HUMBERSIDE MATERIALS LABORATORY LIMITED

Atherton Way
Brigg
North Lincolnshire
DN20 8AR
Telephone & Fax 01652 652753
www.humbersidematerialslab.co.uk

Site investigation report

Land adjacent to 37 St Pauls Road, Spalding

Client: A. Dungarwalla

Date: May 2018

Report number: 1107/4518/P/P2

Contents

1	Introduction		3
	1.1	Aims	
	1.2	Scope	
	1.3	Conditions and limitations	
2	Review of desk study information		4
	2.1	Sources of information	
	2.2	Site Description and Topography	
	2.3	Site History	
	2.4	Geology and hydrogeology	
	2.5	Waste-related data	
	2.6	Radon	
	2.7	Industrial land use	
	2.8	Initial contamination assessment	
3	Site investigation works		8
	3.1	Fieldwork	
	3.2	Laboratory testing	
4	Encountered ground conditions		10
	4.1	Sequence of sub-strata	
	4.2	Topsoil	
	4.3	Tidal flat deposits	
	4.4	Groundwater observations	
	4.5	Geochemical testing	
	4,6	Percolation/Soakaway test results	
5	Revised Contamination Assessment		13
	5.1	Revised CSM	
	5.2	Revised risk assessment	
6	Engineering issues		14
	6.1	Foundations	
	6.2	Buried concrete	
	6.3	Excavations and groundwater control	
	6.4	Radon	
	6.5	Gas protection measures	
	6.6	Soakaway design	
7	Summary and conclusion		16
	7.1	Ground conditions	
	7.2	Geotechnical properties	
	7.3	Foundations	
	7.4	Buried concrete	
	7.5	Excavations and groundwater	
	7.6	Gas protection measures	
	7.7	Soakaway design	
	7.8	Contamination assessment	
8	References		18

Appendix A	-	Site plans and photographs
Appendix B	-	Borehole logs
Appendix C	-	Laboratory test results

1 Introduction

The client, Mr. A Dungarwalla, has engaged Humberside Materials Laboratory Limited (HML) to undertake a geo-environmental site investigation report for a proposed development on land adjacent to number 37 St Pauls Road, Spalding, Lincolnshire. The land will be hereinafter described as *the site*.

1.1 Aims

The aim of the investigation is to assess relevant engineering and environmental aspects of the site in relation to the proposed development works. This includes an evaluation of encountered ground conditions, potential contamination hazards and geotechnical issues.

1.2 Scope

The scope of the investigation includes:

- A windowless sampler intrusive investigation with in-situ strength assessment
- Geochemical and geotechnical laboratory testing
- Contamination risk assessment based on a conceptual site model
- An assessment of engineering issues

1.3 Conditions and Limitations

This report is produced solely for the above client and should only be copied in full. When transmitted electronically, the definitive copy of the report is held by Humberside Materials Laboratory Ltd.

This report is prepared on the assumption that all facts have been disclosed.

The comments given in this report and the opinions expressed assume that conditions do not vary beyond the range revealed by this study and the information provided in the production of this report is complete and reliable.

2 Review of desk study information

2.1 Sources of information

The main source of desk study information used is the HML Phase 1 report (HML reference: 1107/4518/P/P1) dated April 2018. The Phase 1 report contains various sources of information, including an Envirocheck report with historical maps.

2.2 Site description

2.2.1 Location and size

The site is situated in the northeast part of the town of Spalding, Lincolnshire (post code: PE11 2LZ). The site is centred around national grid reference (NGR) 525560, 323480.

The site is mostly comprised of the unused land to the rear of a Londis convenience store. The remainder of the site is made up of the driveway and part of the gardens to number 37 St Pauls Road. The site is about 20m long by about 15m wide.

A site location plan is included in Appendix A.

2.2.2 Site features

The site contains no buildings or structures. The ground is mostly bare earth or grassed lawn but there is some concrete hardstanding adjacent to the dwelling at 37 St Pauls Road and in the northwest corner of the site.

Part of a domestic garage building recently occupied a few square metres in the west corner of the site. However, this has been recently removed.

Views of the site are presented in Appendix A.

2.2.3 Site topography

The site is relatively even and flat, with ground levels at site estimated to be approximately 3m-4m above Ordnance Datum. However, there is a very slight incline up towards the west (by about 0.5m across the site).

2.2.4 Surrounding land use

The site is bounded by the following:

- North: A hedgerow beyond which is a grassed public open space
- East: The residential property at number 37 St Pauls Road

- South: rear gardens to residential properties accessed from Burge Close
- West: (Rear of) a Londis convenience store

2.2.5 Initial evidence of potential contamination

No initial evidence of potential contamination has been found at the site. No unusual odours were detected. No oil sheen was observed. The vegetation around the site showed no apparent signs of distress. No tanks, barrels or other liquid storage containers were seen.

2.2.6 Proposed development

The proposed development is understood to be a single structure to form two semi-detached domestic dwellings. The proposed new dwellings are to be towards the northeast boundary of the site with small garden areas to the rear. To the southeast boundary of the site will be the driveway and associated parking areas with access from the end of St Pauls Road. It is expected to be a double storey structure.

A plan of the proposed works is contained within Appendix A.

2.3 Site History

2.3.1 On-site development

During its history, there appears to have been two small outbuilding structures on the site as evidenced in the historical map from 1980. One of the structures consisted of the rear part of a garage in the southwest corner of the site. The other is a small structure to the northwest corner. It is not known what this structure was and by the 1992 maps it has been removed.

The only previous use identified on the historical maps is allotments.

2.3.2 Off-site development

No evidence from off-site has been identified to be of significance to the development of the site. There is no evidence of major industry near the site, landfills, factories or mining or quarrying activity. The site is located within a large housing estate developed sometime between 1950 and 1970.

2.4 Geology and hydrogeology

Based on the reviewed desk top information, the anticipated ground conditions are as shown below (in Table 1).

Table 1: Anticipated geology			
Strata	*Description*	*Approx. anticipated thickness (m)*	*Approx. anticipated depth to base of stratum (m bgl)*
Topsoil / Made ground	Organic soil / Demolition materials	0.4	~0.4
Tidal flat deposits	Sandy SILT with some clay (generally becoming more sandy with depth)	15	14 - 16
	Sandy GRAVEL	2	15 - 20
Boulder clay	Stiff silty clay with (chalk) gravel	6	20 - 25
Oxford Clay	(weathered) Mudstone formation	40	60 - 70
Notes: Anticipated groundwater table: 1-2m bgl			

According to the Coal Authority, the site is not in an area which may be affected by coal mining. Therefore, a coal mining report is not required.

The anticipated geology is comprised predominantly of silts and clays. Therefore, the ground conditions are likely to be of relatively low permeability.

2.5 Waste-related data

There are no reported (*BGS recorded*, *Historical*, *Registered or Local authority-recorded*) *landfill sites* near to the site. The nearest is 662m to the north of the site.

There are no reported *licensed waste management facilities* near to the site. The nearest is 260m to the northwest of the site.

There is no reported *potentially infilled land* near to the site. There is none within 1km.

There are 10 reports of *potentially infilled land (water)* near to the site. The nearest is 58m to the southwest of the site and appears to pertain to the backfilling of an open land drain.

There are no reported *waste transfer sites* or *registered waste treatment or disposal sites* near to the site. The nearest is 344m to the northwest of the site.

2.6 Radon

With respect to *Radon potential*, the site is in a Lower probability area with less than 1% of homes above the action level. No radon protection measures are therefore necessary for new developments.

2.7 Industrial land use

As discussed, the site forms part of garden areas with some of the site being the rear garden area to a convenience store and the other that of the garden area to a domestic dwelling. The site was once used as allotments. However, there is no evidence of any significant industrial activity at or near the site.

2.8 Initial contamination assessment

The HML Phase 1 report produced an initial conceptual site model (CSM) of potential land contamination sources, pathways and receptors. The CSM indicated that potential made ground could contain metals, PAH and asbestos.

The preliminary risk assessment indicated that there could be potentially significant risks associated with these pollutants. There are possible contamination linkages relating to site occupiers and workers inhaling, absorbing or ingesting the potential contaminants.

3 Site Investigation Works

3.1 Fieldwork

All fieldwork took place on Wednesday 25th April 2018.

Exploratory holes (including windowless sampler boreholes and a hand-dug trial pit) were carried out to explore the ground conditions around the proposed development. The procedures adopted for this site investigation are based on BS 5930 (2015) – Code of Practice for Site Investigations and BS 10175 (2013) Investigation of potentially contaminated sites – code of practice. The soils and rocks encountered have been described with reference to BS5930 (2015), BS EN ISO 14688-1 (2002) and BS EN ISO 14689-1 (2003).

3.1.1 Boreholes

Three borehole locations (BH1, BH2 & BH3) were selected to encompass the area of the site and were drilled to depths of up to 3.0m bgl using a Dando Terrier window sampler rig. This involved the percussive driving of a 1m-long steel tube with a plastic sample tube inserted (approx. 100mm in diameter). Each tube was then removed and sealed. Each hole was progressed to the required depth by repeating the process with extension rods. All sample tubes were returned to the HML laboratory for logging and testing.

Samples were taken at various depths as indicated on the borehole logs (in Appendix B).

The positions of the boreholes were established relative to existing site features.

Approximate locations of all site works are shown in the exploratory hole location plan (in Appendix A).

3.1.2 In-situ testing

In-situ standard penetration tests (SPTs) were performed at 1m intervals within the boreholes. The SPT conditions were such that corrected SPT blow-counts (N_{60} values) should be approximately equal to uncorrected N values.

Dynamic probing was carried out at the base of BH2 and BH3 using the Dando Terrier rig with a super heavy probe configuration and an SPT hammer and fall height. The probing extended to a depth of 10m bgl.

A percolation (i.e. soakaway) test was carried out in BH1. Water was quickly poured into the 2m-deep uncased borehole and the water level was then monitored over a period of 180 minutes.

3.1.3 Hand-dug trial pit

A hand-dug trial pit (HP1) was excavated to a depth of 1.0m bgl to inspect ground conditions and retrieve samples for testing. HP1 was situated in the north corner of the site, where made ground was suspected.

3.2 Laboratory Testing

Geotechnical testing was undertaken at the HML UKAS-accredited laboratory. The scope of geotechnical testing comprised:

- 2 number plasticity index (PI) tests
- 2 number natural moisture content tests

Geochemical testing was undertaken by Chemtech, a UKAS and MCERTS accredited laboratory. The scope of geochemical testing comprised:

- 2 number sulphate and pH tests
- 2 number asbestos identification tests

Results for all the testing undertaken are included later in this report (in Appendix C).

4 Encountered Ground Conditions

4.1 Sequence of sub-strata

The encountered ground conditions as revealed by the borehole logs (in Appendix B) were generally as expected and agreed with the anticipated site geology. A summary is shown below (in Table 2).

Table 2: Summary of encountered ground conditions

Stratum	*General description*	*Locations encountered*	*Depth to base of stratum (m bgl)*	
			Min.	*Max.*
TOPSOIL	Dark brown sandy SILT with occasional rootlets (TOPSOIL)	All BHs	0.4	0.6
TIDAL FLAT DEPOSITS	Very loose to loose brown becoming grey sandy to very sandy SILT (with occasional thin bands of soft sandy silt/clay)	All BHs	>3.0	>3.0
Water observations:	Groundwater (slow) ingresses: 1.5m – 1.7m bgl			

4.2 Topsoil

A dark brown sandy silt topsoil was encountered in all exploratory holes. It varied between 0.3m (HP1) and 0.6m (BH1) in thickness.

No made ground was revealed. No anthropogenic material was recorded within the topsoil and no visual or olfactory evidence of potential contamination was reported.

4.3 Tidal Flat Deposits

Tidal flat deposits were encountered across the site. They were revealed in all exploratory holes (BH1, BH2, BH3 and HP1) down to the full depths of exploration (1.0m to 3.0m bgl).

As discussed, the actual depth of the base of the tidal flat deposits is expected to be about 15m-20m bgl. This is based on nearby BGS historical borehole records.

The encountered tidal flat deposits were generally described as sandy to very sandy SILT. This description indicates the soil is on the borderline between a sandy SILT and a very silty SAND. Such soil material is typical of near surface tidal flat deposits.

The overall behaviour of the sandy silt (tidal flat deposits) was described in terms of relative density as it was found to more closely resemble that of a granular (or coarse soil) material, displaying little or no plasticity. Linear shrinkage test results, as shown later (in Appendix C), found that a shallow sample of the tidal flat deposits (from BH3 at

0.5m-1.0m bgl) shrunk by <1%. Even a sample from within BH2 (at 1.0m – 1.5m bgl) where thin bands of clay were encountered only revealed 3% shrinkage. Correlations (e.g. Fanourakis, 2012) indicate that PI (%) is approximately 2 times the linear shrinkage (%). Therefore, the plasticity index of the tidal flat deposits material (to the revealed depths of at least 3.0m bgl) is probably between about 0% and 6%, which means it is not a shrinkable soil (e.g. according to NHBC, 2006).

As discussed, the amount of granular material (e.g. sand and gravel) within the tidal flat deposits is expected to generally increase with depth. This has been shown in nearby borehole records and is typical of tidal flat deposits. Therefore, the tidal flat deposits beneath the site are expected to be predominantly granular in nature throughout, although there is a possibility of occasional bands of finer soil (e.g. clay).

The relative density of the near surface (i.e. <3m bgl) tidal flat deposits is recorded in the logs as *very loose to loose* based on the SPT results (of between 0 and 7). However, equivalent SPT N values can also be determined from the results of the dynamic probing, as shown later (in Appendix B). The results indicate that the equivalent SPT N value ranges from 2 to 33 and tends to increase with depth. Therefore, the relative density of the tidal flat deposits appears to change with depth, changing from *very loose*/*loose* up to *dense*, as shown below (in Table 3).

The engineering properties of the tidal flat deposits can be estimated from the SPT N values (and equivalent values), as shown below (in Table 3) using established correlations (e.g. Stroud 1974). Assuming the material is granular in nature, an angle of internal friction angle of 35 – 40 degrees should be available at depths of 7.0m to 8.0m bgl, for example. If the tidal flat deposits are cohesive (i.e. not granular) in behaviour, then the undrained shear strength is likely to be 75kPa – 100kPa (at the same depths).

Table 3: Properties of tidal flat deposits

Depth (m bgl)	*SPT N values*	*Equivalent SPT N values**	*Relative density*	*Angle of friction, φ (°)***	*Undrained shear strength (kPa)****
1.0 – 1.45	6 – 7	-	Loose	30 – 35	-
2.0 – 2.45	0	-	Very loose	25 – 30	-
3.0 – 4.6	-	2 – 9	Very loose to loose	25 – 35	<40
4.6 – 7.0	-	5 – 20	Loose to medium dense	30 – 40	20 – 90
7.0 – 8.0	-	18 – 30	Medium dense	35 – 40	75 – 100
8.0 – 9.0	-	28 - 30	Medium dense to dense	35 - 45	100 – 120
9.0 – 10.0	-	30 – 33	Dense	40 – 45	120 – 150

* Based on MacRobert et al. (2011) using results of dynamic probing from BH2 and BH3
** Assuming soil is granular in nature
*** If soil is cohesive in nature

4.4 Groundwater observations

Slow groundwater ingresses were recorded in the tidal flat deposits between depths of 1.5m and 1.7m bgl. This could roughly represent the position of the water table, although it could be slightly shallower and could vary with seasonal fluctuations.

4.5 Geochemical test results

The results of geochemical testing are presented later (in Appendix C).

4.5.1 Asbestos

Two samples of soil were tested for the presence of asbestos. One sample was of near surface made ground (from BH1) and the other was of near surface natural soil (from BH2). No asbestos was detected in either of the two samples tested.

4.5.2 Sulphate and pH

Geochemical test results, as shown later (in Appendix C), revealed water-soluble sulphate concentrations of 124mg/kg to 223mg/kg and total sulphate of 0.07% as summarised below (in Table 4), with pH levels of 8.9. These results indicate a classification for buried concrete of DS-1 and AC-1s, based on BRE Special Digest 1 (BRE, 2005).

Table 4: Soil sulfate content and pH

Stratum	Sampling location	Sample ref.	Depth (m bgl)	Water-soluble sulphate (mg/l)	Total sulphate [TPS] (%)	pH
Tidal flat deposits	BH1	S/48493	2.0 – 2.5	223	0.0730	8.9
	BH3	S/48496	1.0 – 1.5	124	0.0702	8.9

4.6 Percolation/Soakaway test results

A percolation (i.e. soakaway) test was undertaken within BH1, which was about 100mm in diameter down to a depth of 2.0m bgl. Water was quickly poured into the borehole raising the water level to 0.98m bgl and the water level monitored against time for 180 minutes.

The results of the test indicate that the water level fell from 0.98m to 1.00m bgl over a three-hour period. The fall in water level was insufficient to determine a reasonably accurate soil infiltration rate (e.g. using the BRE Digest No. 365 method). Consequently, it is concluded that the soil infiltration rate within the encountered ground conditions is very low, which is normal for a silt soil.

5 Revised Contamination Assessment

5.1 Revised conceptual site model (CSM)

Based on the Phase 1 initial CSM, preliminary RA and analysis of the contamination test data, a revised CSM has been developed, as shown below (in Table 5). Potential RCLs are those linkages that might possibly pose more than a *low* or *very low* risk to receptors.

Table 5: Revised Conceptual Site Model				
Source, S		Pathway, P		Receptor, R
Source type/area	Contaminant	Route	Sub-route	
		Ingestion	Soils Indoor dust Outdoor dust Root uptake In water supply	Workers, future occupants
		Absorption	Dermal contact	Workers, future occupants
		Inhalation	Indoor dust Outdoor dust Vapours	Workers, future occupants
		Leachate migration	Vertically in unsaturated zone Laterally/vertically in saturated zone Along services	Surface water, bedrock aquifer
				Building materials & services
		Gas migration, ingress and accumulation	Through pores and fissures Along services	Future occupants, building materials
		Aggressive attack	Permeation of material Chemical reaction	Future occupants, building materials,
Not applicable				
Item		Rationale		
Source: Contamination within made ground		No made ground identified on site (within exploratory holes)		

5.2 Revised risk assessment (RA)

The revised conceptual site model has failed to identify any plausible contamination linkages. Therefore, there no significant risks can be identified at site with respect to potential land contamination.

Nevertheless, any unforeseen contamination encountered during the development of the site should be reported to the local authority. Work should be halted in that area and the contamination investigated/assessed to the satisfaction of the local authority.

6 Engineering Issues

6.1 Foundations

The tidal flat deposits beneath the site have been found to be (very) loose at shallow depths (e.g. 1.0m-2.45m bgl). Therefore, the shallow tidal flat deposits might not be able to provide an adequate bearing material for the proposed structure, subject to final structural loadings and details. Consequently, traditional shallow foundations (e.g. strip/pad footings or trench fill) might not be feasible and a deeper foundation solution (e.g. driven piles) might be required.

The tidal flat deposits tend to increase in penetration resistance with depth, as evidenced by dynamic probing results. Consequently, at depths of at least 7m bgl, net allowable bearing pressures of more than 125kN/m^2 should be available (for settlements no greater than approximately 25mm), while these should increase to at least 175kN/m^2 below depths of 8m bgl. Therefore, piling down to these depths could be feasible.

The tidal flat deposits beneath the site have been found to be predominantly granular in nature (to depths of at least 3.0m bgl) with only occasional thin bands (2cm to 5cm in thickness) of clayey material. Linear shrinkage tests indicate the tidal flat deposits are not shrinkable (i.e. PI <10%). They are expected to generally become more granular with depth based on local geological knowledge. Therefore, soil shrinkage should not be an issue.

All foundations should be designed by a competent engineer with consideration to all factors and the information within this report.

6.2 Buried concrete

As discussed, sulphate and pH testing has indicated that the classification for buried concrete is DS-1 and AC-1s, based on BRE Special Digest 1 (2005).

6.3 Excavations and groundwater control

Conventional earth moving plant should be able to readily excavate the natural ground material on site. Nevertheless, there are some existing concrete slabs that will require additional effort to break down and remove.

Slow water ingresses have only been observed at relatively shallow depth (i.e. 1.5m – 1.7m bgl). However, the ground conditions include considerable amounts of low permeability silts which can inhibit groundwater flow. Therefore, the position of the water table is unknown, and could be even shallower (e.g. <1.0m bgl).

Groundwater ingresses are likely in excavations at depths of around 1.5m bgl and possibly shallower. Therefore, some form of groundwater control might be needed to maintain dry excavations.

6.4 Radon

Desk study information indicates that the site is not in an area that may be affected by radon. Therefore, radon protection measures should not be required.

6.5 Gas protection measures

The results of the investigation have not revealed any significant source of hazardous ground gas at the site. The boreholes have not revealed any organic material within the tidal flat deposits beneath the site. Deeper BGS boreholes drilled nearby the site have also revealed the local tidal flat deposits to be a relatively inert sandy silt material with little or no organic material.

Accordingly, with reference to RB17, A Pragmatic Approach to Ground Gas Risk Assessment (Card *et al.*, 2012), a CIRIA C655 and BS8485 classification of CS-1 should be appropriate. Therefore, no special gas protection measures are anticipated.

6.6 Soakaway design

As discussed, the results of the percolation testing in BH1, the soil infiltration rate in the ground conditions is very low. Therefore, it is considered that soakaways will not be feasible at the site.

7 Summary and Conclusions

7.1 Ground conditions

The exploratory hole log records (in Appendix B) indicate the following general sequence of sub-strata at the site (in descending order).

- Topsoil: a dark brown sandy silt material (across most of the site) to 0.4-0.6m bgl
- Tidal flat deposits: Initially loose/very loose (becoming medium dense/dense) brown/grey sandy to very sandy silt (across the site) to at least 3.0m bgl

Slow groundwater ingresses have been recorded between 1.5m and 1.7m bgl.

7.2 Geotechnical properties

The geotechnical properties of the encountered tidal flat deposits are summarised below (in Table 6). These are based on engineering evaluations and estimations and the results of testing, as described previously.

Table 6: Summary of properties of tidal flat deposits

Depth (m bgl)	*(Equivalent*) SPT N values*	*Relative density*	*Angle of friction, φ (°)***	*Undrained shear strength (kPa)****
1.0 – 4.6	0 – 9	Very loose / Loose	25 – 35	0 – 40
4.6 – 7.0	5 – 20	Loose to medium dense	30 – 40	20 – 90
7.0 – 8.0	18 – 30	Medium dense	35 – 40	75 – 100
8.0 – 9.0	28 - 30	Medium dense to dense	35 - 45	100 – 120
9.0 – 10.0	30 - 33	Dense	40 – 45	120 – 150

* Based on findings of MacRobert et al. (2011) using results of dynamic probing from BH2 and BH3
** Assuming soil is granular in nature
*** If soil is cohesive in nature

7.3 Foundations

The proposed buildings comprise two low-rise semi-detached houses. Each house has a rear garden.

The more-resistant deeper tidal flat deposits material could provide a suitable bearing stratum for the proposed low-rise residential structures, using a deep foundation solution (e.g. driven piles). This deeper material is likely to be sand or gravel but could conceivably be cohesive (i.e. clayey) in nature. Allowable net bearing pressures of at least 125kN/m^2 should be available at depths greater than 7.0m bgl (for settlements no

greater than approximately 25mm), while at least 175kN/m^2 should be available at depths below 8.0m bgl.

The tidal flat deposits beneath the site have been found to be predominantly granular in nature. The shallow ground conditions are not considered to constitute shrinkable soil.

All foundations should be designed by a competent engineer with consideration to all factors and the information within this report.

7.4 Buried concrete

A BRE (2005) buried concrete specification for the site should be DS-1 with AC-1s.

7.5 Excavations and groundwater

Conventional earth moving plant should be able to readily excavate the natural ground material on site. However, there is some concrete present.

Groundwater levels are likely to be subject to seasonal variations. However, ingresses are likely in excavations below depths of 1.5m to 1.7m bgl and possibly shallower.

7.6 Gas protection measures

The results of the investigation indicate there is no significant source of hazardous ground gas at the site. Therefore, no special protection measures for hazardous ground gases are anticipated at the site and a CIRIA C655 classification of CS-1 is considered appropriate.

7.7 Soakaway design

The results of a percolation test in a borehole (BH1) indicate a negligible soil infiltration rate. Therefore, soakaways are unlikely to be feasible at the site.

7.8 Contamination assessment

Asbestos analysis has been carried out on two samples of near surface topsoil. No fibres were detected in either sample.

The revised CSM and risk assessment have not identified any potentially significant contamination linkages. Therefore, there is not considered to be any significant risk of contamination at the site.

Nevertheless, any unforeseen contamination encountered during the development of the site should be reported to the local authority. Work should be halted in that area and the contamination investigated/assessed to the satisfaction of the local authority.

8 References

Bowles, J. E. (1996) Foundation Analysis and Design, 5th Edn.. McGraw-Hill, New York, NY, USA.

Boyle, R. and Witherington, P. (2007) Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating 'traffic lights' Report Edition No.: 04 for National House Building Council and RSK Group PLC, March 2007.

BRE (2005) BRE Special Digest 1, Concrete in Aggressive Ground, British Research Establishment.

BS 5930 (2015) Code of Practice for Site Investigations, British Standards Institute.

BS 10175:2011 (plus A1:2013) Investigation of potentially contaminated sites – code of practice, British Standards Institute

BS 8485:2007 Code of practice for the characterisation and remediation from ground gas in affected developments, British Standards Institute

Card G, Wilson S, Mortimer S. (2012) A Pragmatic Approach to Ground Gas Risk Assessment. CL:AIRE Research Bulletin RB17. CL:AIRE, London, UK.

Carter, M and Bentley, S. P. (1991) Correlations of Soil Properties, Pentech Press, London.

CLEA documents published by DEFRA and the Environment Agency.

Defra (2014) Development of Category 4 Screening Levels for assessment of land affected by contamination - SP1010. Contaminated Land: Applications in Real Environments (CL:AIRE), 24th September 2014. Annex: Appendix H, Lead. Available online: http://randd.defra.gov.uk/

EA/Defra (2004) Model Procedures for the Management of Land Contamination, Contaminated Land Report 11, Environment Agency, Department for Environment Food and Rural Affairs. Bristol: Environment Agency.

Fanourakis, G C. (2012). Estimating soil plasticity properties from pedological data. Journal of the South African Institution of Civil Engineering, 54(2), 117-125.

Irvine, D. J. & Smith, R. J. (1992) CIRIA Report 97 – Trenching Practice – 2nd Edition.

LQM/CIEH (2015) LQM/CIEH S4ULs for Human Health Risk Assessment. Authors: Nathanail, C.P.; McCaffrey,C.; Gillett, A.G.; Ogden, R.C. & Nathanail, J.F. Land Quality Press: Nottingham.

NHBC (2006) NHBC Standards.

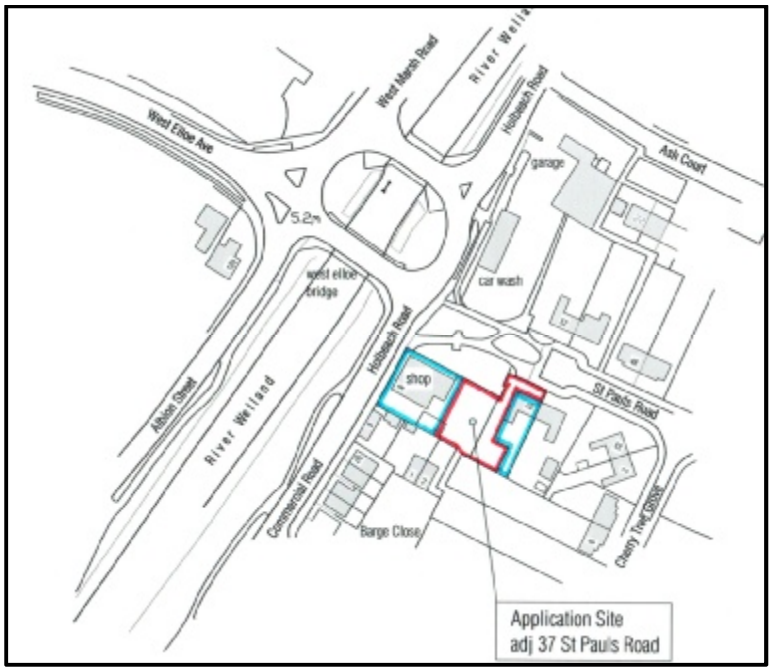
Powell, W.D., Potter, J.F., Mayhew, H.C., and Nunn, M.E. (1984) The structural design of bituminous roads. TRRL Report LR 1132, 62 pages.

Rudland, D. J., Lancefield, R. M., Mayell, P. N. (2001) CIRIA C552 Contaminated Land Risk Assessment: A guide to good practice, London: CIRIA.

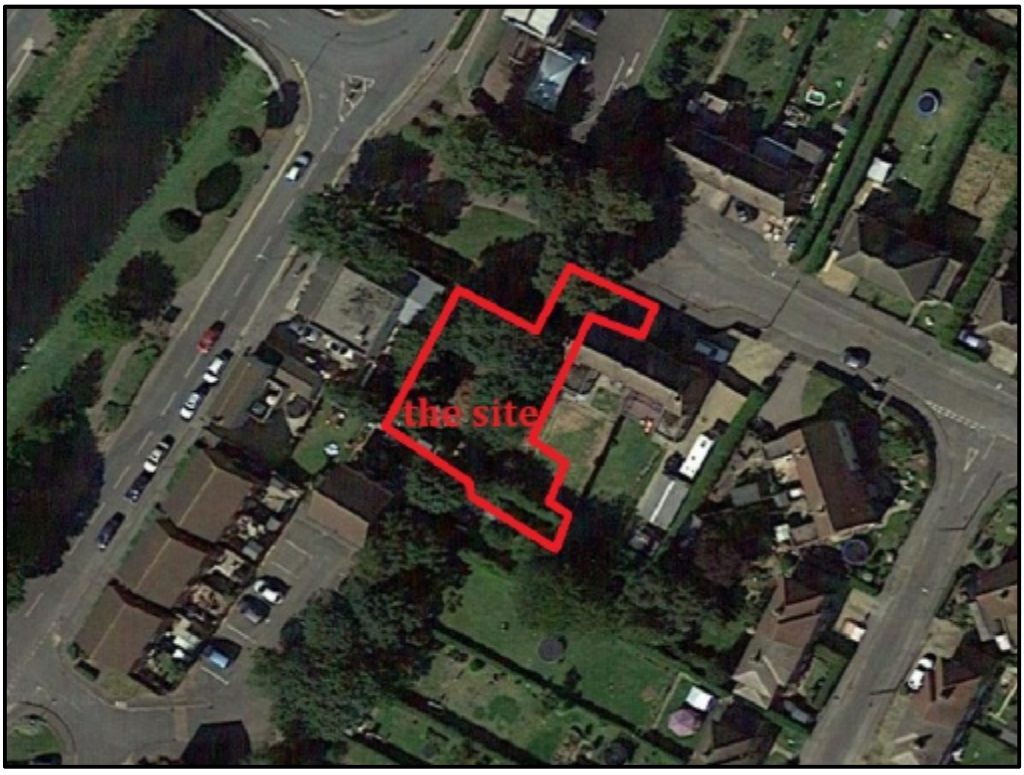
Stroud, M. A. (1974) "The standard penetration test in insensitive clays and soft rock," Proceedings of the 1st European Symposium on Penetration Testing, Sweden: Stockholm, vol. 2(2), 367-375.

Wilson, S; Oliver, S; Mallett, H; Hutchings, H; Card, G (2007) CIRIA C665: Assessing risks posed by hazardous ground gases to buildings. London: CIRIA.

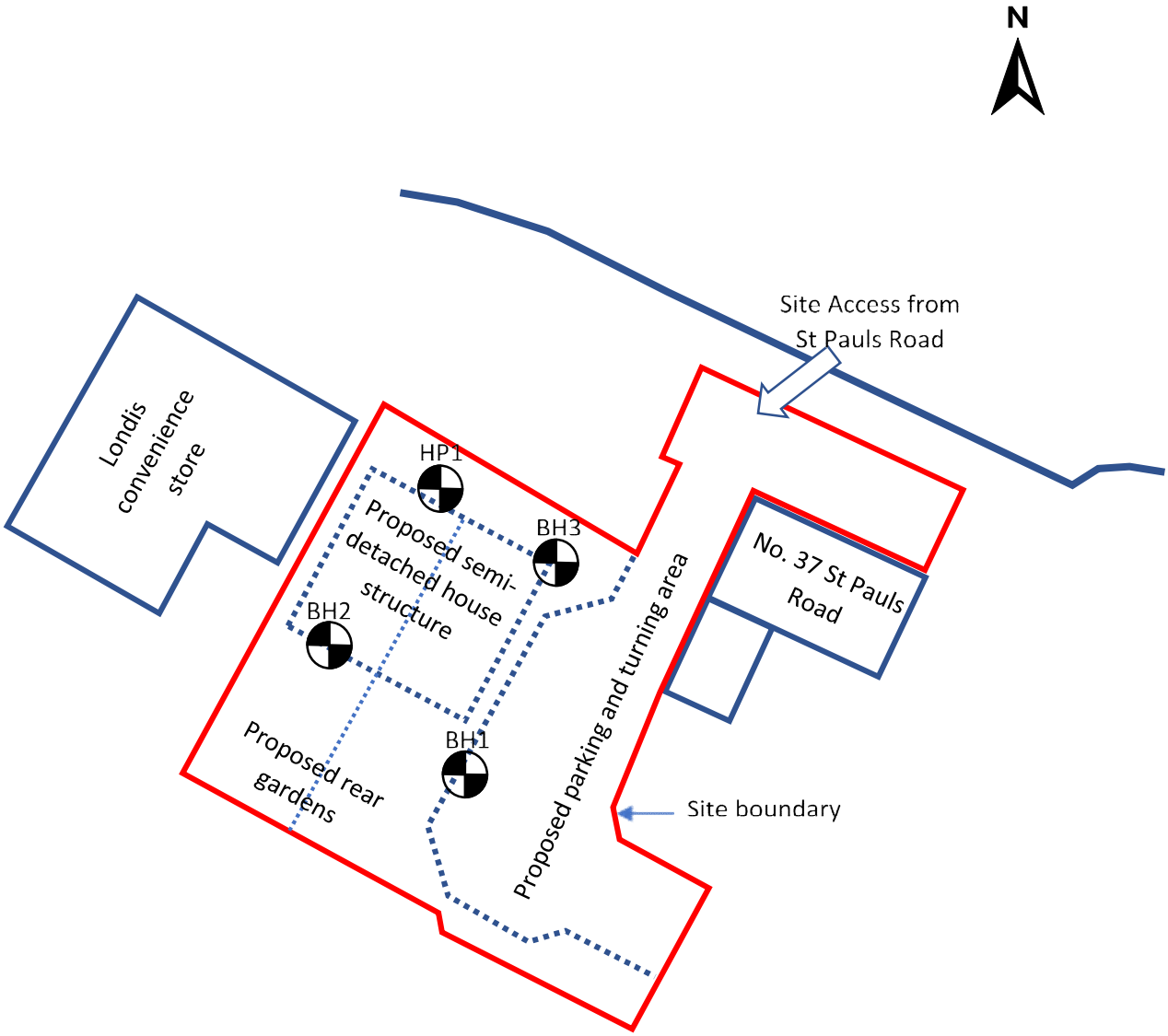
Appendix A



Site location



Aerial view of site (north is up page)



SITE PLAN - BOREHOLE / TRIAL PIT LOCATIONS

Humberside Materials Laboratory Ltd
Atherton Way, Brigg
North Lincs, DN20 8AR
Tel Fax 01652 652753

CLIENT :- Mr Dungarwalla

SITE :- St Pauls Road, Spalding

Date :-

File Ref :- /



The site (Southwest View)



Adjacent Dwelling (Southwest View)



The site (North View)



The site entrance (North view)



Centre of the site (East view)



Proposed Rear parking area (East view)



Proposed driveway (Northeast View)



The site as seen from public green area (South View)

Appendix B

HUMBERSIDE MATERIALS LABATORY Ltd.
Atherton Way, Brigg
North Lincs DN20 8AR
Tel & Fax 01652 652753

email info@humbersidematerialslab.co.uk

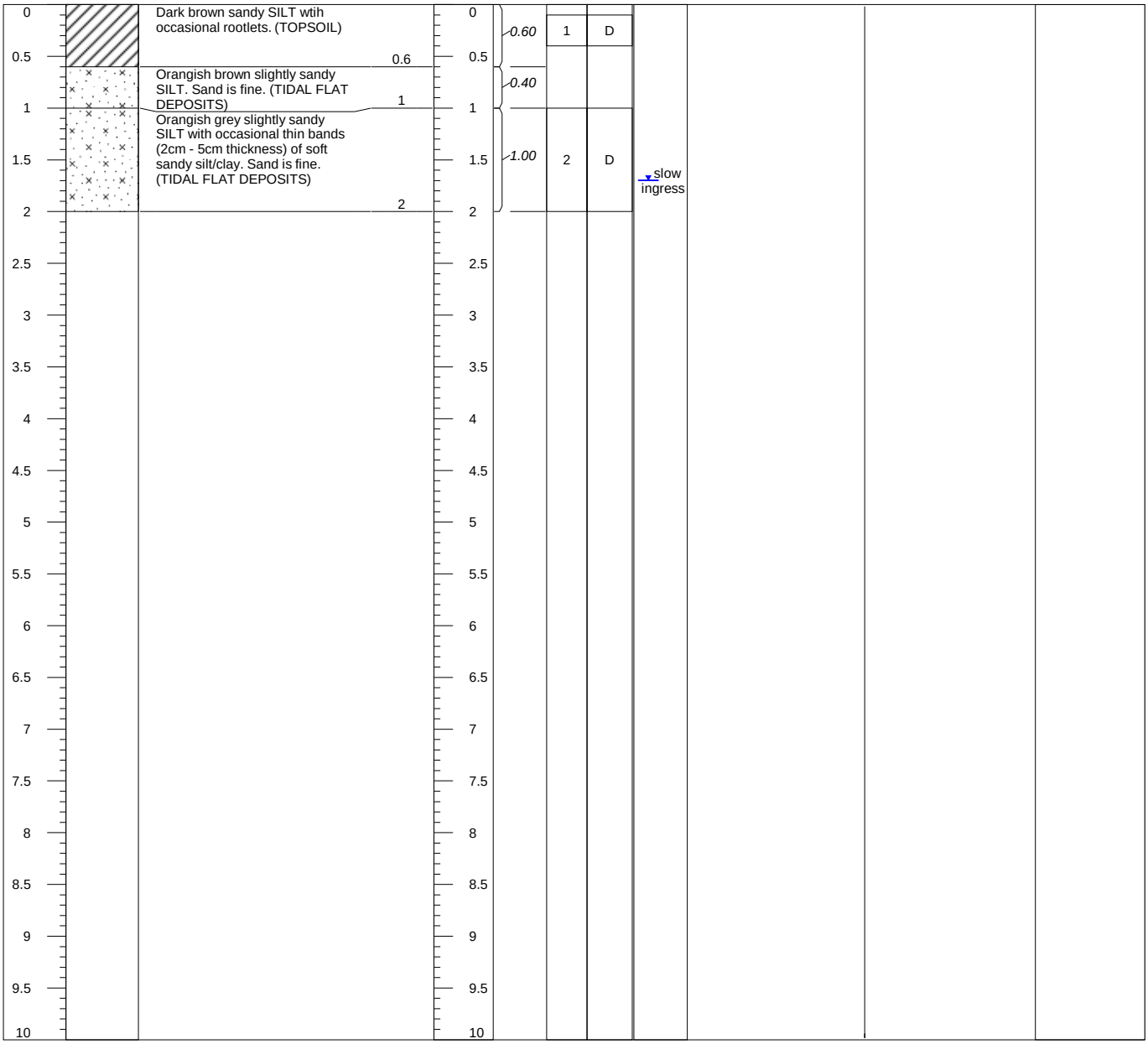
BOREHOLE LOG

Borehole No **BH1**

Client :- Mr Dungarwalla
Site :- St Pauls Road, Spalding
Project No :- 4518

Location :- see site plan
Date :- 25-Apr-18

Coordinates E: 525557 N: 323477
Elevation :-
Excavated by :- Dando Terrier
Drilled by :- MD & CC



Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
U undisturbed
DCP SHDCP
HV Hand Vane

Notes :-

Depth drilled :-2
Casing depth :-

File Ref :- 1107/ 4518
Logged by :- M Driver

HUMBERSIDE MATERIALS LABATORY Ltd.
Atherton Way, Brigg
North Lincs DN20 8AR
Tel & Fax 01652 652753

email info@humbersidematerialslab.co.uk

BOREHOLE LOG

Borehole No
BH2

Client :- Mr Dungarwalla
Site :- St Pauls Road, Spalding
Project No :- 4518

Location :- see site plan
Date :- 25-Apr-18

Coordinates E: 525551 N: 323485
Elevation :-
Excavated by :- Dando Terrier
Drilled by :- MD & CC

Depth (m)	Lithology / Description / Depth (m)	Thickness (m)	Samples	Water level & well	SPT / SH DCP	Notes
0	Dark brown sandy SILT wtih occasional rootlets. (TOPSOIL) 0.4	0.40	1 D			
1	Orangish brown sandy to very sandy SILT. Sand is fine. (TIDAL FLAT DEPOSITS) 1.1	0.70	2 D	slow ingress	7	SPT at 1.0m: 1,1,1,2,2,2
2	Very loose to loose orangish grey mottled brown sandy to very sandy SILT. Sand is fine. Between 1.0m to 2.0m bgl: occasional thin bands (2cm to 5cm in thickness) of soft sandy silt/clay. (TIDAL FLAT DEPOSITS) 3	1.90	3 D		0	SPT at 2.0m: 0,0,0,0,0,0

SPT: 0 10 20 30 40
SH DCP: 0 10 20 30 40

SH DCP profile: 1 2 2 2 1 2 1 1 1 1 2 1 1 1 2 2 3 4 4 6 6 6 7 8 8 7 9 10 11 10 4 3 3 3 2 3 2 3 5 6 6 8 14 15 18 17 18 16 17 22 20 21 22 21 19 18 18 18 18 19 19 20 22 22 22 24 24 24 26 26

Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
U undisturbed
DCP SHDCP
HV Hand Vane

Notes :-

Depth drilled :-10
Casing depth :-

File Ref :- 1107/ 4518
Logged by :- M Driver

HUMBERSIDE MATERIALS LABATORY Ltd.
Atherton Way, Brigg
North Lincs DN20 8AR
Tel & Fax 01652 652753

email info@humbersidematerialslab.co.uk

BOREHOLE LOG

Borehole No
BH3

Client :- Mr Dungarwalla
Site :- St Pauls Road, Spalding
Project No :- 4518

Location :- see site plan
Date :- 25-Apr-18

Coordinates E: 525561 N: 323488
Elevation :-
Excavated by :- Dando Terrier
Drilled by :- MD & CC

Depth (m)	Lithology / Description / Depth (m)	Thickness (m)	Samples	Water level & well	SPT / SH DCP	Notes
0	Dark brown sandy SILT wtih occasional rootlets. (TOPSOIL)	0.50	1 D			
0.5	Orangish brown slightly sandy SILT. (TIDAL FLAT DEPOSITS)	1.00	2 D			
1.05	Very loose to loose orangish grey mottled brown sandy to very sandy SILT. Sand is fine. Between 1.0 and 2.2m bgl: occasional thin bands (2cm to 5cm in thickness) of soft sandy silt/clay. (TIDAL FLAT DEPOSITS)	1.95		slow ingress	SPT at 1.0m: 6 SPT at 2.0m: 0	SPT at 1.0m 1,0,1,2,1,2 SPT at 2.0m: 0,0,0,0,0,0
3					SH DCP: 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 1 1 1 1 1 2 2 3 4 4 5 5 6 6 6 6 7 7 4 4 4 4 3 3 4 5 6 6 7 7 8 10 12 12 13 14 18 18 20 20 21 21 20 19 19 19 19 19 21 21 21 21 24 24 24 24 26 27	

Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
U undisturbed
DCP SHDCP
HV Hand Vane

Notes :-

Depth drilled :-10
Casing depth :-

File Ref :- 1107/ 4518
Logged by :- M Driver

HUMBERSIDE MATERIALS LABATORY Ltd.
Atherton Way, Brigg
North Lincs DN20 8AR
Tel & Fax 01652 652753

email info@humbersidematerialslab.co.uk

TRIAL PIT LOG

Trial pit No

HP1

Client :- Mr Dungarwalla
Site :- St Pauls Road, Spalding
Project No :- 4518

Location :- see site plan
Date :- 25-Apr-18

Coordinates E: 525555 N: 323492
Elevation :-
Excavated by :- Hand tools

Depth (m)	Lithology / Description / (thickness) / Depth	Elevation	Samples	Water level	Notes
0	Dark brown sandy SILT wtih occasional rootlets. (TOPSOIL) (0.3)	0			
0.2	0.3	0.2			
0.4	Orangish brown sandy to very sandy SILT. Sand is fine. (TIDAL FLAT DEPOSITS) (0.7)	0.4			
0.6		0.6			
0.8		0.8			
1	1	1			
1.2		1.2			
1.4		1.4			
1.6		1.6			
1.8		1.8			
2		2			
2.2		2.2			
2.4		2.4			
2.6		2.6			
2.8		2.8			
3		3			
3.2		3.2			
3.4		3.4			
3.6		3.6			
3.8		3.8			

Sample Key
B Bulk
D Disturbed
W Water
SS Split spoon
C Cone

Notes :-

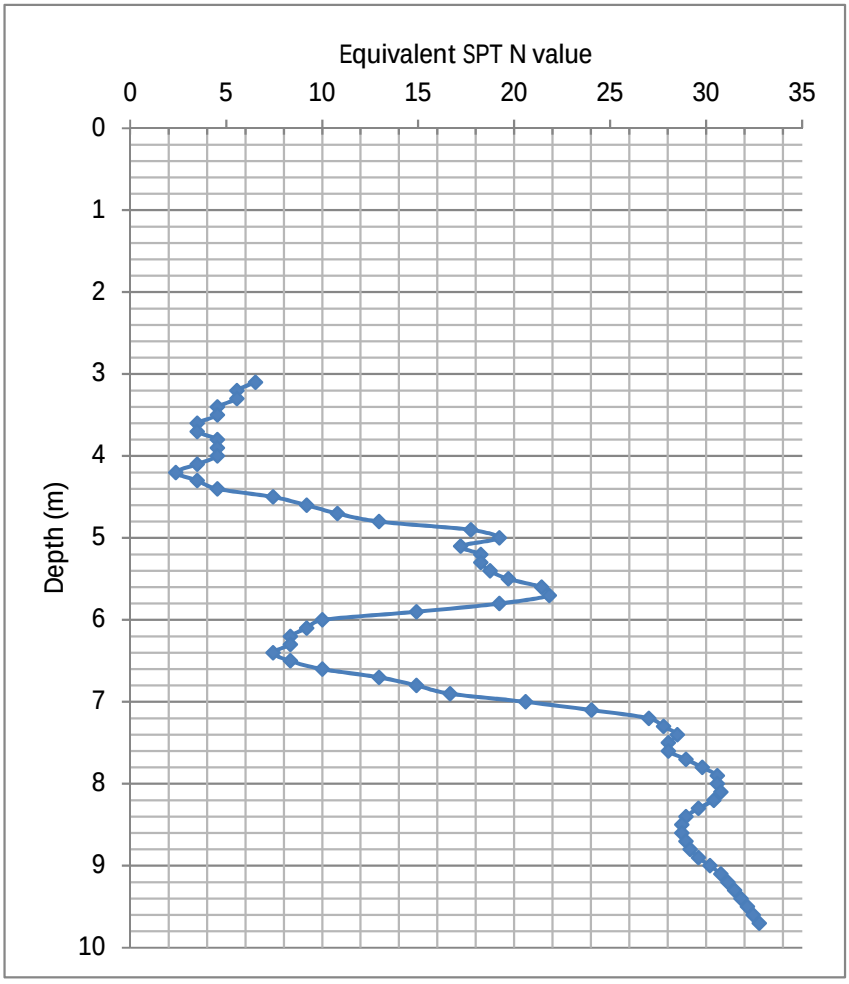
File Ref :- 1107 / 4518
Logged by :- M Driver

HUMBERSIDE MATERIALS LABORATORY LTD.
Atherton Way, Brigg
North Lincolnshire DN20 8AR
Tel Fax 01652 652753

DETERMINATION OF EQUIVALENT SPT FROM SUPER HEAVY DYNAMIC PROBE TEST RESULTS

Site: Land adj. to 37 St Pauls Rd, *Client:* Mr Dungarwalla
Borehole: BH2
Date Tested: 25/04/2018

Equivalent SPT determination method: MacRobert et al. (2011)



MacRobert, C, Kalumba, D, & Beales, P. (2011). Correlating Standard Penetration Test and Dynamic Probe Super Heavy penetration resistance values in sandy soils. Journal of the South African Institution of Civil Engineering, 53(1), 46-54

File ref 135/4511/P
Date tested 04/09/2014

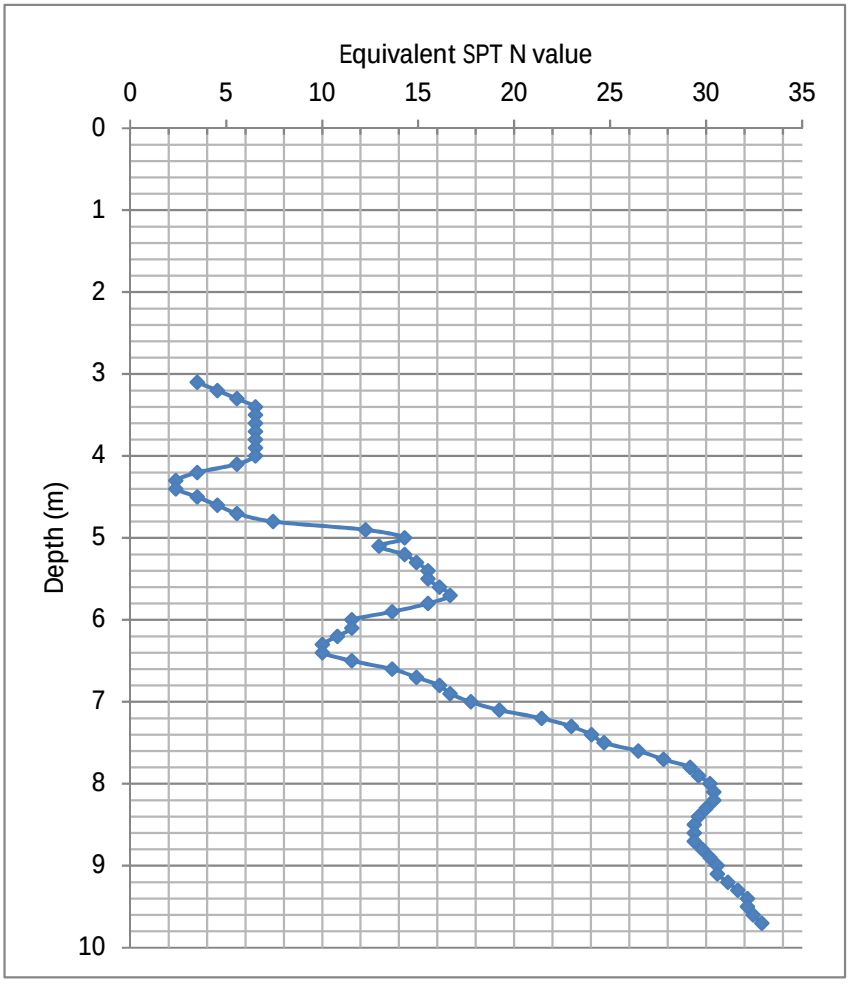
Signed M.J. Green C. Driver
Director

HUMBERSIDE MATERIALS LABORATORY LTD.
Atherton Way, Brigg
North Lincolnshire DN20 8AR
Tel Fax 01652 652753

DETERMINATION OF EQUIVALENT SPT FROM SUPER HEAVY DYNAMIC PROBE TEST RESULTS

Site: Land adj. to 37 St Pauls Rd, *Client:* Mr Dungarwalla
Borehole: BH3
Date Tested: 25/04/2018

Equivalent SPT determination method: MacRobert et al. (2011)



MacRobert, C, Kalumba, D, & Beales, P. (2011). Correlating Standard Penetration Test and Dynamic Probe Super Heavy penetration resistance values in sandy soils. Journal of the South African Institution of Civil Engineering, 53(1), 46-54

File ref 135/4511/P
Date tested 04/09/2014

Signed M.J. Green C. Driver
Director

Appendix C

HUMBERSIDE MATERIALS LABORATORY LTD
Atherton Way, Brigg
North Lincolnshire, DN20 8AR
Tel _Fax 01652 652753
e-mail info@humbersidematerialslab.co.uk

SOIL CLASSIFICATION TESTS

Sample Ref S 48495 Client Mr A Dungarwalla

Site	Spalding
Location	BH2-2
Date/Time sampled	25/04/18
Client sample No	BH2-2
Sampled by	M. Driver
Sample point	
Trial pit / Bore hole No	2
Depth of sample	1-1.5 m
Sample type	Small Bulk
Description	Soft, orange/brown sandy SILT/CLAY with occasional medium fine gravels.
comments	Linear Shrinkage (BS 1377: Pt 2: 1990) - < 1%

Determination of moisture content
Test method BS 1377 Part 2 1990 - Clause 4.4 Single Point / Definitive Method Clause 4.3 (As Below)

Portion No	02
Method	Oven dried
% Moisture	**25**

Determination of liquid limit, Plastic limit and Plasticity index
Test method BS 1377 Part 2 1990

Portion No	01
Test condition	Sieved
Method	No test
% retained 0.425mm sieve	1
Liquid limit	**n/a**
% passing 0.425mm sieve	99
Plastic limit	**non**
Plasticity Index	**n/a**

File ref 1107 4518 / G
Date tested 26/04/18
Date reported 08/05/18
Date received 25/04/18

Signed :- M.J. Green C. Driver
Director

Certificates of sampling when submitted are retained by the Laboratory and is available upon request
Samples will normally be kept for 14 days from the date reported

HUMBERSIDE MATERIALS LABORATORY LTD
Atherton Way, Brigg
North Lincolnshire, DN20 8AR
Tel _Fax 01652 652753
e-mail info@humbersidematerialslab.co.uk

SOIL CLASSIFICATION TESTS

Sample Ref S 48496 Client Mr A Dungarwalla

Site	Spalding
Location	BH3-2
Date/Time sampled	25/04/18
Client sample No	BH3-2
Sampled by	M. Driver
Sample point	
Trial pit / Bore hole No	3
Depth of sample	0.5-1.0 m
Sample type	Small Bulk
Description	Soft, brown Silty SAND with occasional coarse to fine gravels and many rootlets
comments	Linear Shrinkage (BS 1377: Pt2: 1990) - 3%

Determination of moisture content
Test method BS 1377 Part 2 1990 - Clause 4.4 Single Point / Definitive Method Clause 4.3 (As Below)

Portion No	02
Method	Oven dried
% Moisture	**22**

Determination of liquid limit, Plastic limit and Plasticity index
Test method BS 1377 Part 2 1990

Portion No	01
Test condition	Sieved
Method	No test
% retained 0.425mm sieve	5
Liquid limit	**n/a**
% passing 0.425mm sieve	95
Plastic limit	**n/a**
Plasticity Index	**n/a**

File ref 1107 4518 / G
Date tested 26/04/18
Date reported 08/05/18
Date received 25/04/18

Signed :- M.J. Green C. Driver
Director

Certificates of sampling when submitted are retained by the Laboratory and is available upon request
Samples will normally be kept for 14 days from the date reported

2531

ANALYTICAL TEST REPORT

Contract no: 71484

Contract name: St Pauls Road, Spalding

Client reference: 1107/4518/P

Clients name: Humberside Materials Laboratory

Clients address: Atherton Way
Brigg
North Lincolnshire
DN20 8AR

Samples received: 27 April 2018

Analysis started: 27 April 2018

Analysis completed 08 May 2018

Report issued: 08 May 2018

Notes:
Opinions and interpretations expressed herein are outside the UKAS accreditation scope.
Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling.
Methods, procedures and performance data are available on request.
Results reported herein relate only to the material supplied to the laboratory.
This report shall not be reproduced except in full, without prior written approval.
Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed.

Key:
U UKAS accredited test
M MCERTS & UKAS accredited test
$ Test carried out by an approved subcontractor
I/S Insufficient sample to carry out test
N/S Sample not suitable for testing
NAD No Asbestos Detected

Approved by: K Campbell

Karan Campbell
Director

Chemtech Environmental Limited

SAMPLE INFORMATION

MCERTS (Soils):

Soil descriptions are only intended to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions. MCERTS accreditation applies for sand, clay and loam/topsoil, or combinations of these whether these are derived from naturally occurring soils or from made ground, as long as these materials constitute the major part of the sample. Other materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

All results are reported on a dry basis. Samples dried at no more than 30°C in a drying cabinet.
Analytical results are inclusive of stones.

Lab ref	Sample id	Depth (m)	Sample description	Material removed	% Removed	% Moisture
71484-2	S/48493 BH1-2	0.10-0.40	Clayey Sand	-	-	19.5
71484-4	S/48496 BH3-2	1.00-1.50	Clayey Loamey Sand with Roots	-	-	18.0

Chemtech Environmental Limited

SOILS

Lab number			71484-1	71484-2	71484-3	71484-4
Sample id			S/48492 BH1-1	S/48493 BH1-2	S/48494 BH2-1	S/48496 BH3-2
Depth (m)			0.10-0.40	2.00-2.50	0.10-0.40	1.00-1.50
Date sampled			25/04/2018	25/04/2018	25/04/2018	25/04/2018
Test	**Method**	**Units**				
pH	CE004 M	units	-	8.9	-	8.9
Magnesium (2:1 water soluble)	CE061	mg/l Mg	-	19	-	8.1
Chloride (2:1 water soluble)	CE049 U	mg/l Cl	-	79	-	14
Nitrate (2:1 water soluble)	CE049 U	mg/l NO_3	-	8.1	-	<1
Nitrite (2:1 water soluble)	CE049	mg/l NO_2	-	<1	-	<1
Sulphate (2:1 water soluble)	CE061 M	mg/l SO_4	-	223	-	124
Sulphate (total)	CE062 M	mg/kg SO_4	-	730	-	702
Sulphur (total)	CE127	mg/kg S	-	304	-	305
Subcontracted analysis						
Asbestos (qualitative)	$	-	NAD	-	NAD	-

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE004	pH	Based on BS 1377, pH Meter	Wet	M	-	units
CE061	Magnesium (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry		1	mg/l Mg
CE049	Chloride (2:1 water soluble)	Aqueous extraction, IC-COND	Dry	U	1	mg/l Cl
CE049	Nitrate (2:1 water soluble)	Aqueous extraction, IC-COND	Dry	U	1	mg/l NO_3
CE049	Nitrite (2:1 water soluble)	Aqueous extraction, IC-COND	Dry		1	mg/l NO_2
CE061	Sulphate (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry	M	10	mg/l SO_4
CE062	Sulphate (total)	Acid extraction, ICP-OES	Dry	M	100	mg/kg SO_4
CE127	Sulphur (total)	Acid extraction, ICP-MS	Dry		100	mg/kg S
$	Asbestos (qualitative)	HSG 248, Microscopy	Dry	U	-	-

Chemtech Environmental Limited

DEVIATING SAMPLE INFORMATION

Comments
Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.
For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.
Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

Key

N	No (not deviating sample)
Y	Yes (deviating sample)
NSD	Sampling date not provided
NST	Sampling time not provided (waters only)
EHT	Sample exceeded holding time(s)
IC	Sample not received in appropriate containers
HP	Headspace present in sample container
NCF	Sample not chemically fixed (where appropriate)
IT	Sample not cooled
OR	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
71484-2	S/48493 BH1-2	0.10-0.40	N	
71484-4	S/48496 BH3-2	1.00-1.50	N	