

GEOTECHNICAL DEVELOPMENTS
GEOTECHNICAL INVESTIGATION SERVICES

Geotechnical Developments

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**REPORT
ON
GROUND INVESTIGATION
FOR
NEW SHED, WESTERN PENINSULAR
TILBURY FREE PORT, LONDON
FOR
CLARK SMITH PARTNERSHIP**

PROJECT No: E708/94
October, 1994

 **Corporate**
Member of the
British Drilling
Association

Partners: J. C. Eaton BSc (Hons), PGD, MIHT, FGS. S. M. Eaton BSc (Hons)

GENERAL NOTES

1. The assessment made in this report is based on the ground conditions encountered in the boreholes, together with the results of in-situ and laboratory testing of soils. There may be special conditions appertaining to the site, however, which have not been revealed by the boreholes and which, therefore, have not been taken into account in this report.
2. Whilst the report may express an opinion on possible configurations of strata between or beyond the boreholes or on the possible presence of features based on either visual, verbal or published evidence, this is for guidance only and no liability can be accepted for its accuracy.
3. The comments on ground conditions are based on observations made at time of the investigation, unless otherwise stated. It should be noted, however, that ground water levels vary due to seasonal or other effects.

CONTENTS

Fig 1 Site Location Plan

1.0	INTRODUCTION	1
2.0	THE SITE	1
3.0	SITE HISTORY	1
4.0	PUBLISHED GEOLOGY	2
5.0	FIELDWORK	2
6.0	GROUND CONDITIONS	3
6.1	Made Ground	3
6.2	Alluvial Deposits	3
6.3	Flood Plain Gravels (Thames Valley Gravels)	4
6.4	Cretaceous Upper Chalk	4
6.5	Groundwater	4
7.0	LABORATORY TESTING	5
7.1	Engineering Laboratory Testing	5
8.0	COMMENTS AND RECOMMENDATIONS	5
8.1	Foundation Assessment	5
8.2	Foundation Design and Construction	6

APPENDICES

- A) BOREHOLE LOCATION PLAN
- B) BOREHOLE LOGS
- C) LABORATORY TEST RESULTS
- D) REFERENCES



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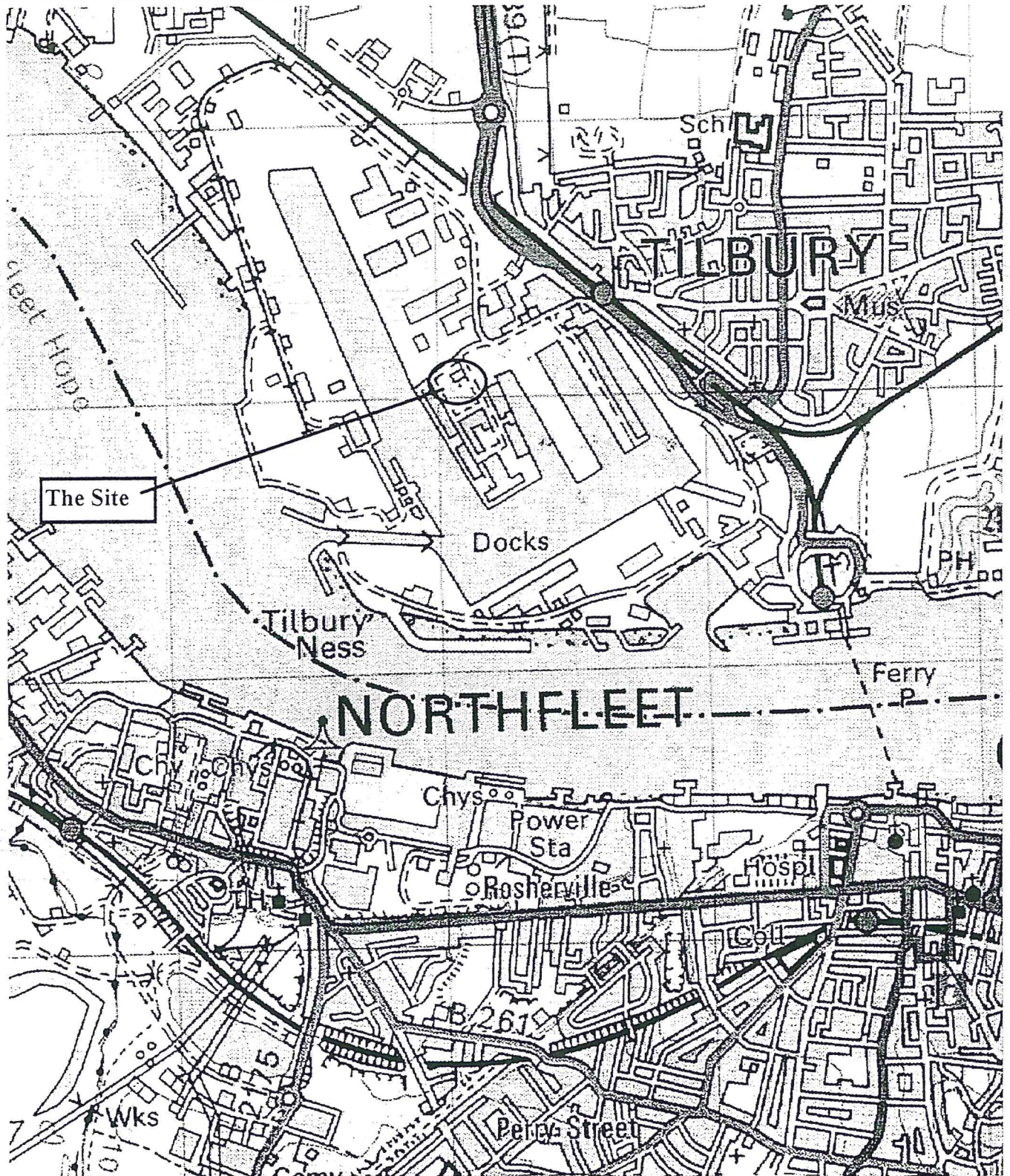
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Site Location Map
(Not to Scale)

Site New Shed, Western Peninsular,
Tilbury

Date October 1994

Project No E708/94



**REPORT
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1.0 INTRODUCTION

- 1.1 An area of land adjacent to No. 4 and No. 38 sheds, within The Port of Tilbury Docks, London is being considered for development comprising an open warehouse/shed. The site currently comprises a tarmac surfaced area used for the open storage of timber and vehicles.
- 1.2 Geotechnical Developments, was instructed by Mr J McSweeney of the Clark Smith Partnership (CSP) on the 14th July 1994, to undertake a Ground Investigation at the site and provide comments and recommendations on its findings.
- 1.3 The report contains details of the fieldwork and laboratory testing undertaken, strata encountered, laboratory test results, and an interpretive assessment of the site's ground conditions with regards to the proposed development.

2.0 THE SITE

- 2.1 The site is located on the Western Peninsular of Tilbury Docks, London to the north of the New Branch Dock, approximately 1km west of Tilbury town centre as shown on Figure 1 'Site Location Plan'. The National Grid Reference to the centre of the site is approximately TQ 631760.
- 2.2 The site is rectangular in plan measuring approximately 140 metres square. The site is bounded by existing shed No. 4 to the north, an access road to the west and Neptune House and open tarmac timber storage to the east.

3.0 SITE HISTORY

- 3.1 Whilst no specific brief was given to provide a historical summary of the sites development, the following general comments may be made.

The area of Tilbury docks has been used for many hundreds of years for the loading and unloading of shipping. The whole area has been reclaimed from former marshland and estuarine mud flats. The fills used to reclaim the area have in the past comprised in the main whatever granular fills were available at the time, including ash, slag, glass tiles etc. Previous ground investigation data available for the area in general has confirmed that the site has been made up in level by between 1.5 to in excess of 5 metres of fill, which rests directly upon the former soft and loose river estuarine sediments, which occur to a thickness of 10 to 15 metres and rest above very dense river gravels. The river estuarine sediments being normally consolidated are subject to considerable consolidation settlement under applied loads, and it is this settlement that has often caused buildings built above the sediments to suffer such high degrees of movement.

4.0 **PUBLISHED GEOLOGY**

4.1 Reference to the 1:50,000 scale published British Geological Survey map, Sheet No 271 'Dartford' indicates that the site is underlain by Recent and Pleistocene alluvium and Flood Plain gravel deposits (Thames Valley Gravels) overlying the Cretaceous Upper Chalk strata.

4.2 The alluvium deposits generally comprise up to 20 metres of very soft to firm and loose to medium dense, alternating, thinly bedded, often laminated dark grey and brown, silts, clayey sands and organic to peaty clayey silts with intact tree stumps, bog wood and many marine and fresh water crustacea and worm burrow systems. The Flood Plain gravels are mainly composed of flint with occasional chalk fragments. The underlying Cretaceous Upper Chalk strata is generally composed of often deeply weathered white and grey sometimes red brown fissured clayey siltstone and silty mudstone with occasional to many flint gravels and cobbles. The Chalk strata weathers to clays and silts of varying consistency, with variable proportions (subject to extent of weathering) of lithorelic fragments of the original weak rock.

4.3 It should be noted that the dock area has a series of locks that control the water levels within the docks, this will result in ground water within the soils immediately adjacent to the docks being effected by these controls, in that tidal rises and falls in ground water will be significantly reduced if not halted.

5.0 **FIELDWORK**

5.1 Three light cable percussion boreholes were undertaken at the site between the 27th July and the 8th August 1994, to depths of 30m bgl.

5.2 The borehole positions were set out by Clark Smith Partnership's Engineer, and the

work was supervised by an Engineering Geologist. Prior to works commencing, surface tarmac and concrete was broken out by a sub-contractor under the direction of CSP. Reinstatement works were also subsequently carried out by a sub-contractor, again under the direction of CSP.

- 5.3 Disturbed jar and bulk samples were obtained from the strata encountered in the boreholes for inspection and subsequent laboratory testing. Undisturbed U100 samples were obtained from within the fine grained 'cohesive' strata for extrusion, identification and testing using hand vane/penetrometer instruments by an Engineering Geologist. In addition, standard penetration tests (SPT and CPT) were undertaken within the cohesive strata to obtain an approximate and relative measure of shear strength, and granular fill materials to obtain a measure of approximate relative density. Standard penetration tests (SPT/CPT) were carried out in the Flood Plain Gravels to obtain a measure of relative density and the Upper Chalk to obtain a measure of shear strength (highly weathered material) and rock strength (moderately weathered to Fresh Material).
- 5.4 Descriptions and depths of the strata exposed are presented on the cable percussion borehole logs, together with sample depths, field test results, ground water information and other pertinent remarks, in Appendix B.
- 5.5 Installation of standpipes to record standing water levels was not required by the Engineer Messrs. Clark Smith Partnership, although all water ingresses encountered during the formation of the boreholes were recorded by the drillers and detailed on the drillers' logs.

6.0 GROUND CONDITIONS

6.1 **Made Ground**

- 6.1.1 Made ground was encountered in all the boreholes to depths of between 1.9 and 3.3 metres bgl.
- 6.1.2 The made ground generally comprised a surface layer of 0.6 metres to 1.1m of hard asphalt above dry mix concrete, sand and cement or concrete resting above variable very loose brown gravelly sand with pockets of black silty organic clay, and soft to firm bluish grey, brown/black mottled sandy silty clays with some gravel, brick rubble, wood and ceramic debris.
- 6.1.3 SPT 'N' values of between N=3 and N=8 were recorded within this strata.

6.2 Alluvial Deposits

- 6.2.1 The Made Ground was underlain directly by Recent and Pleistocene alluvial deposits to depths of between 11.9 and 13.3 m bgl. These soils generally comprised alternating thinly bedded very soft to firm bluish grey to grey silty organic clays and firm brown to black clayey silty fibrous peat.
- 6.2.2 Undisturbed U100 samples of this stratum were not tested in triaxial compression, although were extruded and examined in detail by an Engineering Geologist, with hand vane/penetrometer measurements carried out where possible. The detailed descriptions and test results are presented in Appendix C.

6.3 Flood Plain Gravels (Thames Valley Gravels)

- 6.3.1 Flood Plain Gravels were encountered directly beneath the Alluvial deposits to depths of between 19.8 and 20.6m bgl giving a total stratum thickness of between 6.8 and 8.3 metres.
- 6.3.2 The gravels generally comprised medium dense to very dense dark grey to black sandy sub-angular to rounded fine to coarse flint gravels and grey to brown, gravelly to very gravelly fine to coarse sands with rare thin bands of firm to stiff greyish green sandy clay with some gravel and organic matter.
- 6.3.3 SPT 'N' Values in this stratum varied between N=15 and N=52 where full test penetration was achieved.

6.4 Cretaceous Upper Chalk

- 6.4.1 The Upper Chalk was encountered directly beneath the Flood Plain Gravels at depths between 19.8 and 20.6m bgl and proved to 30m bgl in each borehole.
- 6.4.2 In boreholes A and C the stratum generally comprised moderately to highly weathered Chalk to a depth of around 25m bgl, and comprised firm to stiff white/cream and brown clayey silt with lumps/blocks of hard chalk and occasional flint gravel. Below this depth in boreholes A and C the stratum comprised hard/very weak white/grey closely to very closely jointed blocking chalk with some firm/stiff clayey silt between joints and occasional bands of flint gravel. In borehole B the Upper Chalk Stratum comprised a similar blocky Chalk from 19.80m bgl, becoming stronger and with tighter joint openings with depth.

6.5 Groundwater

- 6.5.1 Ground water was encountered in all three boreholes at depths of between 0.9 and 2.1 metres bgl, rising to standing water levels of between 0.9 and 1.4 metres bgl. The

ground water was found to be brackish. As standpipes were not installed, variations in ground water level due to tidal conditions are not known.

7.0 LABORATORY TESTING

7.1 Engineering Laboratory Testing

7.1.1 Engineering Laboratory Testing was in general carried out in accordance with BS1377, 1990 'Methods of test for soils for Civil Engineering Purposes', at a 'NAMAS' accredited testing laboratory.

7.1.2 The following tests were undertaken on selected samples obtained from the boreholes in order to provide information on soil and water properties for assessment purposes, Ref: Appendix D.

- a) Chloride content of water samples.
- b) Soluble sulphate of fills, soils and water.
- c) pH of soils and water.

8.0 COMMENTS AND RECOMMENDATIONS

8.1 Foundation Assessment

8.1.1 The proposed building will be located in an area underlain by up to 3.3 metres of very loose to loose/soft to firm fill materials, resting above soft and firm recent alluvial silts, clays and peaty soils. These soils are unsuitable to support conventional strip or pad foundations or ground bearing floor slabs, unless significant total and differential settlements can be tolerated.

8.1.2 With regards to the poor ground bearing capacity of the fills and alluvium the main structural loads should be supported off a piled foundation, taken into the Flood Plain Gravels. Consideration could be given to the use of pre-cast driven steel or concrete end bearing piles or continuous flight auger end bearing piles. Pile foundation designs should take into account the limited lateral support available at shallow depth in view of the soft/weak alluvial soils present and continued settlement of the alluvial soils as a result of future surface loading or potential change in groundwater level, (i.e. negative skin friction).

8.1.3 Preliminary calculations on the basis of the standard penetration test results indicate a net unit base resistance of 8 to 12 MN/m² would be achievable within the sands and gravels. Adopting a pile size of 0.2m square would hence enable total loads of up to 480 KN to be carried purely in end resistance. As a general rule *"the allowable*

working load on an isolated pile driven to refusal (by normal driving equipment) in a dense sand or gravel, consisting predominantly of quartz particles, is given by the allowable load on the pile considered as a structural member, rather than by a consideration of failure of the supporting soil, or if the permissible working stress on the material of the pile is not exceeded, then the pile will not fail (Ref 1)."

It is considered unlikely that piles driven to a set into the sands and gravels would significantly stress the underlying weathered Chalk stratum, though this should be confirmed by a specialist contractor as part of their design.

8.1.4 The settlements of floor slabs would depend on the stiffness of the slab, method of loading and size of loaded area. Assuming a loaded area of 10m x 10m under a sustained load of 45 KN/m² we would anticipate total long term settlements in the range 350 to 700 mm, based on the variable soils encountered including highly compressible organic clays, silts and peats.

8.2 Foundation Design and Construction

8.2.1 Anticipated settlements of foundations supported off a piled foundation will be provided by the specialist piling contractor and will be subject to pile type and method of installation adopted.

8.2.2 Support of shallow (maximum 1.2 metres deep) excavations is likely to be required to maintain stability in the short term, as localised collapse is likely to occur where loose granular fill materials are encountered at this depth. Full support should be provided for any excavation greater than 1.2m deep where man entry is envisaged, in compliance with statutory requirements and in all cases where the possibility of collapse is to be avoided.

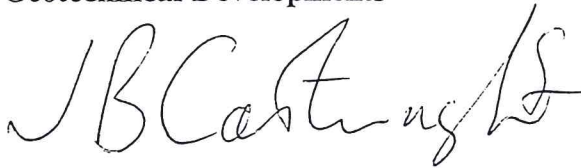
8.2.3 Shallow excavations could be achieved using mechanical excavators with breaker attachment to break out surface hardstanding.

8.2.4 Generally it is considered likely that groundwater would be encountered in shallow (less than 1.5 metres) foundation or service excavations as minor seepages/ingress which could be dealt with by localised sump type pumping. However, this assessment is based upon the groundwater regime at the time of the investigation, as observed in small diameter bores, therefore allowance should be made for seasonal groundwater changes, and the need for well point dewatering for any deep excavations needed to remain open longer than 24 hours.

8.2.5 Seventeen chemical analyses undertaken on fills, natural soils and groundwater indicate near neutral to slightly alkaline pH conditions (pH 6.7 to 8.75), together with soluble sulphate (as SO₄) concentrations of between 0.1 and 2.2 g/l, for soils and 0.38 and 0.50 g/l for groundwaters, i.e. within Classes 1 and 2 of BRE Digest 363 (July

1991). Special precautions to avoid attack on good quality subsurface concrete in accordance with Class 2 conditions are therefore considered necessary. Analysis for chloride indicate that brackish conditions occur within the ground water contained within the Alluvial Deposits.

Geotechnical Developments



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APPENDIX A

APPENDIX B



GEOTECHNICAL DEVELOPMENTS

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BOREHOLE LOG

Borehole A

Sheet 1 of 3

Method		Date	Site			
Cable Percussion		27/07/94 - 29/07/94	New Shed, Western Peninsular, Tilbury Free Port			
Dia mm		Ccord	Ground Level m.OD	Client		
150mm		631000E 761000N		Clark Smith Partnership		
Soil Samples/Tests		Field Records	OD Level m.	Depth m.	Description of Strata	Legend
Type/Test	Depth m.					
D1	0.30			0.30	Tarmac over concrete. (FILL) (0.30)	
B1	0.60 - 0.90			0.60	Greyish white fine to coarse limestone gravel. (FILL) (0.30)	
W1	0.90	STRIKE at 0.9m		1.10	Soft to firm grey brown to black silty organic clay with fine to coarse gravel, wood and organic remains. (FILL) (0.50)	
C1 N=3	1.10 - 1.55	Seepage, after 15 mins rose to 0.9m ,3/1,0,1,1				
D2	1.70			1.70	Very loose grey brown to dark grey gravelly slightly clayey fine to coarse sand, with occasional pockets of soft to firm brown to grey brown peaty clay. (FILL) (0.60)	
B2	1.10 - 1.60			1.90	Soft grey, bluish grey, buff and brownish green mottled slightly sandy silty clay with some fine and medium gravel. (POSSIBLY FILL) (0.20)	
D3	1.90			2.45	Soft to firm light to dark grey/light greyish green/black/buff mottled silty CLAY with occasional organic matter (preserved wood). (ALLUVIUM) (0.55)	
U1 (8)	2.00 - 2.40					
D4	2.45			3.00	Firm stiff light bluish grey to dark grey speckled black in places, closely blocky fissured (brown staining on fissure planes) silty CLAY. (ALLUVIUM) (1.55)	
U2 (19)	3.00 - 3.40			3.45	Water level at 3.4m 29/7/94 am	
D5	3.45			4.00	Very soft to soft light grey to grey/light greenish grey silty CLAY, with occasional organic matter (preserved wood), and with thin bands of firm dark brown to black amorphous peat below 5.25m. (ALLUVIUM) (1.45)	
U3 (15)	4.00 - 4.40			5.45	Firm brown to black fibrous PEAT. (ESTUARINE PEAT) (0.55)	
D6	4.60			6.00	Very soft to soft light grey to grey silty CLAY, with some organic matter. (ALLUVIUM) (0.45)	
U4 (9)	5.00 - 5.40	Water level at 5.1m 29/7/94 pm		6.45	Soft to firm light greenish grey and grey brown silty CLAY with much organic matter. (ALLUVIUM) (1.60)	
D7	5.45			8.05	Firm dark brown to black fibrous PEAT. (ESTUARINE PEAT) (0.95)	
U5 (8)	6.00 - 6.40			9.00	Very soft to soft light grey silty CLAY, with some organic matter, with pockets of black spongy amorphous peat below 9.22m. (ALLUVIUM) (0.30)	
D8	6.45	Water level at 6.3m 28/7/94 am		9.30	Firm dark brown to black thinly laminated fibrous slightly clayey PEAT. (ESTUARINE PEAT) (0.70)	
U6 (9)	7.00 - 7.40			10.00		
D9	7.45					
U7 (15)	8.00 - 8.40					
D10	8.45					
U8 (8)	9.00 - 9.45					
D11	9.45					
U9 (7)	10.00 - 10.40					

Remarks

*S14 48 blows for 225mm (test), *S18 49 blows for 225mm (test).
Chiselling from 0.3 to 1.1m for 1 hour.
Groundwater encountered at 0.9m.

Logged by	Scale	End Casing Depth	Job No.
SF	1:50	m. 25.00	E70894
Sample/Test key:		Penetration Tests	
U ()	U100 sample (blows)	S ()	Standard (N value)
D	Disturbed sample	C ()	Cone (N value)
B	Bulk sample	*	Blows and penetration
W	Water sample		when 300mm not
-	Progress & Day		achieved



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BOREHOLE LOG

Borehole A

Sheet 2 of 3

Method		Date		Site									
Cable Percussion		27/07/94 - 29/07/94		New Shed, Western Peninsular, Tilbury Free Port									
Dia mm		Coord		Ground Level m.OD									
150mm		631000E 761000N		Clark Smith Partnership									
Soil Samples/Tests		Field Records		Description of Strata									
Type/Test	Depth m.	OD Level m.	Depth m.	Legend									
D12	10.45		10.45	Friable dark brown to black amorphous slightly clayey PEAT, with thin bands of very soft light to dark grey/buff mottled silty clay. (ESTUARINE PEAT) (0.45)									
U10 (10)	11.00 - 11.40		11.00	Firm dark brown to black thinly laminated amorphous PEAT. (ESTUARINE PEAT) (0.55)									
D13	11.45		11.45	Soft light grey thinly laminated silty CLAY, with some organic matter. (ALLUVIUM) (0.45)									
U11 (10)	12.00 - 12.40			Soft to firm light grey to dark grey mottled thinly laminated silty CLAY, organic in places, with much organic matter below 12.45m. (ALLUVIUM) (1.85)									
D14	12.45												
S2 N=25 B3	13.30 - 13.75 13.30 - 13.80	,4/4,4,8,9	13.30	Medium dense to dense dark grey to black sandy subangular to rounded fine to coarse flint GRAVEL, with occasional cobbles, and with pockets of greyish green sandy clay from 14.5-16.0m. (THAMES VALLEY GRAVEL) (7.30)									
C3 N=34 B4	14.50 - 14.95 14.50 - 15.00	,3/1,5,12,16											
C4 N=39 B5	15.50 - 15.95 15.50 - 16.00	,5/6,8,11,14											
C5 N=40 B6	16.50 - 16.95 16.50 - 17.00	,6/6,6,12,16											
C6 N=29 B7	17.50 - 17.95 17.50 - 18.00	,6/6,7,9,7											
C7 N=39 B8	18.50 - 18.95 18.50 - 19.00	,6/4,6,12,17											
C8 N=23 B9	19.50 - 19.95 19.50 - 20.00	,5/4,7,7,5											
Remarks				<table border="1"> <tr> <td>Logged by</td> <td>Scale</td> <td>End Casing Depth</td> <td>Job No.</td> </tr> <tr> <td>SF</td> <td>1:50</td> <td>m. 25.00</td> <td>E70894</td> </tr> </table>		Logged by	Scale	End Casing Depth	Job No.	SF	1:50	m. 25.00	E70894
Logged by	Scale	End Casing Depth	Job No.										
SF	1:50	m. 25.00	E70894										
<p>*S14 48 blows for 225mm (test), *S18 49 blows for 225mm (test). Chiselling from 0.3 to 1.1m for 1 hour. Groundwater encountered at 0.9m.</p>				<p>Sample/Test key:</p> <p>U () U100 sample (blows) D Disturbed sample B Bulk sample W Water sample - Progress & Day</p> <p>Penetration Tests</p> <p>S () Standard (N value) C () Cone (N value) * Blows and penetration when 300mm not achieved</p>									



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BOREHOLE LOG

Borehole A

Sheet 3 of 3

Method		Date		Site		
Cable Percussion		27/07/94 - 29/07/94		New Shed, Western Peninsular, Tilbury Free Port		
Dia mm	Coord	Ground Level m.OD		Client		
150mm	521000E 761000N			Clark Smith Partnership		
Soil Samples/Tests		Field Records	OD Level m.	Depth m.	Description of Strata	Legend
Type/Test	Depth m.					
S9 N=4 D16	20.60 - 21.05 20.60	,4/1,1,1,1		20.60	Firm white/greyish white clayey SILT, with many lithorelics of blocky hard/very weak chalk and occasional bands of angular to subrounded flint gravels. Fragments of chalk ranging in size from 5mm to in excess of 100mm (broken fragments). (WEATHERED UPPER CHALK IV-V) (4.40)	
S10N=7 D17	21.50 - 21.95 21.50	,3/1,2,2,2				
S11N=8 D18	22.50 - 22.95 22.50	,3/2,2,2,2				
S12N=11 D19	23.50 - 23.95 23.50	,4/2,2,3,4				
S13N=16 D20	24.50 - 24.95 24.50	,8/3,4,4,5			Hard/weak white/grey white very closely to closely jointed blocky CHALK, with occasional firm putty chalk and bands of angular to subrounded flint gravels. (UPPER CHALK II-III) (5.00)	
S14* D21	25.50 - 25.88 25.50	,7/4,30,14,		25.00		
S15N=29 D22	26.50 - 26.95 26.50	,6/5,7,8,9				
S16N=34 D23	27.50 - 27.95 27.50	,8/5,7,9,13				
S17N=42 D24	28.50 - 28.95 28.50	,10/8,9,11,14				
S18* D25	29.50 - 29.88 29.50	,15/16,16,17,		30.00		

Remarks

*S14 48 blows for 225mm (test), *S18 49 blows for 225mm (test).
Chiselling from 0.3 to 1.1m for 1 hour.
Groundwater encountered at 0.9m.

Logged by	Scale	End Casing Depth	Job No.
SF	1:50	m. 25.00	E70894
Sample/Test key:		Penetration Tests	
U ()	U100 sample (blows)	S ()	Standard (N value)
D	Disturbed sample	C ()	Cone (N value)
B	Bulk sample	*	Blows and penetration when 300mm not achieved
W	Water sample		
-	Progress & Day		



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BOREHOLE LOG

Borehole B

Sheet 1 of 3

Method		Date		Site			
Cable Percussion		01/08/94 - 04/08/94		New Shed, Western Peninsular, Tilbury Free Port			
Dia mm		Coord		Ground Level m.OD			
150mm		631000E 761000N					
Soil Samples/Tests		Field Records		Description of Strata		Legend	
Type/Test	Depth m.			OD Level m.	Depth m.		
D1	0.10				0.10	Tarmac over concrete. (FILL) (0.10)	
D2	0.40				0.30	Loose black ash. (FILL) (0.20)	
						CONCRETE. (0.60)	
B1	1.00 - 1.20				0.90	Very loose brown gravelly sand with brick and firm brown to black sandy organic clay with gravel. (FILL) (0.30)	
U1 (6)	1.20 - 1.60				1.20		
D3	1.65				1.40	Firm light blue grey/green grey silty clay, with pockets of firm brown silty clay, brick rubble, gravel and cinders. (FILL) (0.20)	
C1 N=3	2.00 - 2.45	,2/1,0,1,1 STRIKE at 2.1m Seepage, after 15 mins rose to 1.4m sealed out at 4.0m				Soft to firm bluish grey, grey and brown mottled clay with pockets of brown, very sandy gravelly clay, very soft black organic clay, occasional pieces of wood, brick and ceramic tiles (FILL) (1.90)	
B2	2.00 - 2.50						
W1	2.50						
C2 N=3	3.00 - 3.45	,1/0,1,1,1 Water level at 3.2m 3/8/94 am				Firm bluish grey, brown and grey green mottled slightly silty CLAY with occasional plant roots (ALLUVIUM) (1.70)	
B3	3.00 - 3.50						
D4	3.30				3.30		
U2 (7)	3.90 - 4.30	Water level at 3.9m 2/8/94 am Water level at 4.0m 4/8/94 pm				Very soft to soft light grey to light grey green occasionally closely blocky fissured with sandy silty partings, silty CLAY, with some organic matter. (ALLUVIUM) (0.45)	
D5	4.35						
U3 (8)	5.00 - 5.40				5.00		
D6	5.45	Water level at 5.6m 3/8/94 pm			5.45	Soft to firm grey silty CLAY with many plant roots. (ALLUVIUM) (0.55)	
U4 (8)	6.00 - 6.40						
D7	6.45				6.45	Very soft to soft light grey to light brown silty CLAY, with pockets of firm dark brown to black amorphous peat below 6.15m. (ALLUVIUM) (0.45)	
U5 (9)	7.00 - 7.40				7.00	Firm dark brown to black clayey fibrous PEAT. (ESTUARINE PEAT) (0.55)	
D8	7.45					Soft to firm light grey thinly laminated silty CLAY with some organic matter. (ALLUVIUM) (2.00)	
U6 (11)	8.00 - 8.40						
D9	8.45						
U7 (20)	9.00 - 9.40				9.00	Firm dark brown to black thinly laminated amorphous becoming fibrous PEAT. (ESTUARINE PEAT) (1.30)	
D10	9.45						
W2	9.60						

Remarks

*C4 44 blows for 225mm (test).
Chiselling from 0.3 to 1.2m for 3.5 hours.
Groundwater encountered at 2.1m and 13.2m.

Logged by	Scale	End Casing Depth	Job No.
SF	1:50	m. 24.00	E70894
Sample/Test key:		Penetration Tests	
U ()	U100 sample (blows)	S ()	Standard (N value)
D	Disturbed sample	C ()	Cone (N value)
B	Bulk sample	*	Blows and penetration
W	Water sample		when 300mm not
-	Progress & Day		achieved



GEOTECHNICAL DEVELOPMENTS

GEOTECHNICAL INVESTIGATION SERVICES

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BOREHOLE LOG

Borehole B

Sheet 2 of 3

Method		Date	Site			
Cable Percussion		01/08/94 - 04/08/94	New Shed, Western Peninsular, Tilbury Free Port			
Dia mm		Coord	Ground Level m.OD	Client		
150mm		631000E 761000N		Clark Smith Partnership		
Soil Samples/Tests		Field Records	OD Level m.	Depth m.	Description of Strata	Legend
Type/Test	Depth m.					
U8 (17)	10.10 - 10.50			10.30	Soft to firm light grey /olive green/light brown thinly laminated very peaty CLAY. (ALLUVIUM) (0.70)	
D11	10.55					
U9 (10)	11.00 - 11.40			11.00	Soft to firm light grey thinly laminated silty CLAY, with some organic matter. (ALLUVIUM) (2.00)	
D12	11.45					
U10 (8)	12.00 - 12.40					
D13	12.45					
U11 (21)	13.00 - 13.30			13.00	Medium dense brown grey to grey clayey fine and medium SAND with some organic matter (THAMES VALLEY GRAVELS) (0.70)	
D14	13.45	STRIKE at 13.2m Seepage, after 15 mins rose to 9.1m		13.70		
C3 N=52 B4	14.00 - 14.45 14.00 - 14.50	Not sealed out, 14/9,12,14,17			Very dense grey gravelly fine to coarse SAND slightly clayey in places (THAMES VALLEY GRAVELS) (2.10)	
C4 * B5	15.00 - 15.38 15.00 - 15.50	,11/11,14,19,				
D15	15.80			15.80	Firm to stiff greyish green sandy CLAY with some gravel and traces of organic matter (THAMES VALLEY GRAVELS) (0.20)	
C5 N=33 B6	16.00 - 16.45 16.00 - 16.50	,10/5,6,9,13		16.00		
C6 N=29 B7	17.00 - 17.45 17.00 - 17.50	,3/4,8,8,9			Medium dense to dense grey gravelly fine to coarse SAND (THAMES VALLEY GRAVELS) (2.00)	
C7 N=15 B8	18.00 - 18.45 18.00 - 18.50	,3/1,2,5,7		18.00		
C8 N=22 B9	19.00 - 19.45 19.00 - 19.50	,5/3,5,5,9		19.00	Medium dense grey very gravelly fine to coarse SAND (THAMES VALLEY GRAVELS) (0.80)	
C9 N=33	20.00 - 20.45	,14/12,8,7,6		19.80		
Hard/very weak white/grey rubbly to blocky						
Remarks						
*C4 44 blows for 225mm (test). Chiselling from 0.3 to 1.2m for 3.5 hours. Groundwater encountered at 2.1m and 13.2m.						
Logged by		Scale	End Casing Depth	Job No.		
SF		1:50	m. 24.00	E70894		
Sample/Test key:			Penetration Tests			
U () U100 sample (blows)			S () Standard (N value)			
D Disturbed sample			C () Cone (N value)			
B Bulk sample			* Blows and penetration			
W Water sample			when 300mm not			
- Progress & Day			achieved			



GEOTECHNICAL DEVELOPMENTS

GEOTECHNICAL INVESTIGATION SERVICES

Telephone (0926) 813747. Fax (0926) 813302.

BOREHOLE LOG

Borehole B

Sheet 3 of 3

Method		Date		Site	
Cable Percussion		01/08/94 - 04/08/94		New Shed, Western Peninsular, Tilbury Free Port	
Dia mm		Coord		Ground Level m.OD	
150mm		631000E 761000N		Clark Smith Partnership	
Soil Samples/Tests		Field Records		Description of Strata	
Type/Test	Depth m.	OD Level m.	Depth m.	Legend	
B10	20.00 - 20.50			CHALK with occasional bands of angular to subrounded flint gravels and firm to stiff silty clay fill to joints. (WEATHERED UPPER CHALK, III to IV) (5.20)	
S10N=21 D16	21.00 - 21.45 21.00	,4/5,7,5,4			
S11N=21 D17	22.00 - 22.45 22.00	,5/5,6,4,6			
S12N=20 D18	23.00 - 23.45 23.00	,5/6,5,5,4			
S13N=23 D19	24.00 - 24.45 24.00	,6/5,6,6,6			
S14N=27 D20	25.10 - 25.55 25.10	,5/6,7,6,8	25.00	Hard/weak white/brownish white blocky closely to very closely fissured CHALK, with firm white silty clay fill to joints. (WEATHERED UPPER CHALK, II) (2.00)	
S15N=27 D21	26.00 - 26.45 26.00	,6/5,6,6,10			
S16N=36 D22	27.00 - 27.45 27.00	,8/7,9,9,11	27.00	Hard/weak white/brownish white blocky closely to very closely fissured CHALK. (UPPER CHALK, I) (3.00)	
S17N=38 D23	28.00 - 28.45 28.00	,12/9,9,10,10			
S18N=42 D24	29.50 - 29.95 29.50	,13/8,11,10,13	30.00		

Remarks

*C4 44 blows for 225mm (test).
Chiselling from 0.3 to 1.2m for 3.5 hours.
Groundwater encountered at 2.1m and 13.2m.

Logged by	Scale	End Casing Depth	Job No.
SF	1:50	m. 24.00	E70894
Sample/Test key:		Penetration Tests	
U ()	U100 sample (blows)	S ()	Standard (N value)
D	Disturbed sample	C ()	Cone (N value)
B	Bulk sample	*	Blows and penetration when 300mm not achieved
W	Water sample		
-	Progress & Day		



GEOTECHNICAL DEVELOPMENTS

GEOTECHNICAL INVESTIGATION SERVICES

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BOREHOLE LOG

Borehole C

Sheet 1 of 3

Method		Date		Site					
Cable Percussion		04/08/94 - 08/08/94		New Shed, Western Peninsular, Tilbury Free Port					
Dia mm		Coord		Ground Level m.OD					
150mm		631000E 761000N		Clark Smith Partnership					
Soil Samples/Tests		Field Records		Description of Strata		Legend			
Type/Test	Depth m.			OD Level m.	Depth m.				
D1	0.40				0.40				
B1	0.50 - 0.80								
D2	1.10	Water level at 0.9m 5/8/94 am			1.10				
C1 N=6	1.20 - 1.65	,3/1,2,2,1							
B2	1.20 - 1.70								
D3	1.80				1.80				
C2 N=6	2.00 - 2.45	,4/2,2,1,1			2.00				
B3	2.00 - 2.50								
D4	2.70	STRIKE at 2.6m			2.70				
C3 N=7	3.00 - 3.45	Seepage, after 15 mins rose to 1.7m sealed out at 6.0m							
B4	3.00 - 3.50	,3/1,2,2,2							
W1	3.00	Water level at 3.1m 8/8/94 am							
D5	3.70								
C4 N=7	4.00 - 4.45	,3/2,2,1,2			4.00				
B5	4.00 - 4.50								
U1 (7)	5.00 - 5.40	Water level at 4.2m 8/8/94 pm							
D6	5.45								
U2 (9)	6.00 - 6.40	Water level at 5.7m 5/8/94 pm & 4/8/94 am			6.00				
D7	6.45				6.45				
U3 (11)	7.00 - 7.40				7.00				
D8	7.45				7.45				
U4 (9)	8.00 - 8.40				8.00				
D9	8.45								
U5 (9)	9.00 - 9.40				9.00				
D10	9.45								
W2	10.00								
Remarks *C7 44 blows for 225mm (test). Chiselling from 0.3 to 1.1m for 2 hrs and 45 mins. Groundwater encountered at 2.6m and 11.6m.						Logged by SF	Scale 1:50	End Casing Depth m. 23.50	Job No. E70894
Sample/Test key: U () U100 sample (blows) D Disturbed sample B Bulk sample W Water sample - Progress & Day						Penetration Tests S () Standard (N value) C () Cone (N value) * Blows and penetration when 300mm not achieved			



GEOTECHNICAL DEVELOPMENTS

GEOTECHNICAL INVESTIGATION SERVICES

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BOREHOLE LOG

Borehole C

Sheet 2 of 3

Method		Date	Site			
Cable Percussion		04/08/94 - 08/08/94	New Shed, Western Peninsular, Tilbury Free Port			
Dia mm	Coord	Ground Level m.OD	Client			
150mm	531000E 761000N		Clark Smith Partnership			
Soil Samples/Tests		Field Records	OD Level m.	Depth m.	Description of Strata	Legend
Type/Test	Depth m.					
U6 (10)	10.00 - 10.40					x
D11	10.45					x
U7 (9)	11.00 - 11.40			11.05		x
D12	11.45	STRIKE at 11.6m Fast, after 15 mins rose to 9.8m		11.45	Medium dense grey brown to dark grey brown/ grey clayey fine and medium SAND, with a trace of organic matter and gravel. (ALLUVIUM) (0.40)	
C5 N=45 B6	12.50 - 12.95 12.50 - 13.00	,11/6,8,13,18		11.90	Soft dark greyish brown very sandy CLAY. (ALLUVIUM) (0.45)	
C6 N=48 B7	13.50 - 13.95 13.50 - 14.00	,9/7,9,14,18			Dense to very dense very sandy slightly clayey angular to subrounded fine to coarse flint GRAVEL, medium dense from 16.5-18.0m. (THAMES VALLEY GRAVEL) (5.60)	
C7 * B8	14.50 - 14.88 14.50 - 15.00	,10/10,15,19,				
C8 N=31 B9	15.50 - 15.95 15.50 - 16.00	,7/8,9,7,7				
C9 N=24 B10	16.50 - 16.95 16.50 - 17.00	,6/5,5,6,8				
C10N=27 B11	17.50 - 17.95 17.50 - 18.00	,5/4,7,7,9		17.50	Medium dense to dense brown to grey brown very gravelly fine to coarse SAND. (THAMES VALLEY GRAVEL) (2.00)	
C11N=43 B12	18.50 - 18.95 18.50 - 19.00	,6/9,14,11,9				
C12N=15 B13	19.50 - 19.95 19.50 - 20.00	,6/4,5,3,3		19.50	Medium dense very sandy angular to subrounded fine to coarse flint GRAVEL, with occasional cobbles. (THAMES VALLEY GRAVEL) (0.70)	

Remarks

*C7 44 blows for 225mm (test).
Chiselling from 0.3 to 1.1m for 2 hrs and 45 mins.
Groundwater encountered at 2.6m and 11.6m.

Logged by	Scale	End Casing Depth	Job No.
SF	1:50	m. 23.50	E70894
Sample/Test key:		Penetration Tests	
U ()	U100 sample (blows)	S ()	Standard (N value)
D	Disturbed sample	C ()	Cone (N value)
B	Bulk sample	*	Blows and penetration when 300mm not achieved
W	Water sample		
-	Progress & Day		



GEOTECHNICAL DEVELOPMENTS

GEOTECHNICAL INVESTIGATION SERVICES

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BOREHOLE LOG

Borehole c

Sheet 3 of 3

Method		Date		Site				
Cable Percussion		04/08/94 - 08/08/94		New Shed, Western Peninsular, Tilbury Free Port				
Dia mm	Coord	Ground Level m.OD		Client				
150mm	631000E 761000N			Clark Smith Partnership				
Soil Samples/Tests		Field Records	OD Level m.	Depth m.	Description of Strata	Legend		
Type/Test	Depth m.							
S13N=11 D13	20.50 - 20.95 20.50	,3/2,3,3,3		20.20	Firm to stiff cream/pale brown to greyish white clayey SILT, with many lithorelics of blocky hard chalk, and occasional bands of angular to subrounded flint gravels (fragments of chalk ranging in size from 5mm to 20mm). (WEATHERED UPPER CHALK IV-V) (4.80)			
S14N=15 D14	21.50 - 21.95 21.50	,4/3,4,4,4						
S15N=16 D15	22.50 - 22.95 22.50	,4/4,4,3,5						
S16N=17 D16	23.40 - 23.85 23.40	,5/3,4,5,5						
S17N=20 D17	24.50 - 24.95 24.50	,5/4,5,5,6						
S18N=23 D18	25.50 - 25.95 25.50	,5/4,6,6,7		25.00			Hard/very weak cream/pale brown very closely blocky jointed CHALK, with some firm/stiff clayey silty to joints. (WEATHERED UPPER CHALK 11-111) (3.00)	
S19N=34 D19	26.50 - 26.95 26.50	,6/7,9,12,6						
S20N=19 D20	27.50 - 27.95 27.50	,5/4,4,4,7						
S21N=36 D21	28.50 - 28.95 28.50	,8/5,9,10,12		28.00				
S22N=28 D22	29.50 - 29.95 29.50	,7/6,6,7,9		30.00				

Remarks

*C7 44 blows for 225mm (test).
Chiselling from 0.3 to 1.1m for 2 hrs and 45 mins.
Groundwater encountered at 2.6m and 11.6m.

Logged by	Scale	End Casing Depth	Job No.
SF	1:50	m. 23.50	E70894
Sample/Test key:		Penetration Tests	
U ()	U100 sample (blows)	S ()	Standard (N value)
D	Disturbed sample	C ()	Cone (N value)
B	Bulk sample	*	Blows and penetration when 300mm not achieved
W	Water sample		
-	Progress & Day		

APPENDIX C



HAND VANE/ EXTRUSION DESCRIPTION & PENETROMETER RESULTS

PROJECT New Shed, Western Peninsular, Tilbury Free Port
PROJECT No E708/94

BOREHOLE No	DEPTH (m)	HV (KPa)	PEN (Kg/cm ²)	DESCRIPTION
BH A (U 1) 2.0-2.4m (0.4m recovered)	2.0-2.4	21 (in top)	0.4-0.8	Soft light greyish green/light to dark grey/black/buff mottled silty organic CLAY, occasional organic matter (preserved wood). (ALLUVIUM)
BH A (U 2) 3.0-3.4m (0.4m recovered)	3.0-3.4	80-98 (in top)	1.4-2.0	Stiff light bluish grey to dark grey speckled black in parts closely blocky fissured (brown staining on fissure planes) silty CLAY. (ALLUVIUM)
BH A (U 3) 4.0-4.4m (0.35m recovered)	4.0-4.4	9 (in top)	<0.1-0.2	Very soft light grey to grey/light greenish grey silty organic CLAY, with occasional organic matter (preserved roots). (ALLUVIUM)
BH A (U 4) 5.0-5.4m (0.32m recovered)	5.0-5.4	20 (in top)	0.5-1.0	Soft light grey/greenish grey/buff/dark grey mottled silty CLAY, with much organic matter and occasional thin bands of firm dark brown to black amorphous peat below 5.25m. (ALLUVIUM)
BH A (U 5) 6.0-6.4m (0.38m recovered)	6.0-6.4	12 (in top)	0.2-0.5	Very soft to soft light grey to grey CLAY, with some organic matter (preserved roots). (ALLUVIUM)
BH A (U 6) 7.0-7.4m (0.38m recovered)	7.0-7.4	22 (in top)	0.4-0.7	Soft olive green and light grey to grey silty CLAY, with much organic matter (preserved plant remains). (ALLUVIUM)
BH A (U 7) 8.0-8.4m (0.25m recovered)	8.0-8.05	21 (in top)	0.36	Soft light grey silty CLAY. (ALLUVIUM)
	8.05-8.4		0.8-1.3	Firm dark brown to black fibrous PEAT. (ALLUVIUM)
BH A (U 8) 9.0-9.4m (0.38m recovered)	9.0-9.22	12 (in top)	0.4-0.7	Very soft to soft light grey silty CLAY, with some organic matter. (ALLUVIUM)
	9.22-9.3			Very soft to soft light grey silty CLAY, with pockets of black spongy amorphous peat. (ALLUVIUM)
	9.3-9.4		1.0-1.2	Firm dark brown to black mottled thinly laminated fibrous slightly clayey PEAT. (ESTUARINE PEAT)



HAND VANE/ EXTRUSION DESCRIPTION & PENETROMETER RESULTS

PROJECT New Shed, Western Peninsular, Tilbury Free Port
PROJECT No E708/94

BOREHOLE No	DEPTH (m)	HV (KPa)	PEN (Kg/cm ²)	DESCRIPTION
BH A (U 9) 10.0-10.4m (0.25m recovered)	10.0-10.03	13 (in top)	<0.1-0.7	Very soft light grey to dark grey/buff mottled silty CLAY, with some organic matter. (ALLUVIUM)
	10.03-10.25			Friable very dark brown to black amorphous slightly clayey PEAT. (ESTUARINE PEAT)
BH A (U 10) 11.0-11.4 (0.4m recovered)	11.0-11.4	27 (in top)	0.6-0.9	Soft light grey thinly laminated silty CLAY, with some organic matter. (ALLUVIUM)
BH A (U 11) 12.0-12.4 (0.4m recovered)	12.0-12.4	26 (in top)	0.6-0.8	Soft light grey thinly laminated silty CLAY, with some organic matter. (ALLUVIUM)



HAND VANE/ EXTRUSION DESCRIPTION & PENETROMETER RESULTS

PROJECT New Shed, Western Peninsular, Tilbury Free Port
PROJECT No E708/94

BOREHOLE No	DEPTH (m)	HV (KPa)	PEN (Kg/cm ²)	DESCRIPTION
BH B (U 1) 1.2-1.6m (0.4m recovered)	1.2-1.4	40 (in top)	1.2-1.4	Firm light blue grey/green grey silty clay, with pockets of firm brown silty sandy clay and occasional brick rubble, gravel and cinders. (FILL)
	1.4-1.6			Firm light blue grey/green grey/olive green mottled silty clay. (FILL)
BH B (U 2) 3.9-4.3m (0.4m recovered)	3.9-4.3	33 (in top)	1.0-1.2	Firm light blue grey/green grey/olive green mottled silty CLAY. (ALLUVIUM)
BH B (U 3) 5.0-5.4m (0.4m recovered)	5.0-5.4	9 (in top)	0.3-0.6	Very soft to soft light grey to light greyish green occasionally closely blocky fissured with sandy (fine) silty partings, silty CLAY, with some organic matter. (ALLUVIUM)
BH B (U 4) 6.0-6.4m (0.4m recovered)	6.0-6.4	13 (in top)	0.4-0.6	Very soft to soft light grey to light brown silty CLAY, with pockets of firm very dark brown to black amorphous peat below 6.15m. (ALLUVIUM)
BH B (U 5) 7.0-7.4m (0.4m recovered)	7.0-7.4	20 (in top)	0.4-0.6	Soft to firm light grey thinly laminated silty CLAY, with some organic matter (plant remains). (ALLUVIUM)
BH B (U 6) 8.0-8.4m (0.4m recovered)	8.0-8.4	23 (in top)	0.6-0.8	Soft to firm light grey thinly laminated silty CLAY, with some to much organic matter below 8.35m. (ALLUVIUM)
BH B (U 7) 9.0-9.4m (0.26m recovered)	9.0-9.4		1.2-1.8	Firm dark brown to black thinly laminated amorphous PEAT, with occasional plant remains. (ESTUARINE PEAT)
BH B (U 8) 10.0-10.4 (0.3m recovered)	10.1-10.3		1.2-1.8	Firm dark brown to black thinly laminated amorphous PEAT, with occasional plant remains. (ESTUARINE PEAT)
	10.3-10.4		0.8-1.2	Soft light grey/light olive/light brown thinly laminated very peaty CLAY. (ALLUVIUM)

CHEMICAL ANALYSIS RESULTS (SOIL)

PROJECT
PROJECT NO

New Shed, Western Peninsular, Tilbury Free Port
E70894

Sample Location	BH A	BH A	BH A	BH A
Sample Number	D2	D9	B4	D16
Depth (m)	1.7	7.45	14.5	20.6
Chloride (as Cl) %	0.05	0.14	0.06	0.1
pH	8.1	6.7	8.3	8.5
Acidic				
Alkaline				
Water Soluble Sulphate (SO ₄)g/l	0.6	2.2	0.22	0.19

Sample Location	BH B	BH B	BH B	BH B
Sample Number	D3	D13	B5	B10
Depth (m)	1.65	12.45	15.0	20.0
Chloride (as Cl) %	0.03	0.2	0.05	0.08
pH	7.95	7.75	8.3	8.7
Acidic				
Alkaline				
Water Soluble Sulphate (SO ₄)g/l	0.41	0.89	0.1	0.1

Sample Location	BH C	BH C	BH C	BH C
Sample Number	D3	D11	B7	D14
Depth (m)	1.8	10.45	13.5	21.5
Chloride (as Cl) %	0.04	0.21	0.03	0.08
pH	7.9	7.55	8.0	8.75
Acidic				
Alkaline				
Water Soluble Sulphate (SO ₄)g/l	0.93	1.0	0.46	0.58

CHEMICAL ANALYSIS RESULTS (WATER)

PROJECT
PROJECT NO

New Shed, Western Peninsular, Tilbury Free Port
E70894

Sample Location	BH A	BH B	BH B	BH C	BH C
Sample Number	W1	W1	W2	W1	W2
Depth (m)	0.9	2.5	9.6	3.0	10.0
Chloride (as Cl) mg/l	1500	1200	5200	1600	6300
pH	7.35	7.05	7.15	7.0	6.95
Acidic					
Alkaline					
Sulphate (SO ₄)g/l	0.38	0.5	0.47	0.3	0.48

APPENDIX D

REFERENCES

- 1 'Foundation Design & Construction,' 5th Edition
M.J. Tomlinson, Longman Scientific & Technical.
pp 407