85	Very stiff brown sandy CLAY with a little gravel and cobbles		6R	3.00	4.00		
			3.10	Brown SAND with a little gravel and stiff clay lenses						
			3.50	Stiff to very stiff brown silty sandy CLAY with a little gravel						
			4.00	Brown SAND with a little gravel		7R	4.00	5.00		
			4.60	Firm/stiff brown silty sandy CLAY with a little gravel						
23.07.08	2.0		5.0							

Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during boring depths below ground level

depth observed	after 5 mins.	after 10 mins.	after 15 mins.	after 20 mins.	Estimated Seepage	Depth of Casing when sealed N.S. - Not Sealed
None						

Water Added to Assist Boring at:

Water level in Cased/Uncased Borehole on Completion depth below ground level

Date	Water Level	Depth of Casing

REMARKS

Time spent excavating by hand - 30 minutes

SUB SOIL *Surveys Ltd*

MANCHESTER
M29 7LD
0942 883565

Ground Level

Site Reference 2008/92

Borehole No. **WS2** 1 of 1

Boring Method: Window Sampler

CASING: 100mm to depth of 2.0m

Site: MMU, Manchester

Client: Scott Hughes Design

Date	Depth of Casing Below G.L.	Water Level Morning & Evening	Depth of Strata Below G.L.	Description of Strata (all depths given in metres)	Inst. Details	No. & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
23.07.08				Sandy clay, stone, brick fragments, sand, ash, fine roots (MADE GROUND)		1D	0.20			
						2D	0.50			
						3D	1.00			
						4R	1.20	2.00		
			1.30	Soft/firm becoming firm/stiff light brown/grey mottled silty slightly sandy CLAY with grey fissures and coal fragments						
			2.10	Medium dense brown SAND AND GRAVEL with clayey zones, sand lenses and cobbles		5R	2.00	3.00		
						6X	3.15	3.45	20	
						7R	3.00	4.00		
			3.30	Stiff brown silty sandy CLAY with sand and gravel lenses						
						8R	4.00	5.00		NR
23.07.08	2.0		5.0							

Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during boring depths below ground level

depth observed	after 5 mins	after 10 mins.	after 15 mins.	after 20 mins.	Estimated Seepage	Depth of Casing when sealed N.S - Not Sealed
None						

Water Added to Assist Boring at:

Water level in Cased/Uncased Borehole on Completion depth below ground level

Date	Water Level	Depth of Casing

REMARKS

Standpipe inserted to 4.0m, gravel response zone 1.0-4.0m bgl
Time spent excavating by hand - 15 minutes

SUB SOIL *Surveys Ltd*

MANCHESTER Ground Level
M29 7LD
0942 883565

Site Reference 2008/92

Trial Pit No. **TP1**

1 of 1

Site MMU, Manchester

Client Scott Hughes Design

Trialpit
Hand Excavated

Date	Depth of Strata Below G.L.	Description of Strata (all depths given in metres)	Reduced Level	No. & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
23.07.08		Tarmac						
	0.15	Stone (MADE GROUND)						
	0.65	Stone, bitmac, brick and concrete fragments and ash (MADE GROUND)		1D	0.90			
23.07.08	1.2							

Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during excavation depths below ground level

depth observed	after 5 mins.	after 10 mins.	after 15 mins.	after 20 mins.	Estimated Seepage
None					

Water level in Trial Pit on Completion depth below ground level

Date	Water Level	Casing Depth

REMARKS

Pit broke out, excavated and reinstated
Brick footings exceeded depth of trial pit >1.2m

SUB SOIL *Surveys Ltd*

MANCHESTER Ground Level
M29 7LD
0942 883565

Site Rererence 2008/92

Trial Pit No **TP2**

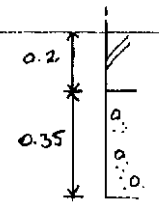
1 of 1

Trialpit
Hand Excavated

Site MMU, Manchester

Client Scott Hughes Design

Date	Depth of Strata Below G.L.	Description of Strata (all depths given in metres)	Reduced Level	No. & Type of Sample	Penetration of Sampler From	Penetration of Sampler To	Number of Blows	Symbolic Log
23.07.08	0.15	Tarmac Stone (MADE GROUND)						
23.07.08	0.7							



Sample Key: B.Bulk D.Disturbed U.Open Tube V.Vane W.Water X.Standard Penetration Test

Water Level Observations during excavation depths below ground level

depth observed	after 5 mins.	after 10 mins.	after 15 mins.	after 20 mins.	Estimated Seepage
None					

Water level in Trial Pit on Completion depth below ground level

Date	Water Level	Casing Depth

REMARKS

Pit broke out, excavated and reinstated

LABORATORY RESULTS-Classification, Strength, U100 Descriptions

Project: MMU Manchester

Project No: 2008/92

Sample				Classification					Strength						
Hole	Depth	Type	Description	% pass. .425 mm	I_P	W_L	W_P	W%	Test	γ_b Mg/m^3	σ_3 kN/m^2	σ_1 σ_3 kN/m^2	c kN/m^2	ϕ deg
1	3.50 3.95	7U	Soft greyish brown organic CLAY with a little gravel and lenses of very sandy clay					26	U2	1.93	138 414	48 58	26	0
	4.70 5.15	10U	Stiff brown sandy CLAY with a little gravel and organic lenses - slight "organic" odour					NO TEST						
	5.50 5.95	12U	Stiff brown silty sandy CLAY with a little gravel					NO TEST						
	6.50 6.95	14U	Firm/stiff brown sandy CLAY with a little gravel, coal fragments and a cobble					15	U2	2.13	138 414	167 188	89	0
	7.50 7.95	16U	Stiff to very stiff brown sandy CLAY with a little gravel					NO TEST						
	8.50 8.95	18U	Firm/stiff brown sandy CLAY with a little gravel and coal fragments					15	U2	2.14	138 414	155 173	82	0
	9.50 9.95	20U	Very stiff brown silty sandy CLAY with a little gravel					NO TEST						
	10.50 10.95	22U	Very stiff brown sandy CLAY with a little gravel and coal fragments					12	U2	2.20	138 414	432 491	231	0
2	3.20 3.65	7U	Stiff to very stiff brown silty sandy CLAY with a little gravel, silty sand lenses and coal fragments					NO TEST						
	4.40 4.85	9U	Stiff brown sandy CLAY with a little gravel and coal fragments					16	U2	2.12	138 414	239 246	121	0
	5.50 5.95	11U	Stiff brown sandy CLAY with a little gravel, coal fragments and cobbles					16	U2	2.12	138 414	249 259	127	0
	6.50 6.95	13U	Stiff brown sandy CLAY with a little gravel and sand and silt lenses					NO TEST						
	7.50 7.95	15U	Firm/stiff brown sandy CLAY with a little gravel					17	U3	2.12	138 276 414	102 225 217	91	0
	8.50 8.95	17U	8.50-8.70 Stiff brown silty sandy CLAY with a little gravel 8.70-8.95 Firm/stiff silty sandy CLAY with a little gravel					NO TEST						
	9.50 9.95	19U	Stiff brown sandy CLAY with a little gravel and laminated zones					13	U2	2.19	138 414	303 263	142	0
	10.50 10.95	21U	Very stiff brown very sandy CLAY with a little gravel / Brown claybound SAND					NO TEST						

Remarks

SUB SOIL

M29 7LD 01942 883565

LABORATORY RESULTS-Classification, Strength, U100 Descriptions

Project: MMU Manchester

Project No: 2008/92

Sample				Classification				Strength						
Hole	Depth	Type	Description	% pass. .425 mm	I_P	W_L	W_P	$W\%$	Test	γ_b Mg/m^3	σ_3 kN/m^2	$\sigma_1-\sigma_3$ kN/m^2	c kN/m^2	ϕ deg
3	3.50 3.95	7U	3.50-3.75 Soft dark grey organic CLAY with peat layers - "organic" odour 3.75-3.95 Very soft grey organic very sandy CLAY with a little to some gravel and cobbles - "organic" odour					NO TEST						
	4.50 4.95	9U	Stiff brown sandy CLAY with a little gravel and coal fragments					16	U2	2.14	138 414	233 256	122	0
	5.50 5.95	11U						NO TEST						
	6.50 6.95	13U						14	U2	2.15	138 414	214 209	106	0
	7.50 7.95	15U	Stiff brown sandy CLAY with a little gravel					NO TEST						
	8.50 8.95	17U	Stiff brown sandy CLAY with a little gravel, small laminated zones, coal fragments and a cobble					17	U3	2.11	138 276 414	183 213 246	107	0
	9.50 9.95	19U	Stiff brown sandy CLAY with a little gravel, an occasional grey fissure, laminated zones and coal fragments					16	U3	2.13	138 276 414	104 204 402	118	0
	10.50 10.95	21U	Very stiff brown very sandy CLAY with a little gravel / Brown claybound SAND with a little gravel					NO TEST						
WS 1	1.20 2.00	4R	1.20-1.40 Stiff light greyish brown, orange brown and yellowish brown mottled sandy CLAY with some gravel and sand lenses 1.40-1.80 Brown SAND AND GRAVEL 1.80-2.00 Brown SAND AND GRAVEL with small clay pockets					20	U2	1.99	138 414	228 233	115	0
WS 2	1.80 2.00	4R	Firm/stiff light yellowish brown and grey mottled sandy CLAY with a little gravel, sand lenses, grey fissures and coal fragments					19	U2	2.04	138 414	170 190	90	0

Remarks

SUB SOIL

M29 7LD 01942 883565