LLANDARCY TIP RESTORATION

GROUND INVESTIGATION REPORT

February 2008

Issue No 1
44382540/BDRP0011

Project Title:	Llandarcy Tip Restoration
Report Title:	Ground Investigation Report
Project No:	44382540
Report Ref:	BDRP0011
Status:	Issue No. 1
Client Contact Name:	Geoff Byrne
Client Company Name:	BP Oil Llandarcy Refinery Ltd.
Issued By:	URS Corporation Ltd. URS House Horne Lane Bedford MK40 1TS United Kingdom Tel: + 44 (0) 1234 349 641 Fax: + 44 (0) 1234 216 268 www.urseurope.com

Document Production / Approval Record

Issue No: 1	Name	Signature	Date	Position
Prepared by	Julian Ashley		11/02/2008	Engineer
Checked by	Charles Bull		11/02/2008	Project Engineer
Approved by	Paul Gross		11/02/2008	Associate Director

Document Revision Record

Issue No	Date	Details of Revisions
1	11/02/2008	Original issue

COPYRIGHT

© This Report is the copyright of URS Corporation Limited. Any unauthorised reproduction or usage by any person other than the addressee is strictly prohibited.

CONTENTS

Section		Page No
EXECUTIVE SUMMARY		1
1.	**INTRODUCTION**	2
1.1.	General	2
1.2.	Background	2
1.3.	Location	3
1.4.	Site History	3
2.	**GEOLOGY**	4
3.	**GEOTECHNICAL CONSIDERATIONS**	5
4.	**PROPOSED WORKS**	6
5.	**GROUND INVESTIGATION**	7
5.1.	Scope of Works	7
5.2.	Fieldwork	7
5.3.	Laboratory Testing	8
6.	**GROUND SUMMARY**	10
6.1.	Geology	10
6.2.	Soil Sequence	10
7.	**GROUND CONDITIONS AND MATERIAL PROPERTIES**	11
7.1.	Ground Conditions	11
7.2.	Groundwater	11
7.3.	Material Properties	12
7.3.1.	Made Ground	12
7.3.2.	Bog Sequence - Peat Deposits	13
7.3.3.	Bog Sequence - Organic Clays, Sands and Gravels	15
7.3.4.	Glacial Till	16
7.3.5.	Glacial Gravel	17
8.	**SLOPE STABILITY**	18
8.1.	Existing Slopes	18
8.1.1.	Haul Road	18
8.1.2.	Sludge Pit	18
8.2.	Proposed Slopes	18
9.	**ACCEPTABILITY CRITERIA**	19

CONTENTS

Section — Page No

10. PERMEABILITY 19

11. SUMMARY AND CONCLUSIONS 20

12. REFERENCES 22

12.1. Bibliography 22

DRAWING

44382540/GI/3035/01 Exploratory Hole Location Plan

FIGURES

Figure 1 Site Location Plan

Figure 2 Site Layout Plan

Figure 3 Photographs of Tip Area

Figure 4 Vertical representation of the submerged peat series for Crymlyn Bog

Figure 5 Geology Map

Figure 6 Aerial Photograph of western side of site showing exploratory hole locations

Figure 7 Aerial Photograph of eastern side of site showing exploratory hole locations

Figure 8 Aerial Photograph of western side of site showing extent of peat

Figure 9 Aerial Photograph of eastern side of site showing extent of peat

Figure 10 Aerial Photograph indicating extent of historic delta below Llandarcy Site

Figure 11 vs Depth

Figure 12 Casagrande Chart

Figure 13 Moisture Content, Liquid Limit and Plastic Limit vs Depth

Figure 14 Undrained

Figure 15 One Dimensional Consolidation Tests

Figure 16 Particle Size Distribution

Figure 17 Shear Strength from SPT 'N' Value vs Depth

Figure 18 M_v from SPT 'N' Value vs Depth

CONTENTS

Section		Page No
APPENDICES		
Appendix A	Borehole Logs	
Appendix B	Laboratory Test Data	

EXECUTIVE SUMMARY

BP the owners and operators of the Llandarcy refinery site are proposing to close the refinery site and the Tip area, so that it can be incorporated in to the Llandarcy Urban Village project. As part of this process a ground investigation was carried out to provide information on the subsurface sequence with in situ geotechnical testing and geotechnical laboratory testing to provide design parameters.

18 No. cable percussion boreholes were drilled to depths of between 2.0 and 26.4m. The results of the ground investigation confirm the findings of the previous environmental investigations, with the boreholes proving a sub-surface sequence comprising the following:

- Made Ground derived from the refinery operations;
- Bog Sequence - Peat Deposits,
- Bog Sequence - Organic Clays, Sands and Gravels,
- Glacial Till,

The Peat was not found in all of the boreholes and was estimated to have an extent predominantly confined to the central area of the site.

Settlement of the peat is likely to be limited due to pre-consolidation caused by the existing thickness of fill within the Tip area. Calculations have indicated that whilst settlements of up to 500mm may still be expected within the peat, this is around 50% of the settlement that might be expected for virgin peat. Similar reductions in the overall settlement of the soft organic clay deposits can be expected. Settlements within the Glacial deposits have been calculated to be of the order of 10mm.

1. INTRODUCTION

1.1. General

URS Corporation Ltd (URS) has been appointed by BP Oil – Llandarcy Refinery Ltd (BPLR) to investigate the ground conditions within the Llandarcy Refinery Tip Area (The Tip). The findings presented in this report are based upon URS proposal PRO 3037328 dated 11th October 2006 as authorised by BPLR.

The aim of this report is to provide information on the likely behaviour of the soils both during and after redevelopment of the Tip, as a recreational area, within the proposed Llandarcy Urban Village development.

1.2. Background

URS has produced an overall strategy document that proposes measures that will enable BPLR to ultimately surrender its waste management licence for the area known as the Tip. Also, the long-term aim is for the Tip to be turned into a recreational area that can be incorporated into the overall development plans for the Llandarcy Urban Village. As a result the restoration plan will result in a landform that is suitable for the overall regeneration scheme, as envisaged within the Llandarcy Remedial Action Plan (2000)[1].

final landform

Llandarcy Urban Village will comprise residential dwellings and commercial properties, educational, health care, community and neighbourhood facilities with a variety of public open spaces and infrastructure including drainage, highways and associated services. It has been estimated that the Urban Village would take approximately 20 years to implement, with completion around 2027.

The restored Tip area is also expected to contain important stormwater management features to support the infrastructure within the Urban Village.

Within the Tip Closure Strategy Report a number of tasks were recommended to lead towards ultimate closure:

Tip Closure Strategy Report Looked at

1. Site investigation to support design of the final Tip profile;
2. Development of the design of the final Tip profile;
3. Preparation of tender documents and procurement support to select a contractor to place materials, arising from the Area 1 development within the refinery site, into the Tip;
4. Site supervision during emplacement of fill materials.

This report covers item 1 above, an intrusive ground investigation, which includes a summary of the ground investigation findings, information on the subsurface sequence and in situ geotechnical properties and the results of the geotechnical testing.

1.3. Location

BP's Llandarcy Oil Refinery is located between the towns of Neath and Swansea in South Wales and is situated approximately 0.5 km to the south of Junction 43 of the M4 motorway.

The Tip is located on the western side of the refinery site, with its centre at approximate OS National Grid reference 270400, 195500. It is bounded to the north and west by Crymlyn Bog, which has been designated a Special Area of Conservation (SAC), to the south by the refinery tank farm and to the east by the main site of the former refinery.

The Tip location is shown on Figure 1.

1.4. Site History

The Tip area has historically contained a series of natural ponds and lagoons, including South Bay and the Crymlyn Bog Lagoon to the south of the area, with higher ground towards the north of the site. The layout of the Tip is shown on Figure 2 and photographs of the Tip area are included on Figure 3. There has been an industrial presence around Crymlyn Bog since the 1700's, most notably mining operations for coal and iron. The Refinery was opened in 1921 and waste has been deposited in the Tip area since then.

Following the enactment of the Deposit of Poisonous Wastes Act 1972, waste disposal was controlled by an annual "season ticket," issued by Neath Rural District Council. This permit allowed the deposition of non-notifiable waste, oil contaminated waste, oily sludge, pyrophoric material, asbestos, and sanitary waste, excluding septic tank waste.

In 1977 BPLR were granted a new licence to operate the Crymlyn Tip by Neath Borough Council. This licence incorporated the requirements of the Control of Pollution Act 1974 and covered the disposal of asbestos, boiler cleanings, oil sludges, bitumens and waxes, ion exchange resin, spent clay, pyrophoric material and contaminated debris. Additional sites within the tip for the disposal of asbestos were introduced in 1984 and 1988.

In 1985, BPLR consolidated production to lubricants and special products only, resulting in a short-term increase in waste disposal due to demolition. The reduction in operations led to a significant decrease in waste disposal.

No waste has been deposited within the Tip since November 1999 and the site was declared non operational in July 2001.

The landform created by the waste disposal operations is not currently suitable as a recreational area. To create an acceptable landform, meeting all the environmental and aesthetic criteria, it is proposed to landscape the area with imported fill material.

2. GEOLOGY

The 1:50,000-scale geological sheet for the area (247 – Swansea), published by the British Geological Survey (BGS), indicates that the area around Crymlyn Bog comprises peat deposits overlying The Upper and Lower Pennant Sandstones of the Upper Coal Measures. To the north and east of the site, undifferentiated Glacial Drift Deposits have been recorded overlying the Upper Coal Measures strata.

The area is shown as being extensively faulted and the strata are shown dipping to the north and north-west at between 22° and 30°.

The Regional Geological Memoir for South Wales[2] describes the peat sequence, as proved in Crymlyn Bog, as showing a transition through different climatic phases and spanning an interval of around 8000 years. The youngest peat, over 6.0m thick and around 6.0m above present sea-level, started forming around 3000 years ago. Figure 4 shows a vertical representation of the submerged peat series for Crymlyn Bog, which indicates the South Wales coast has subsided by approximately 25m, coincident with the sea-level rise at the end of the last ice-age.

Summary of Site Geology

The Tip Closure and Strategy Report (2006), summarises the geology at the site, which was encountered during the previous investigations. It indicates that the natural strata beneath the site comprise peat overlying silty, sometimes sandy, clay (the "bog sequence"), which is underlain by sand, gravel and cobbles overlying the Pennant Sandstone bedrock.

The Made Ground, including the lagoon deposits, which comprises ash, clinker and other placed fill materials, overlie the peat.

An extract of BGS Sheet 247 is included as Figure 5.

3. GEOTECHNICAL CONSIDERATIONS

In 2006, URS produced a Tip Closure Strategy Report, which states:-

"A restoration plan is needed for the Tip because its current topography and layout is not appropriate as a long-term stable landform to contain the deposited wastes and control and direct rainwater run-off. Engineering work is needed to provide

(i) long-term slope stability,
(ii) containment of deposited wastes including hazardous materials,
(iii) a surface water drainage system and,
(iv) a restoration profile that fits with the surrounding landscape.

As part of this restoration and landscaping there is the opportunity to derive ecological benefit from the Tip area.

It is understood from BP that there is currently no planning permission associated with the Tip and therefore no restoration profile other than that loosely described in the Waste Management Licence. It is BP's intention to apply for planning permission from the Local Authority in order to agree the final restoration profile and works are on-going relating to this and the final design for the Tip."

Intend to get final restoration profile from LPA in planning!

Based upon the geology of the area and the proposed works, there are a number of geotechnical issues that must be addressed during the ground investigation and design.

i) Potential consolidation of the materials in the base of the Tip,
ii) Potential secondary compression of the peat and organic clay layers,
iii) Stability of existing steep slopes,
iv) Acceptability of imported fill material,
v) Short term stability of excavations,
vi) The effect of settlement on the hydrocarbon drainage system and the attenuation ponds,
vii) In situ permeability of the material – both placed and in situ,
viii) Consideration of potential long-term developments on the site, such as the Urban Village.

4. PROPOSED WORKS

The restoration of the Tip will take place in conjunction with a series of measures to control and contain the movement of existing contaminants. Poor quality backfill or settlement of the underlying geological strata could seriously compromise this system, with failure resulting in contaminant leakage.

It is understood that around 60,000 m^3 of fill material will be needed to landscape the Tip to meet the requirements envisaged in the Llandarcy Remedial Action Plan (RAP), issued in 2000. The proposed landform is a gently convex area with surface drainage system that is generally directed towards South Bay.

Material has been identified within other areas of the wider Llandarcy regeneration scheme and it is intended to utilise this material, within the Tip area, as it becomes available. Therefore the restoration of the Tip is dependent upon the progress of these other areas of re-development, which is currently anticipated over a two to three year period.

The additional loading due to the filling operations may cause large settlements in the underlying strata, which may result in an unacceptably uneven ground surface profile, with an increased risk to the public using the area.

Large settlements could also make access difficult for maintenance of the contamination interceptor system and at worst, compromise the efficiency of the system.

5. GROUND INVESTIGATION

5.1. Scope of Works

With reference to the identified geotechnical issues at the Tip, it was proposed to carry out a series of cable percussion boreholes across the site. The locations were agreed on site, taking into account problems with access, the proposed works and health and safety issues.

The investigation comprised 18 no. boreholes to a maximum depth of 26.4m, with representative samples taken during the borehole operations being sent for laboratory testing. The following sample types were taken during the investigation.

- Small disturbed samples,
- Bulk disturbed samples,
- Undrained (U100) samples in cohesive material,
- Standard Penetration Test (SPT) in granular material,

The frequency of sampling was carried out in accordance with Thomas Telford's "Site Investigation in Construction Part 3: Specification for Ground Investigation"[3].

5.2. Fieldwork

The ground investigation was carried out by Soil Mechanics Limited (SML) between 14th May 2007 and 27th June 2007. The investigation comprised 18 No. cable percussion boreholes, sunk to depths of between 2.00m and 26.00m, located within the former Tip area. Two boreholes, BH10 and BH11, were not undertaken due to access problems with the sludge pits.

At the time of tender, the site was classified as RED in accordance with Thomas Telford's "Site Investigation in Construction Part 4: Guidelines for the Safe Investigation by Drilling of Landfills and Contaminated Land"[4].

Drawing No. 44382540/GI/3035/01 indicates the locations of the boreholes. Figures 6 and 7 show the borehole locations superimposed on aerial photographs of the site.

Each borehole commenced with a machine dug inspection pit, excavated to a depth of 1.5m, in compliance with BPLR requirements. All boreholes were logged by SML in accordance with BS 5930 (1999)[5]. On completion, each borehole was sealed with bentonite to 1.0m above the base of the Made Ground and then backfilled with arisings.

Groundwater strikes recorded during the boring process are included in Table 1.

To enable future product recovery from the site, 100mm diameter plastic well screens were installed in selected boreholes upon completion. Table 1 indicates the installation depths of the well screens.

Table 1: Well Installation and Groundwater Depths

Hole	Depth to Groundwater Strike (mbgl)	Depth of Well Screen (mbgl)	Comments
BH1	Not Encountered	4.3	
BH2	1.1m	6.0	
BH3	7.0	6.0	
BH5	4.3/8.8	13.0	2 strikes
BH6	2.8/9.1	6.5	2 strikes
BH7	13.1	8.5	
BH8	Not Encountered	6.0	
BH9	0.70	4.5	
BH12	7.10/12.30	-	2 strikes
BH13	5.20	-	
BH14	2.20	-	
BH15	7.70	-	
BH16	0.70	4.0	
BH17	10.40	-	
BH18	7.0	6.0	
BH19	9.30/10.90	-	2 strikes
BH20	0.40	4.0	

The pipes were left uncovered with their threads exposed, so that additional lengths of pipe could be added during the placement of the fill to re-profile the Tip. The annulus around the pipe was backfilled with a gravel filter to 0.5m below ground level and sealed with grout to ground level.

Copies of the borehole logs are included in Appendix A.

5.3. Laboratory Testing

Laboratory testing was scheduled on representative soil samples by URS and undertaken by SML in general accordance with BS 1377:1990.

The following laboratory testing was carried out.

13 No. natural moisture content determinations in accordance with BS 1377: Part 2: 1990[6];

9 No. Atterberg Limit determinations in accordance with BS1377: Part 2: 1990[6];

9 No. particle size distribution analyses, including sedimentation by pipette analyses in accordance with BS1377: Part 2: 1990[6];

13 No. one-dimensional consolidation tests in accordance with BS1377: Part 5: 1990[7].

12 No. unconsolidated undrained multistage triaxial tests in accordance with BS1377: Part 7: 1990[8];

The limited numbers of samples tested was due to the heavily contaminated nature of many of the samples, as identified by SML's testing laboratory

Copies of the laboratory test results are included in Appendix B.

6. GROUND SUMMARY

This summary is based upon the conditions encountered during the ground investigation:

6.1. Geology

BGS Sheet 247 – Swansea, at 1:50,000 scale, indicates the area around Crymlyn Bog to comprise peat and other alluvial deposits overlying the Upper and Lower Pennant Sandstones of the Upper Coal Measures. To the north and east of the Tip, undifferentiated Glacial Drift Deposits have been recorded overlying the Upper Coal Measures strata.

6.2. Soil Sequence

Based on the findings of the ground investigation, the soils encountered are summarised as follows:

Strata		Description	Range of Thickness (m)
Made Ground		Mainly sandy clayey gravel with some soft gravelly clays, highly compressible peat fill, gravel sized fragments of brick and concrete, cobble sized concrete blocks, gravel and cobble size fragments of sandstone and limestone, occasional coal coke, timber	1.20 – 13.30
Crymlyn Bog Sequence	Alluvial / Peat Deposits	Soft to firm, occasionally very stiff, black and brown fibrous PEAT with many roots and rootlets.	0.70 - 2.50
		Soft to stiff dark and light grey and black organic sandy gravelly CLAY or SILT with partially decaying wood.	0.90 – 3.50
		Medium dense brown clayey slightly gravelly SAND.	0.60 – 1.50
		Medium dense brown clayey sandy sub-rounded to rounded GRAVEL.	0.50 – 1.80
Glacial Drift	Glacial Till	Stiff becoming very stiff brown mottled grey slightly sandy slightly gravelly CLAY with occasional cobbles.	0.80 - 13.90+
	Glacial Gravel	Medium dense to very dense brown and grey slightly clayey very sandy sandstone GRAVEL with occasional cobbles. Band of very dense brown slightly clayey slightly sandy slightly gravelly Sandstone COBBLES (BH6 & BH7 only).	0.60 – 5.00+

7. GROUND CONDITIONS AND MATERIAL PROPERTIES

7.1. Ground Conditions

In the following sections the material properties determined from the ground investigation, detailed in Section 5.2, are discussed.

A ground investigation, comprising 18 No. cable percussion boreholes, was carried out by SML between 14th May 2007 and 26th June 2007. Laboratory testing was scheduled on representative soil samples and carried out in general accordance with BS 1377[6-8].

The boreholes indicate that the site was probably dissected by the river system that formed Crymlyn bog, within the River Tawe and River Neath drainage system. The aerial photographs and the occurrence of the peat in the boreholes, suggest the peat is not present under the whole of the tip area. This is discussed further in Section 7.3.2.

Copies of the aerial photographs and the assumed peat distribution are included as Figures 8 and 9. Figure 10 indicates the site location as potentially part of a much larger natural geographical feature.

Made Ground, comprising tipped material from the refinery operations and some excavated peat, appears to have been placed straight over the original ground profile, with no attempt to remove the existing peat or vegetation.

Below this are glacial deposits, consisting of clays and gravels, which have been heavily eroded. These are described as very stiff clay or very dense gravel. Bedrock was not proved in any of the boreholes.

7.2. Groundwater

Water was encountered in both the Made Ground and the more granular layers of the Glacial Deposits. Within the Made Ground, the water level generally remained constant or rose slightly after 20 minutes. Larger rises were noted in the granular layers of the Glacial Deposits, with BH5 encountering water at 14.2m, which rose to 4.3m after 20 minutes. Table 2 summarises the water observations, whilst the water levels are included on the borehole logs in Appendix A.

Table 2: Groundwater observations in Boreholes

BH No.	Level of strike	Level after 20 mins	Water level rise	BH No.	Level of strike	Level after 20 mins	Water level rise
2	1.10	No	-	13	5.2	No	-
5	10.8	8.8	2.0	14	2.5	2.2	0.3
	14.2	4.3	9.9	15	13.7	7.7	6.0
6	3.2	2.8	0.4	16	0.7	No	-
	11.3	9.1	2.2	17	11.6	10.4	1.2
7	13.1	No	-	18	9.5	7.0	2.5
9	1	0.7	0.3	19	9.5	9.3	0.2
12	7.4	7.1	0.3		15.7	10.9	4.8
	15.1	12.3	2.8	20	1.0	0.4	0.6

7.3. Material Properties

The following sections consider the results of the laboratory testing on the various strata and define the geotechnical parameters that will be used in the design of the proposed works.

7.3.1. Made Ground

Given the historical use of this area by the refinery, Made Ground comprises a random mixture of excavated peat, demolition waste, contaminated material, colliery spoil, china clay and coal derived from other parts of the refinery site.

SPT 'N' values ranged from 0 to 50*, indicating that the strength of the material is extremely variable. The variation of SPT N value with depth for Made Ground is shown on Figure 11.

Four undrained triaxial tests were carried out on samples of the Made Ground, of which three were described as peat and the fourth as clay. The results of the triaxial tests vary between 7 kN/m² and 22 kN/m² and are included on Figure 12. These indicate the material is very soft to soft.

Laboratory testing on a single sample of clay in the Made Ground indicated a moisture content of 14%, a liquid limit of 23% and a plastic limit of 15%, with a consequent plasticity index of 8%. A Plasticity chart showing the relationship between the Liquid Limit and Plasticity Index is included as Figure 13. This indicates the sample to be low plasticity clay.

* To determine the SPT N value, BS5930[5] requires the SPT split spoon sampler or CPT cone in gravel, to be driven a total distance of 450mm using a 63.5kg drop weight. The number of blows is recorded for each 75mm increment. The blows for the first 150mm (seating blows) are discarded and the SPT N value is the total number of blows for the remaining 300mm. If the total blow count for this 300mm reaches 50 before full penetration is achieved, the depth of penetration is recorded.

The variation of Moisture Content, Liquid Limit and Plastic Limit with depth is plotted on Figure 14, which shows the moisture content to be slightly less that the plastic limit.

Four one-dimensional oedometer consolidation tests were carried out on samples of the Made Ground. Three one-dimensional oedometer tests on peat within the Made Ground revealed a variation in the coefficient of consolidation (c_v) over the pressure range of p_0' to p_0' + 100 kN/m² of between 0.3 and 11.0 m²/year. The coefficient of volume compressibility (m_v), over the same stress range, varies between 1.392 and 2.879m²/MN.

A single one-dimensional oedometer test on clay within the Made Ground revealed a variation in the coefficient of consolidation (c_v) over the pressure range of p_0' to p_0' + 100 kN/m² of between 9.9 and 15.0 m²/year. The coefficient of volume compressibility (m_v), over the same stress range, was between 0.081 and 0.278m²/MN. A plot of the applied load against voids ratio for all of these samples can be seen on Figure 15.

Based upon a maximum layer thickness of 1.9m within the Made Ground, it has been calculated that primary consolidation of the peat layers will be of the order of 350mm to 420mm, based upon a maximum thickness of fill to be placed of around 4.0m. In addition it has been assumed that there will be a further 75mm to 250mm associated with settlement of the clay deposits within the Made Ground. It is anticipated that these settlements will be substantially complete by the end of the three-year construction period.

Calculations on the secondary compression of the peat deposits within the Made Ground indicate a maximum settlement over a 100-year period of between 190mm and 230mm.

7.3.2. Bog Sequence - Peat Deposits

Peat was encountered in boreholes BH2, BH3, BH6, BH7, BH8, BH9, BH18 and BH19. The extent of the peat beneath the site was confirmed by studying the borehole records included within the BP Llandarcy Remedial Action Plan - Tip Closure and Completion Strategy Report produced by URS in 2006.

Figures 8 and 9 indicate the possible extent of the peat remaining under the site and superimposed on aerial photographs of the site. These indicate a reasonably widespread area of peat beneath the site. Figure 10 shows a wider aerial photograph of the Llandarcy area and indicates that the Crymlyn Bog is part of a much wider historic delta.

Standard Penetration Tests revealed SPT 'N' values of between 3 and 4. There was one result of 35, however this test penetrated an old tree branch. A plot showing the distribution of all SPT N values against depth is included as Figure 11.

The results of the unconsolidated undrained triaxial tests carried out on samples of the natural peat indicate undrained shear strengths of between 15 kN/m² and 34 kN/m², with one anomalous of 107 kN/m². These results indicate that the peat is generally very soft to soft and are included on Figure 12.

One-dimensional consolidation testing on the peat has revealed a variation in the coefficient of consolidation (c_v) over the pressure range of p_0' to p_0' + 100 kN/m² of

between 0.48 and 12.0 m^2/year, with the coefficient of volume compressibility (m_v), over the same stress range, varying between 0.496 and 2.311 m^2/MN. These m_v values are slightly less than the values for peat within the Made Ground and may be as a result of initial consolidation of the layer due to the fill already tipped across the site.

Figure 15 is a plot of voids ratio against effective pressure and shows the great variability in the compressibility of the peat.

The properties of peat are dependent on a wide range of factors that tend to be localised. However, for restoration of the Tip at Llandarcy, the principal consideration will be the degree of settlement.

On loading, free water in the peat is forced out under hydrostatic pressure. Since the peat is initially quite permeable, with high moisture content, the magnitude of settlement is large whilst the period of initial settlement is very short, possibly a matter of days. After this, settlement proceeds at a much slower rate as the permeability of the peat decreases due to the large decrease in volume. During this period the additional load is transferred from the pore water to the solid peat mass.

Secondary consolidation is dependent on the type of peat, with two extreme types recognised. Amorphous peat exhibits an exponential increase in strain with incremental loading, whilst that for fibrous peat is linear. For amorphous peat the water adsorbed around the soil particles becomes highly viscous and the peat behaves more like clay with the particles blocking the vegetable fibres reducing the permeability. In fibrous peat consolidation occurs as the water in the micro-pores of the decomposing vegetation material drains extremely slowly into the macro-structure of the peat. Because of its higher permeability the rate of primary consolidation of a fine fibrous peat is higher than that of an amorphous granular peat. Examples have been given where embankments on peat have recorded continuous settlements lasting over 80 years.

Improved drainage has no beneficial effect on the rate of consolidation. This is because efficient drainage can only accelerate the completion of primary consolidation, which is completed rapidly in any case.

Using an assumed maximum layer thickness of 2.5m for natural Peat, it has been calculated that primary consolidation of the peat layers will be of the order of 340mm to 440mm, based upon a 4.0m additional thickness of fill. It is anticipated that these settlements will be complete by the end of the two to three-year construction period.

Calculations for secondary compression of natural Peat indicate ongoing settlements over a 100-year period of between 125mm and 225mm.

The effect of these settlements on the hydrocarbon drainage system and the attenuation ponds will depend on the final scheme layout. Therefore, provision should be made to allow for rapid initial consolidation and ongoing secondary compression. This consolidation may also result in the movement of contaminated water from both the Made Ground and the Peat, which may temporarily overload the system.

7.3.3. Bog Sequence - Organic Clays, Sands and Gravels

The remainder of the Crymlyn Bog sequence has an irregular occurrence across the site, possibly indicating localised erosional and depositional environments during formation.

Standard Penetration Tests were carried out in all three soil types, with SPT 'N' values for the clays of between 3 and 25, with one result of 40 possibly due to the sampler encountering wood. One test in the sand gave an SPT 'N' value of 8 and tests in the gravels indicated SPT 'N' values of between 9 and 22. The results are plotted on Figure 11.

Laboratory testing on one sample of the Bog Sequence indicated a moisture content of 21%, a liquid limit of 25% and a plastic limit of 16%, with a consequent plasticity index of 9%. The result is shown on the Casagrande chart as Figure 12 and indicates the material to be low plasticity clay.

The variation of Moisture Content, Liquid Limit and Plastic Limit with depth is included on Figure 13, which shows the moisture content to be 5% in excess of the plastic limit.

One particle size distribution, carried out on a cohesive sample of the Bog Sequence showed a material comprising 9% gravel, 35% sand, 41% silt and 15% clay. The grading curve for this sample is shown on.

Four particle size distributions carried out on samples of the Gravels have shown a variation of 10% to 26% fines (Clay and Silt combined), 27% to 58% Sand, 60% to 87% Gravel and 13% to 40% Cobbles. These grading curves are shown on Figure 16.

A single triaxial test carried out on a sample of clay from the Crymlyn Bog Sequence showed an undrained shear strength of 4 kN/m², indicating a very soft clay.

A single one-dimensional consolidation test was carried out on a sample of clay from the Crymlyn Bog Sequence and indicated a coefficient of consolidation (c_v) over the pressure range of p_0' to p_0' + 100 kN/m² of between 4.2 and 1.1 m²/year, with a coefficient of volume compressibility (m_v), over the same stress range, of between 1.581 and 0.693 m²/MN.

Figure 15 includes plots of voids ratio against effective pressure for the clay of the Crymlyn Bog Sequence.

The Bog Sequence has been shown to be present in varying thicknesses below the site. The variation of materials within this stratum will greatly affect the settlement likely to be expected. Consolidation calculations indicate likely settlements within the clays and silts may vary between 75mm and up to 400mm, depending upon the thickness of the material and the presence of organic material within the clay. Settlements within the gravels are likely to be small, no greater that 25mm to 50mm and it is anticipated that these will be built out during construction.

7.3.4. Glacial Till

The extent of this deposit below the site was irregular and was underlain by Glacial Gravel where it was fully penetrated. This suggests that Glacial Till was deposited after the Glacial Gravels and was partially eroded by glacial outwash or river channels.

Standard Penetration Tests carried out within the boreholes gave SPT 'N' values of between 11 and 50*. A plot of SPT N value against depth is presented on Figure 11, which shows a trend of SPT 'N' value increasing with depth with occasional very high 'N' values. SPT 'N' values within the Glacial Till have been converted to undrained shear strengths, based upon the work of Stroud[9], using the following formula:

$$c_u = f_1 \times N$$

where f_1 = 5.7 kN/m², the average value for Glacial Till (Boulder Clay). This gives the undrained shear strength values of between 63 kN/m² and 285 kN/m², indicating a firm to very stiff material. These results are plotted on Figure 17 and indicate an overall trend of increasing strength with depth.

Laboratory testing on a five samples of Glacial Till indicated moisture contents between 7.5% and 16%, liquid limits 21% and 26% and plastic limits between 13% and 17%, with a consequent plasticity index of between 6% and 9%. A Casagrande Chart is included as Figure 12 and indicates this material to be a low plasticity clay/silt.

The variation of Moisture Content, Liquid Limit and Plastic Limit with depth is plotted on Figure 13, which shows the moisture contents to be 1 to 6% less that the plastic limit.

Stroud's work on SPT N values in clays also included an assessment of the relationship between the coefficient of volume compressibility (m_v) and N values. The relationship can be estimated using the following formula:

$$m_v = 1 / (f_2 \times N)$$

where f_2 = 450 kN/m², a lower bound value for Glacial Till (Boulder Clay), based on the low plasticity index values derived from the laboratory testing. This gives rise to a variation of the estimated coefficient of volume compressibility (m_v) of between 0.202 and 0.044 m²/MN. A plot showing the variability of the estimated m_v values is included as Figure 18. Calculations indicate that settlements within the Glacial Till may be of the order of 50mm to 125mm.

* To determine the SPT N value, BS5930[5] requires the SPT split spoon sampler or CPT cone in gravel, to be driven a total distance of 450mm using a 63.5kg drop weight. The number of blows is recorded for each 75mm increment. The blows for the first 150mm (seating blows) are discarded and the SPT N value is the total number of blows for the remaining 300mm. If the total blow count for this 300mm reaches 50 before full penetration is achieved, the depth of penetration is recorded.

7.3.5. Glacial Gravel

Where found, this was towards the base of the boreholes and appears to have been derived from the Pennant Sandstone Bedrock.

Standard Penetration Tests carried out within the boreholes gave SPT 'N' values of between 13 and 50. These results are plotted on Figure 11.

Four particle size distributions carried out on samples of the Glacial Gravel have shown a variation of 3% to 20% fines (Clay and Silt combined), 4% to 44% Sand, 43% to 97% Gravel and 3% to 57% Cobbles. The grading curves for these samples are shown on Graph 21.

8. SLOPE STABILITY

8.1. Existing Slopes

There are two major earthwork slopes within the Tip Area. The first forms the northern boundary between the Tip and Crymlyn Bog, onto which the haul road into the site has been constructed. This is up to 10m above the ground level within Crymlyn Bog. The second slope is located to the north of the sludge pits, towards the eastern extent of the site. The locations of each of these two slopes can be seen on Figure 2.

8.1.1. Haul Road

Borehole 17 was drilled at the eastern end of the haul road, whilst Borehole 15 was sunk midway along the haul road, adjacent to Area 2 of the Tip (see Figure 2). The haul road embankment is vegetated and has been constructed with a slope angle of around 30°. SPT 'N' values varied between 1 and 8, with an average of around 4, which could suggest that the material was loose tipped, with little controlled compaction. However, the granular nature of the material, generally described on the borehole logs as loose slightly sandy angular fine to coarse gravel, may have a angle of internal friction of around 32° to 35° as suggested in Craig (1987)[10]. This would suggest a slope angle of around 30° may be considered as reasonably safe.

8.1.2. Sludge Pit

The slope immediately to the north of the Sludge Pits is up to 5m high, with a slope angle of between 45° and 50°. Boreholes 12 and 19 were sunk close to the crest of the slope, with Borehole 18 located at the toe of the slope. BH12 and BH19 encountered very soft to soft brown and grey sandy gravelly Clay with occasional sandstone cobbles and bands of gravel. BH18 encountered medium dense sandy gravel and cobbles overlying peat and then gravel.

Discussions on site highlighted that China Clay (kaolinite) was used in the process to 'soften' lubricating oils and the waste residue was tipped in this area. SPT 'N' values were recorded between 0 and 50, although the average value was around 8, indicating loose material. The higher 'N' values may be due to the presence of blocks and fragments of rock and concrete. The long-term stability of the slopes adjacent to the Sludge Pits is not considered to be a problem, as the filling operations within the Tip will involve placement of material against these faces. To achieve suitable compaction of the fill material, it may be necessary to bench these slope faces.

8.2. Proposed Slopes

Currently it is proposed to source some of the material for the infill operations from other parts of the Llandarcy site. However, it may be necessary to import material is imported from external sources. Based upon standard earthwork practice, it is proposed that the final finished landform should not have slopes in excess of the angles given below.

Granular – Well-Graded Class 1A	32°
Granular – Uniformly-Graded Class 1B	30°
Cohesive (Class 2)	24°

The final slope angles of the proposed landform shall be confirmed by slope stability analysis.

Topsoiling of any slopes in excess of 30° may require a proprietary retaining system in order to prevent the soil from sliding off the face.

9. ACCEPTABILITY CRITERIA

As part of the restoration process, it has been agreed with the Environment Agency, that material derived from other areas of the refinery site may be re-used within the Tip, subject to adequate treatment prior to being placed. It is estimated that approximately 10,000m^3 to 15,000m^3 of material will be moved from its current location using conventional earthworks processes and placed in a controlled manner in the Tip.

The material, which is believed to conform to a Class 1B uniformly graded, general granular fill material in accordance with the Specification for Highway Works (SHW)[11], will be placed in layers up to 300mm thick and compacted in accordance with the 600 Series (Earthworks) of the SHW. The total thickness of fill to be placed will be up to a maximum of four metres thick.

10. PERMEABILITY

The landfill site has no comprehensive surface drainage system and rainfall will naturally infiltrate into the sub-surface strata. The variability of the Made Ground would indicate that there is no obvious barrier to water infiltration across the site. Following discussions with the Environment Agency it was agreed that the restored surface will be permeable, so that surface water will continue to infiltrate the soft landscaped surface. This will promote the movement of free product towards recovery wells, which will be maintained post restoration, as part of the preparation for the surrender of the waste licence, whilst also allowing the gradual, long-term degradation of any hydrocarbon product contained within the Tip.

Drainage ditches are present at the margins of the landfill to direct flow into interceptor chambers prior to discharge into the Crymlyn Bog Lagoon. However, these ditches receive flow from outside the tip area, and as such contain additional hydrocarbon contamination from elsewhere on the larger refinery site.

As part of the overall restoration of the Tip the peripheral containment ditch will be replaced with a permanent structure to provide a visually acceptable passive interception feature between the Tip and Crymlyn Bog. However, improvement to the structure, including detailed design, will form part of the overall drainage strategy for the wider Llandarcy Urban Village.

11. SUMMARY AND CONCLUSIONS

The results of the ground investigation confirm the findings of the previous environmental investigations, with the boreholes proving a sequence comprising the following:

- Made Ground derived from the refinery operations;
- Bog Sequence - Peat Deposits,
- Bog Sequence - Organic Clays, Sands and Gravels,
- Glacial Till,
- Glacial Gravel.

As a result of previous tipping operations across the site, a significant amount of consolidation within the natural peat is likely to have already occurred. It has been estimated that further settlements of 340mm to 440mm may occur within this layer due to the additional loading of the fill materials. In addition, secondary compression may be anticipated and is expected to last for a considerable period of time following primary consolidation phase. The magnitude of the secondary compression has been estimated at between 125mm and 225mm over the 100-year period following construction.

The ground investigation has indicated that the Made Ground also includes significant peat layers. This peat is likely to have been subjected to much lower vertical loading and therefore will have consolidated less. This was confirmed by the laboratory testing and calculations have indicated that settlements, due to the placement of fill, of 350mm to 420mm may occur in these peat layers. Secondary compression has been estimated at between 75mm and 250mm over the 100-year period following construction.

Based upon the nature of the peat, it is anticipated that the proposed timescale of 2 to 3 years for the restoration works will be sufficient for initial consolidation to have occurred. It is therefore recommended that monitoring of secondary consolidation should be carried out to assess ongoing settlements within the Tip.

Settlements are also anticipated within the remainder of the Bog Sequence and these have been estimated at between 75mm and 400mm within the clays and silts. Within the gravels, settlements of between 25mm to 50mm are anticipated.

Calculations indicate that settlements within the Glacial Till may be of the order of 50mm to 125mm. For the medium dense to dense Glacial Gravel, it has been estimated that settlements in the region of 10mm to 25mm may occur.

Within the Tip, the two major existing slopes do not exhibit any indications of current stability problems. On the north side of the site above Crymlyn Bog, the haul road is largely constructed of end-tipped colliery spoil and the side slopes are well vegetated. The slope angle of around 30° is sufficient, based upon the descriptions given on the borehole logs, to give a reasonable factor of safety against failure.

The China Clay slope above the Sludge Pit, which currently has a slope angle of around 45° to 50° is not considered to be a long term stability problem, as the filling operations will involve placement of material against these faces. To achieve suitable compaction of the fill material, it is recommended that these slope faces are benched.

The likely sources of fill from within the rest of the Llandarcy Oil Refinery site were not tested by the appointed site investigation contractor, due to concerns regarding the contamination of the samples. It is anticipated that the materials on site will conform to either a Class 1B General Granular fill or a Class 2 cohesive fill material.

However, due to the paucity of data on the likely engineering properties of the fill material, it is recommended that each source fill material brought into the Tip area from the remainder of the Llandarcy site is subject to a trial area, where the nature of the fill and the compaction requirements can be determined. All testing would have to be carried out in a laboratory that is able to carry out earthworks classification testing on potentially contaminated soil samples.

Excavations within the Made Ground are likely to be unstable and should be battered back or shored in accordance with the guidelines presented in CIRIA Report 97[12]. If battering to a safe angle is not possible due to space limitations, the excavation should be sheeted and propped to maintain safe working conditions.

The potentially large settlements of the strata below the Tip may have a significant effect on any hydrocarbon drainage system and the attenuation ponds. It is recommended that this system is designed to allow for potentially significant movements and is monitored throughout construction and for a significant period following completion of the work in the Tip, as 50% of the estimated secondary compression is likely occur in the 10 years following construction.

12. REFERENCES

12.1. Bibliography

1) URS Corporation Ltd. (2006). "BP Llandarcy Remedial Action Plan – Tip Closure and Completion Strategy".

2) T. Neville George. 1970. British Regional Geology. South Wales. Third Edition. National Environmental Research Council Institute of Geological Sciences. HMSO. London.

3) Thomas Telford Ltd (1993). "Site Investigation in Construction. Part 3: Specification for Ground Investigation".

4) Thomas Telford Ltd (1993). "Site Investigation in Construction. Part 4: Guidelines for the Safe Investigation by Drilling of Landfills and Contaminated Land".

5) British Standards Institution, BS 5930:1999. Code Of Practice For Site Investigation. HMSO. 1999.

6) British Standards Institution, BS 1377:1990, Part 2. Methods of Test for Soils for Soils for Civil Engineering Purposes, "Classification Tests". HMSO. 1990.

7) British Standards Institution, BS 1377:1990, Part 5. Methods of Test for Soils for Civil Engineering Purposes, "Compressibility, permeability and Durability Tests". HMSO. 1990.

8) British Standards Institution, BS 1377:1990, Part 7. Methods of Test for Soils for Soils for Civil Engineering Purposes, "Shear Strength Tests (total stress)". HMSO. 1990.

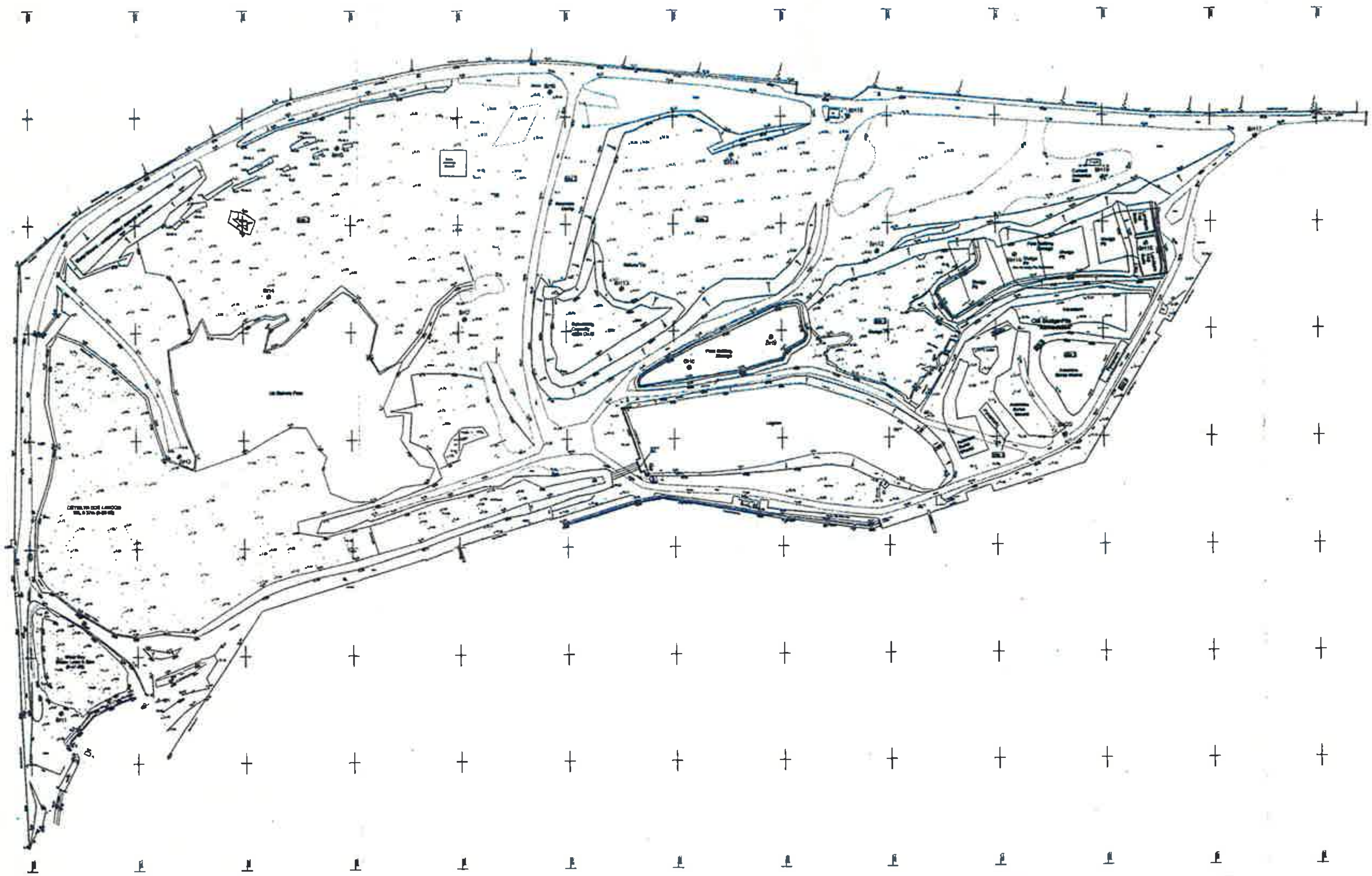
9) Stroud M A (1974). "The Standard Penetration Test in Insensitive Clays and Soft Rocks". Proceedings of the European Symposium on Penetration Testing, Stockholm.

10) Craig, R.F. (1987). "Soil Mechanics". 4th Edition. Published by Van Nostrand Reinhold (UK).

11) Highways Agency (2007). "Manual of Contract Documents for Highway Works, 1998, Volume 1. Specification for Highway Works, as amended 2007". HMSO.

12) Irvine, DJ & Smith RJH (1992), "Trenching Practice – CIRIA Report R97".

Drawing



Notes

Site	Material
1	Clean
2	Oily Solids and other Contaminated Material
3	Oil Sludge
4	Pyrophoric Contaminated
5	(Asbestos Only) Completely filled and capped [illegible]. Site marked accordingly - Part Site 5 to continue as a dump site for [illegible] only
6	Septic
7	New Site now designed as Asbestos Site

BP Oil Llandarcy Refinery Ltd.

CONSULTING ENGINEERS

URS

Bedford

Drawn	J.G.A.	Nov '07
Approved	J.G.A.	Nov '07
Scale	1:1000	A1

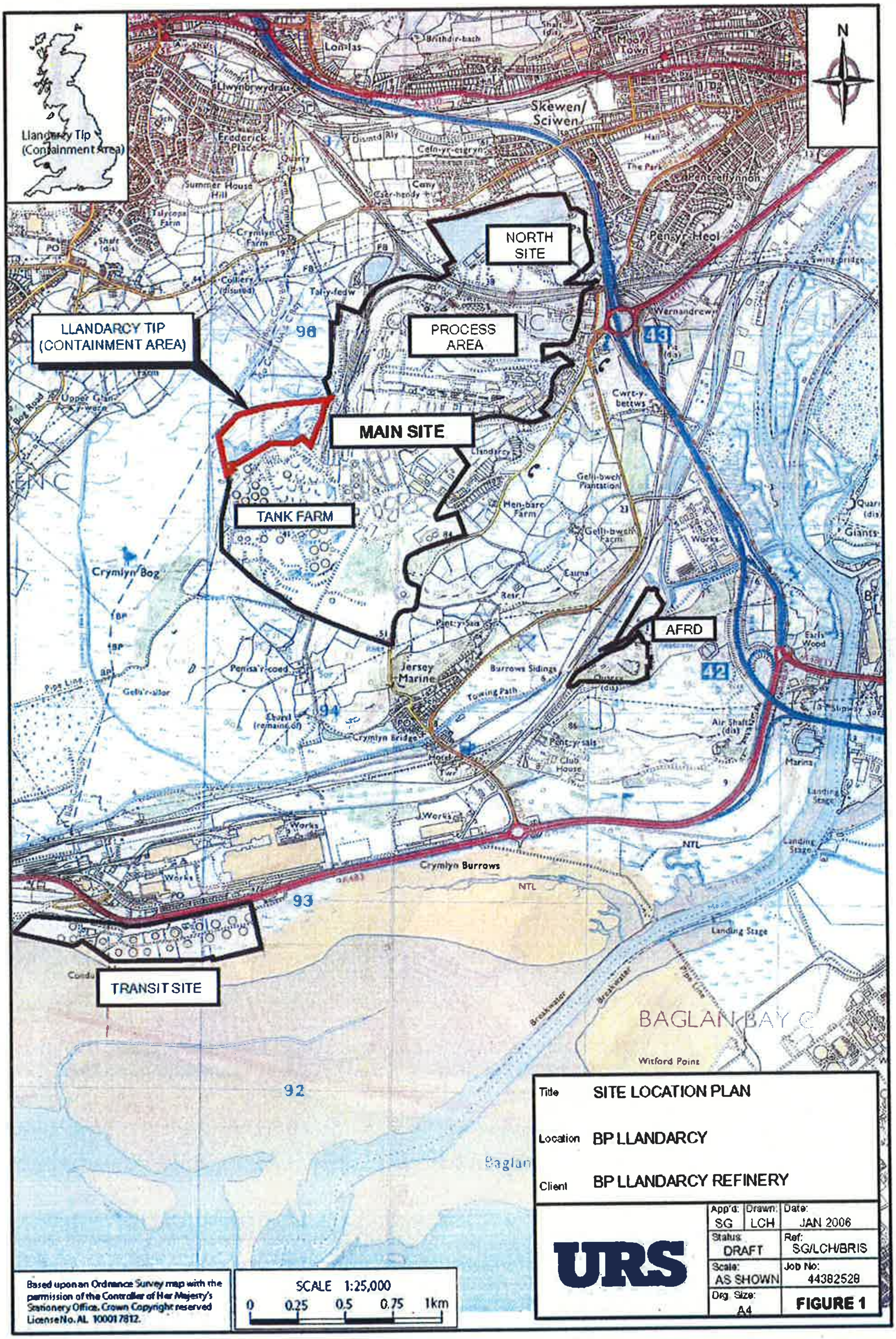
DIMENSIONS IN mm UNLESS STATED OTHERWISE. DO NOT SCALE

Llandarcy Tip Restoration

Exploratory Hole Location Plan

44382540/GI/3035/01

Figures

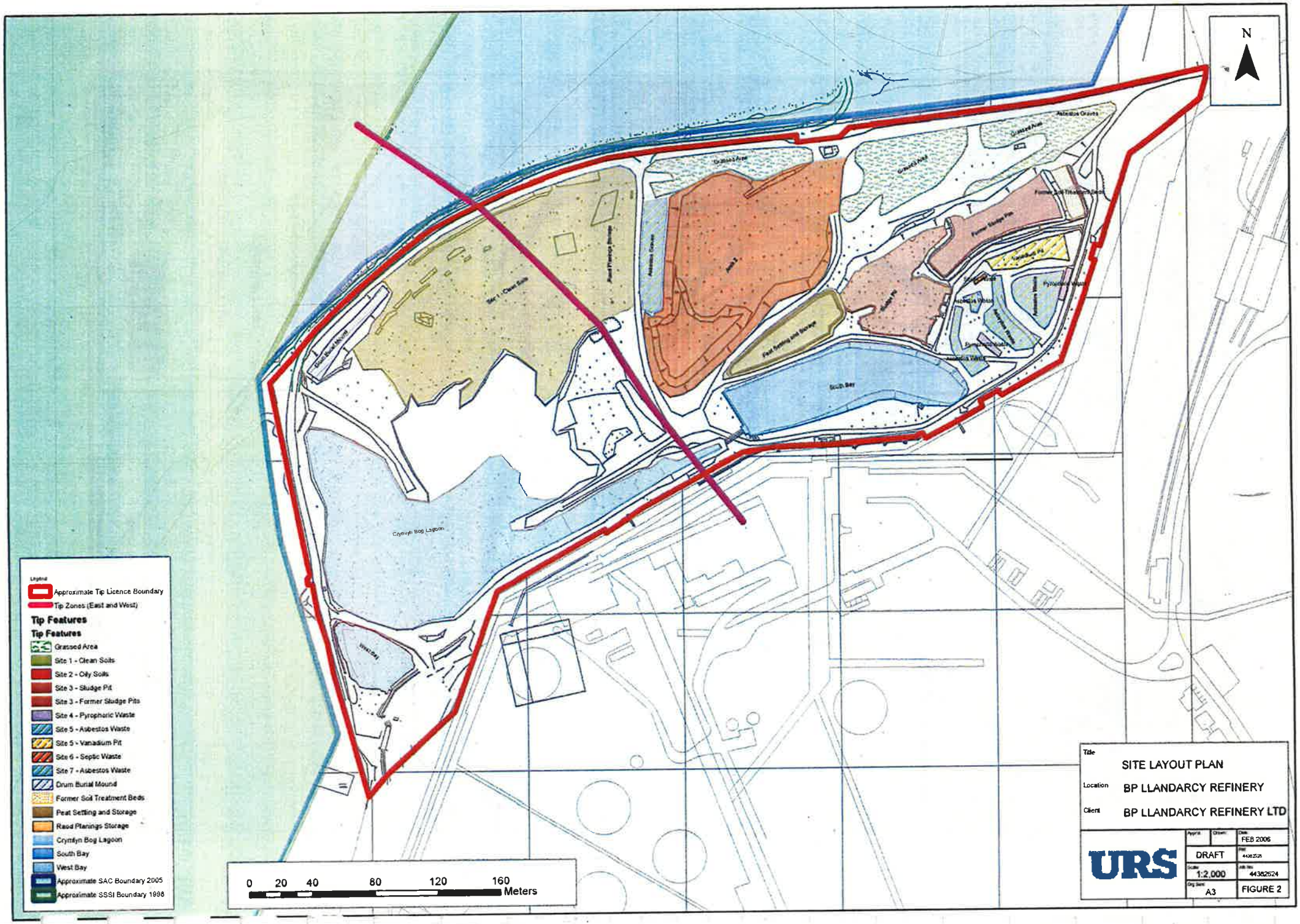


Based upon an Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office. Crown Copyright reserved LicenseNo. AL 100017812.

Title	SITE LOCATION PLAN	
Location	BP LLANDARCY	
Client	BP LLANDARCY REFINERY	

URS

App'd: SG	Drawn: LCH	Date: JAN 2006
Status: DRAFT		Ref: SG/LCH/BRIS
Scale: AS SHOWN		Job No: 44382528
Drg. Size: A4		FIGURE 1


N
Legend
Approximate Tip Licence Boundary
Tip Zones (East and West)
Tip Features
Tip Features
Grassed Area
Site 1 - Clean Soils
Site 2 - Oily Soils
Site 3 - Sludge Pit
Site 3 - Former Sludge Pits
Site 4 - Pyrophoric Waste
Site 5 - Asbestos Waste
Site 5 - Vanadium Pit
Site 6 - Septic Waste
Site 7 - Asbestos Waste
Drum Burial Mound
Former Soil Treatment Beds
Peat Settling and Storage
Raod Planings Storage
Crymlyn Bog Lagoon
South Bay
West Bay
Approximate SAC Boundary 2005
Approximate SSSI Boundary 1998
0 20 40 80 120 160
Meters
Title
SITE LAYOUT PLAN
Location
BP LLANDARCY REFINERY
Client
BP LLANDARCY REFINERY LTD
URS
DRAFT
FEB 2006
1:2,000
44382524
A3
FIGURE 2

1a

Tip Product Recovery Area

1b

Tip Product Recovery Area

2

Vanadium Pit (Pre-Capping)

3

Tip Product Recovery Area

4

South Bay Connection To Crymlyn Bog Lagoon

13

Area By Sludge Pit

12

Crymlyn Bog Lagoon (Southeast)

11

Crymlyn Bog Lagoon (Southwest)

10b

Crymlyn Bog Seperator

10a

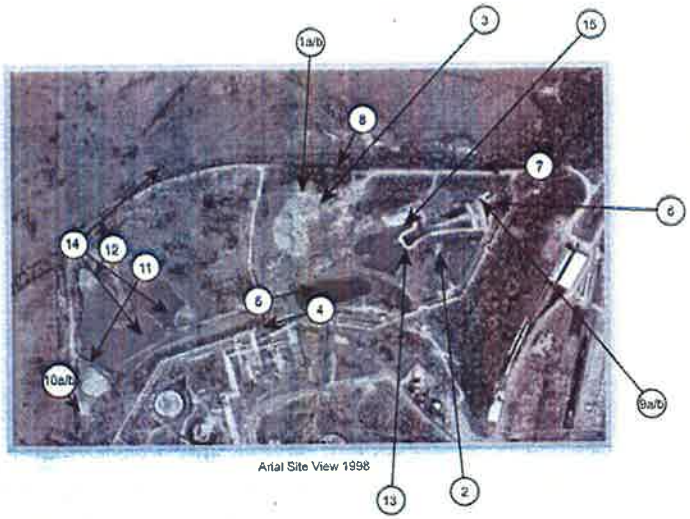
Crymlyn Bog Seperator

14

Panoramic View Of Crymlyn Bog Lagoon (In The Distance Is The Top Terrace Process Area (Centre), South Tank Farm (Right) and Northsea (Left)

15

Former Sludge Pit



Arial Site View 1998

9a

Exposure By Sludge Pit (Ash Bund)

9b

Close up Of Ash Bund

5

South Bay

6

View From MSMW034

7

MSMW033

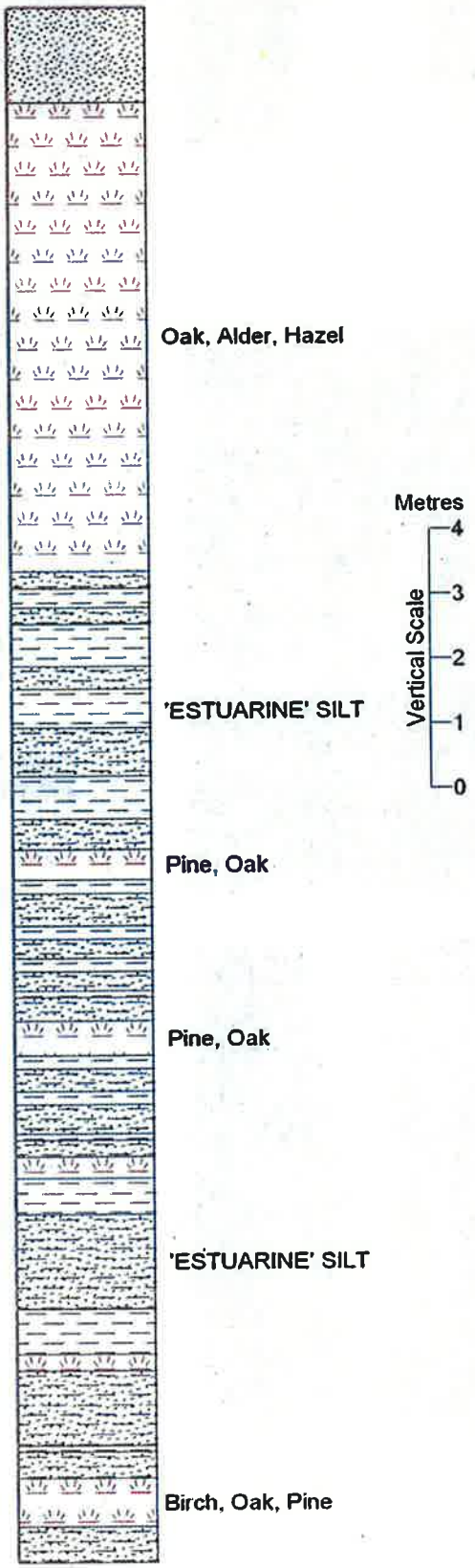
8

MSMW030

Title	PHOTOGRAPHS OF SITE AREA
Location	BP LLANDARCY
Client	BP LLANDARCY REFINERY

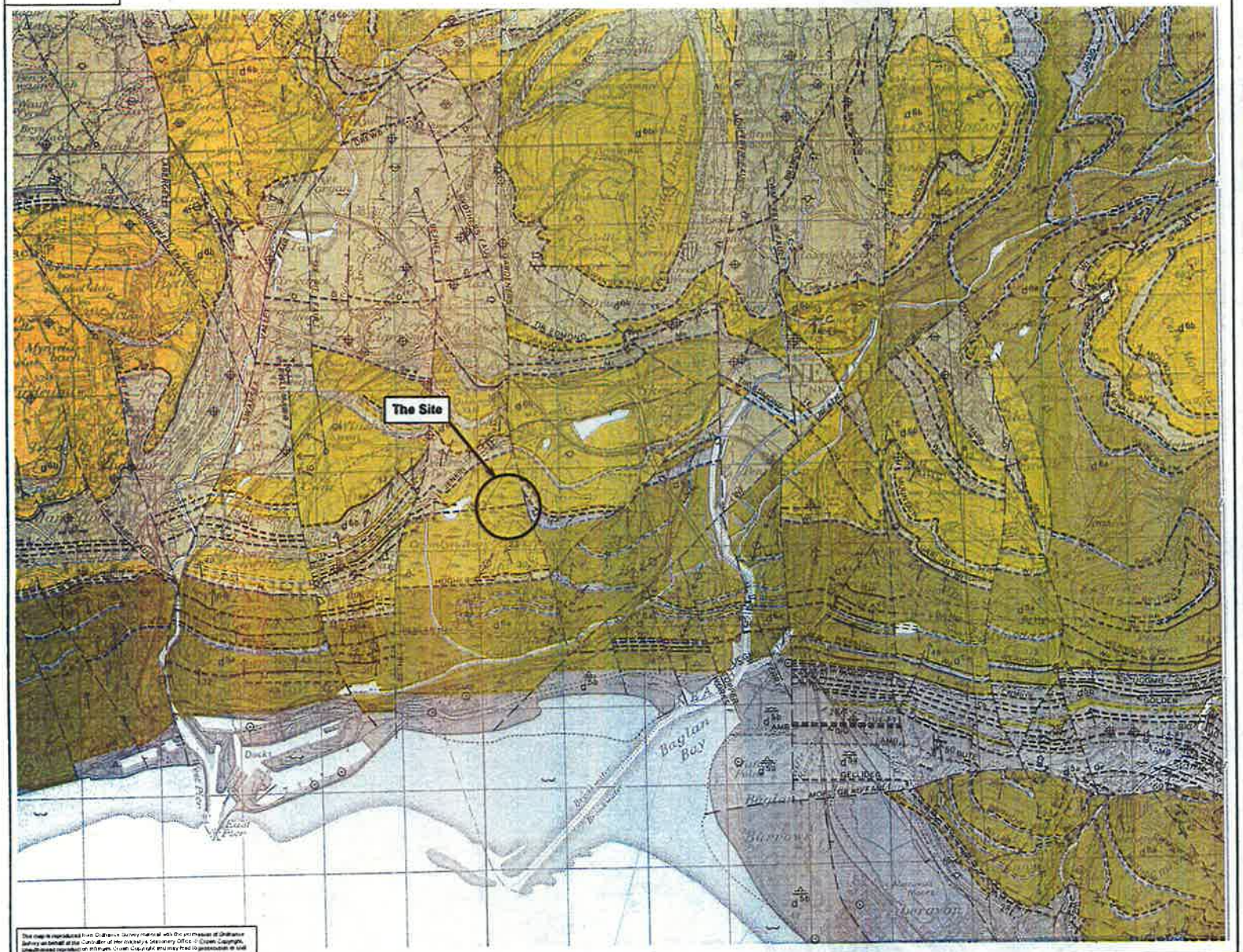
URS

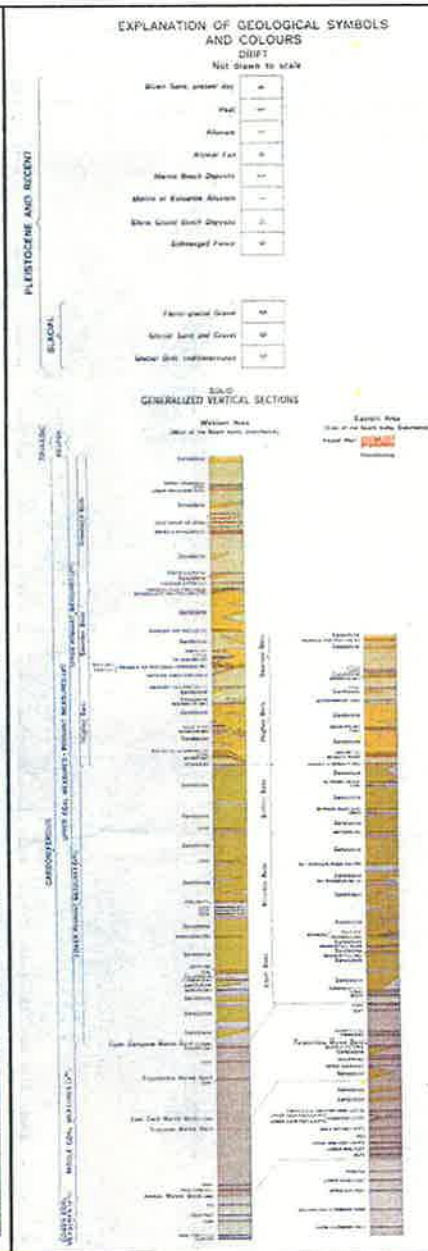
App'd: SG	Drawn: LCH	Date: JANUARY 2006
Status: DRAFT		Ref: SG/LCH/BRIS
Scale: AS SHOWN		Job No: 44382528
Drg. Size: A3		FIGURE 3



Client	Scheme		Drawn	Approved	
BP LLANDARCY REFINERY	LLANDARCY TIP RESTORATION	CONSULTING ENGINEERS URS	JGA	PAG	**Vertical representation of the submerged peat series for Crymlyn Bog**
			Checked CAB	Date DEC '06	
			Scale NTS		**Figure 4:**

Do Not Scale





Client	Rev	Drawn	Apprd	Date	Revision
BP Llandarcy Refinery Ltd.					

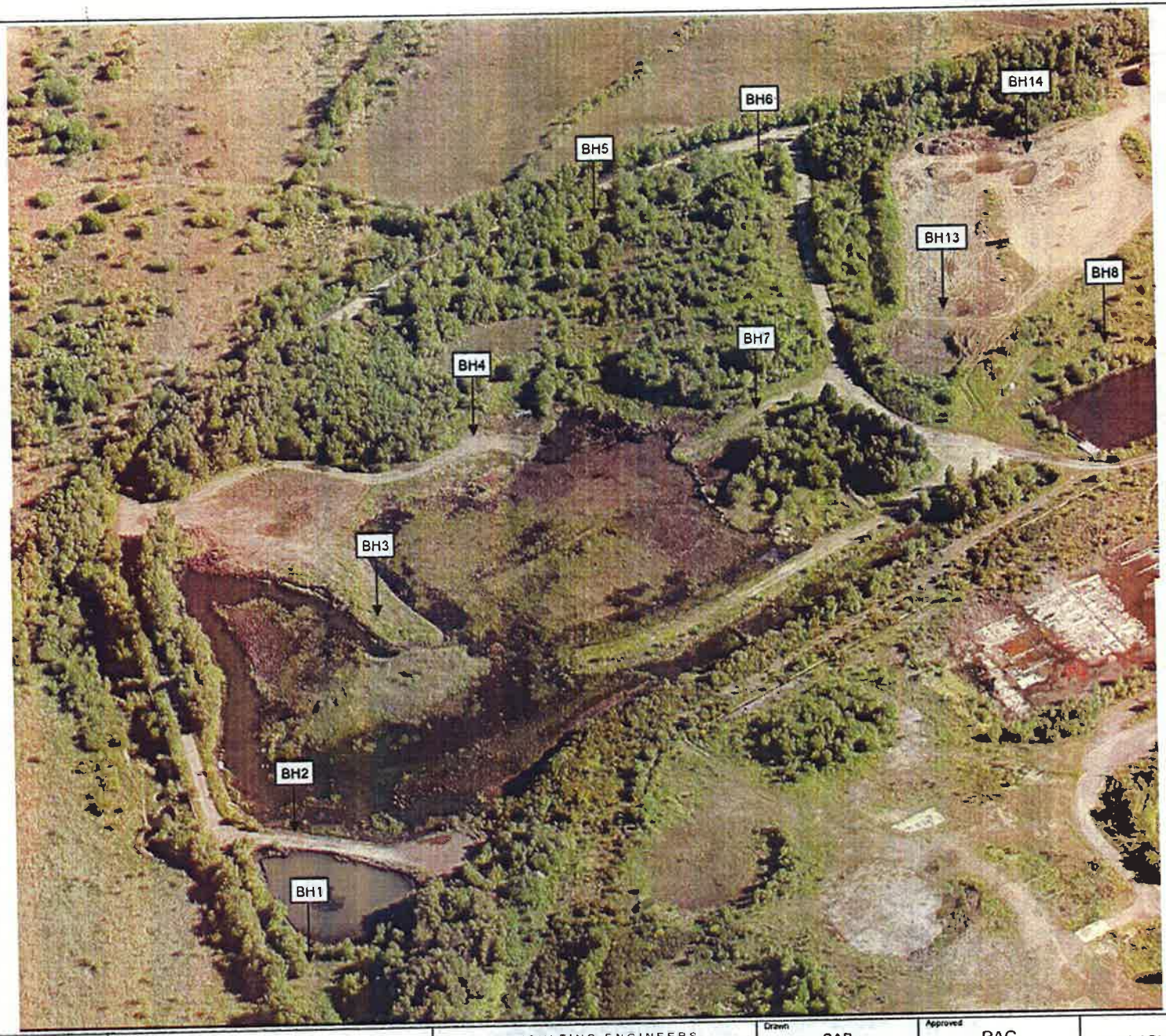
Contract: Llandarcy Tip Restoration

CONSULTING ENGINEERS
URS
URS House, Home Lane
Bedford, Bedfordshire, MK40 1TS
Tel: 01234 349641 Fax: 01234 216268 Email URS_Bedford@URSCorp.com

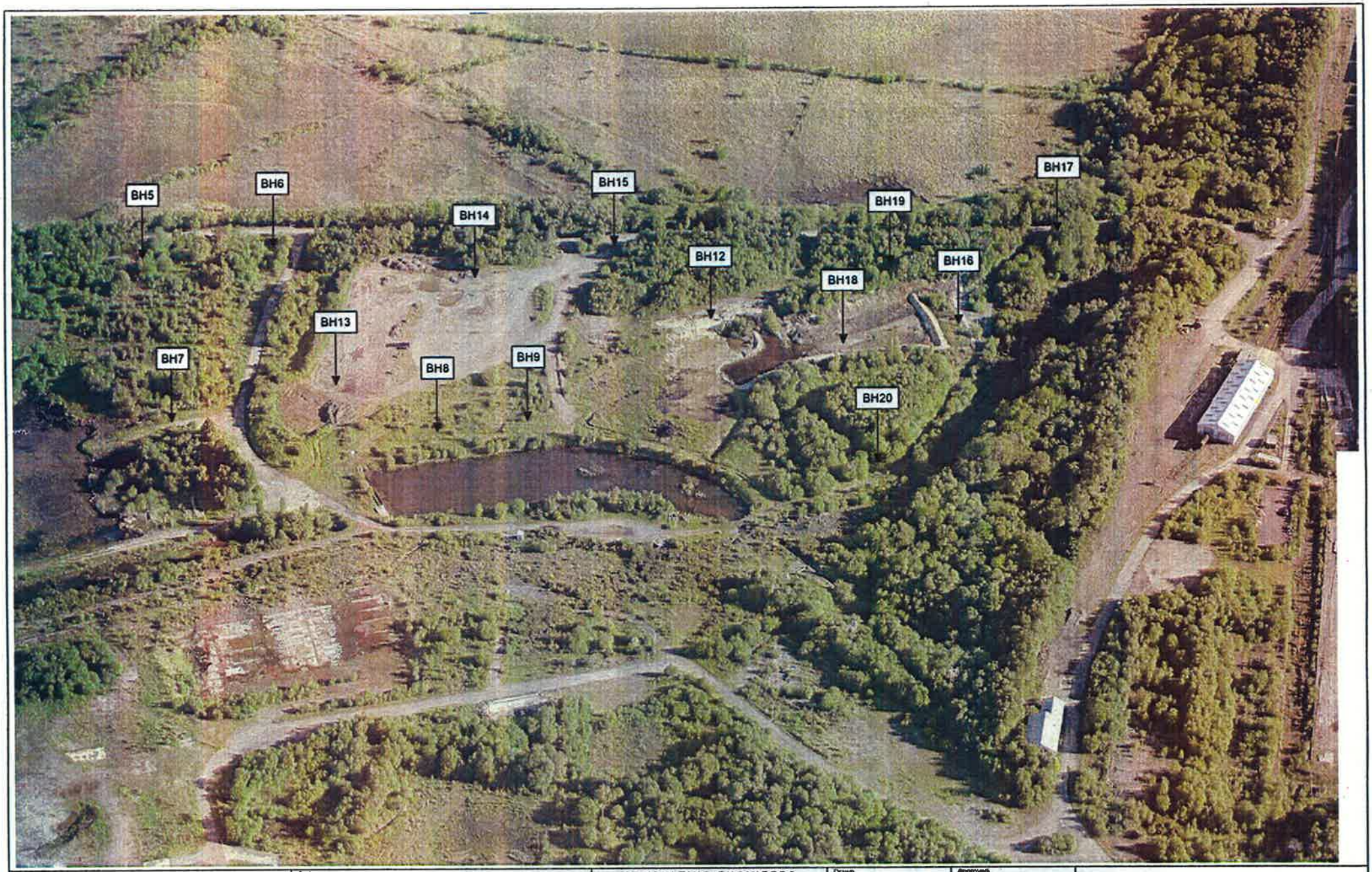
Drawn	Approved	Scale
JGA	PAG	1:50,000
Checked	Date	
CAB	Nov 2007	

Title: Geology Map

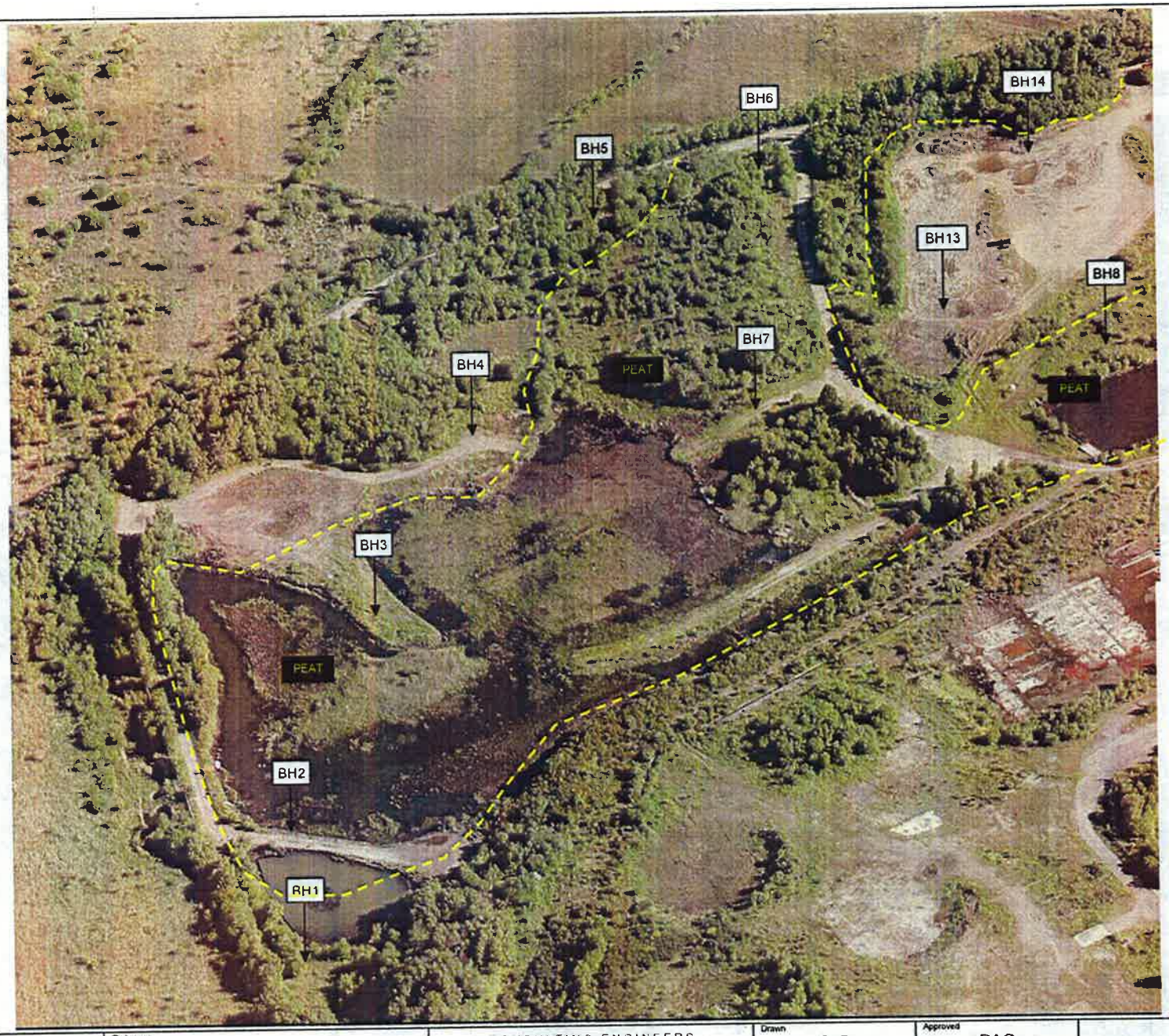
Figure No. 5 | Rev | Sheet A3



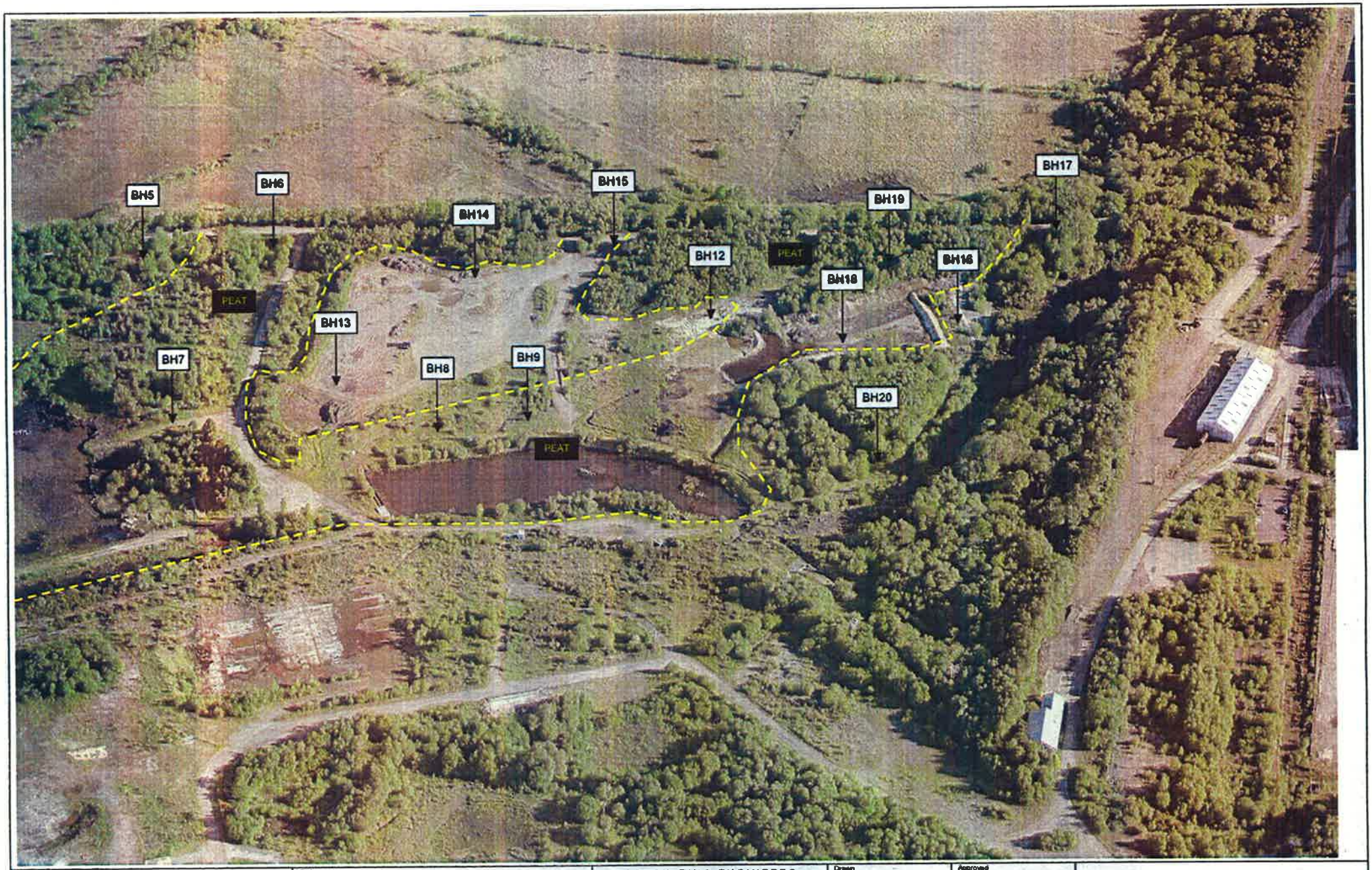
Client: BP LLANDARCY REFINERY	Scheme: LLANDARCY TIP REMEDIATION	CONSULTING ENGINEERS URS	Drawn: CAB	Approved: PAG	Aerial Photograph of western side of site showing exploratory hole locations
			Checked: RJW	Date: DEC '06	
			Scale: NTS		Figure 6



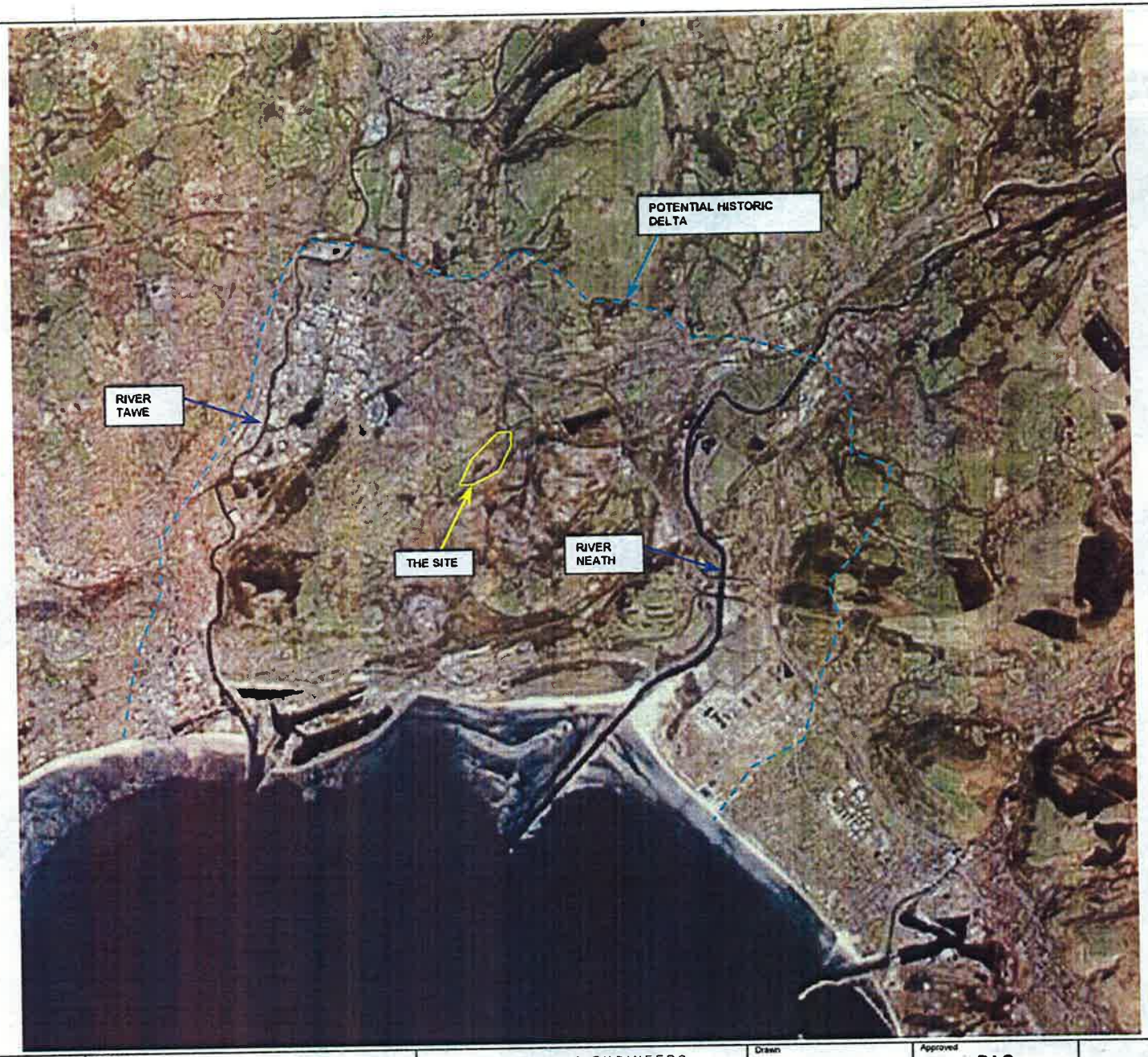
Client: BP LLANDARCY REFINERY	Scheme: LLANDARCY TIP RESTORATION	CONSULTING ENGINEERS URS	Drawn: JGA	Approved: PAG	Aerial Photograph of eastern side of site showing exploratory hole locations
			Checked: CAB	Date: DEC '07	
			Scale: NTS		Figure 7



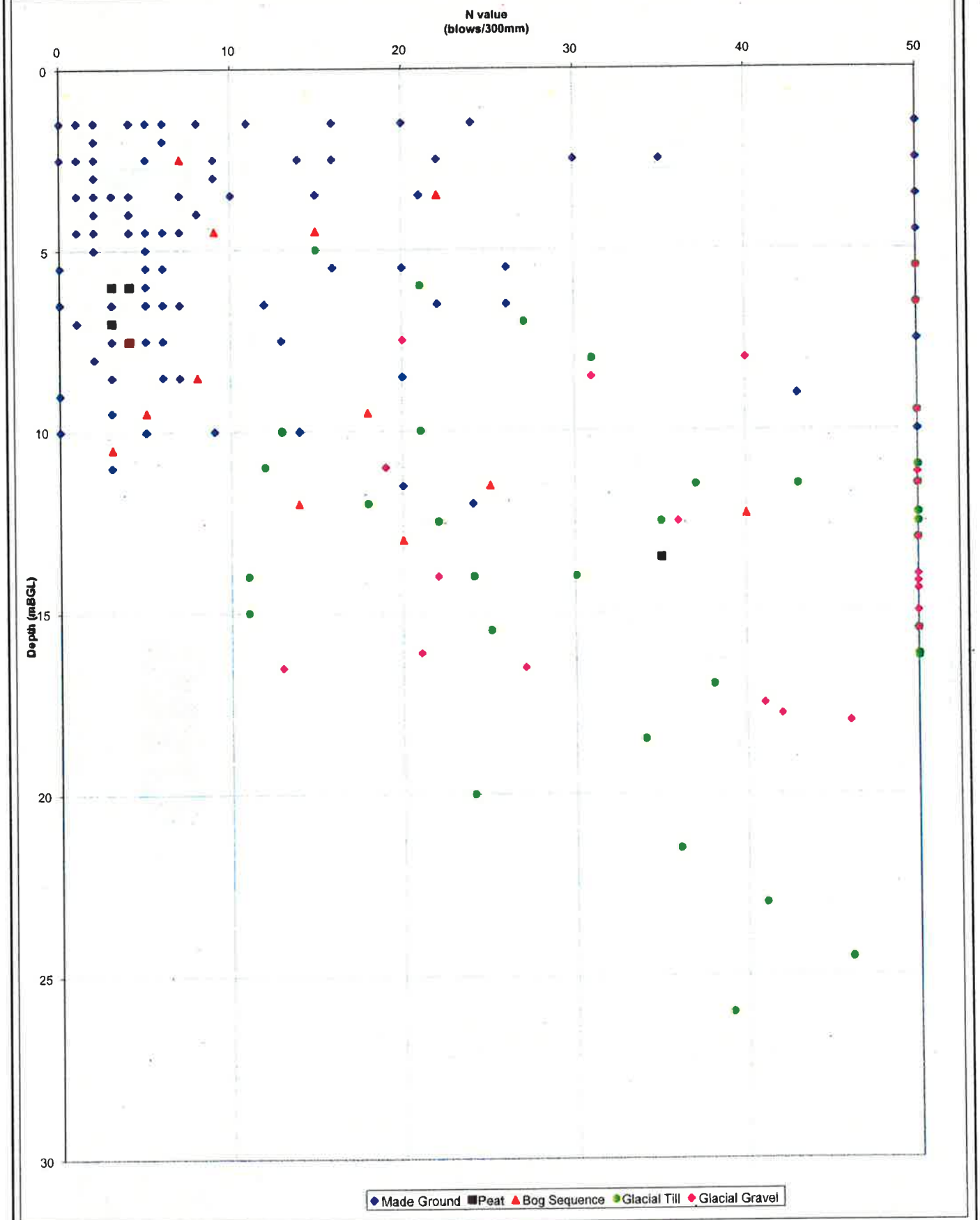
Client: BP LLANDARCY REFINERY	Scheme: LLANDARCY TIP REMEDIATION	CONSULTING ENGINEERS URS	Drawn: CAB	Approved: PAG	Aerial Photograph of western side of site showing inferred extent of remaining peat
			Checked: RJW	Date: DEC '07	
			Scale: NTS		Figure 8



Client: BP LLANDARCY REFINERY	Scheme: LLANDARCY TIP RESTORATION	CONSULTING ENGINEERS URS	Drawn: JGA	Approved: PAG	Aerial Photograph of eastern side of site showing inferred extent of remaining peat
			Checked: CAB	Date: DEC '07	
			Scale: NTS		Figure 9



Client: BP LLANDARCY REFINERY	Scheme: LLANDARCY TIP REMEDIATION	CONSULTING ENGINEERS URS	Drawn: JGA	Approved: PAG	Aerial Photograph indicating extent of historic delta below Llandarcy Site
			Checked: CAB	Date: DEC '07	
			Scale: NTS		Figure 10



BP LLANDARCY REFINERY

CONTRACT

LLANDARCY TIP RESTORATION

CONSULTING ENGINEERS

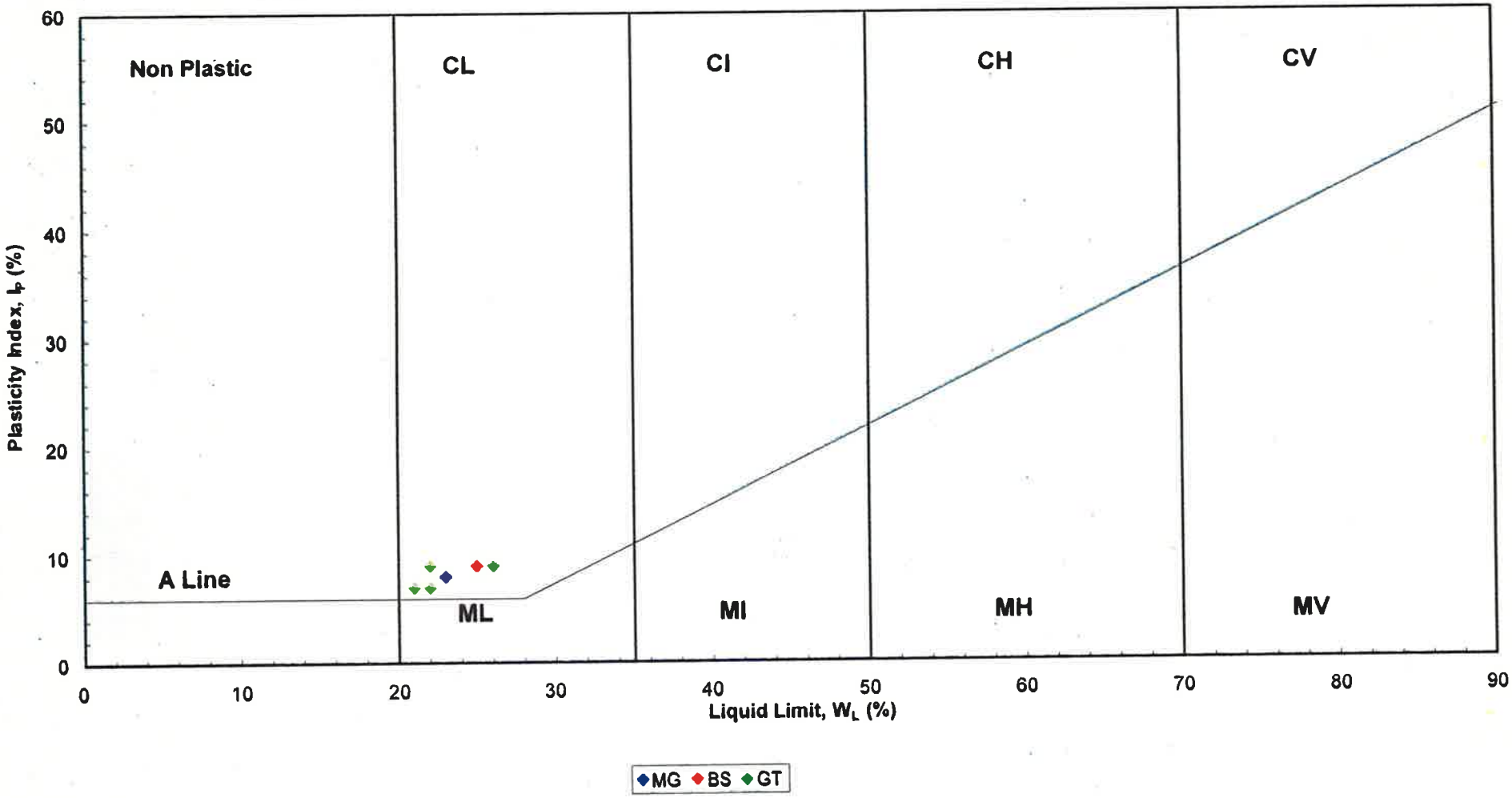
URS

URS Corporation Ltd, URS House, Home Lane
Bedford, Bedfordshire. MK41 1TS
Tel: 01234 349641, Fax: 01234 216268

DRAWING TITLE

SPT N Value vs. Depth

DRAWN JGA	SCALE N.T.S.	DATE AUG'06
TRACED N/A	CHECKED CAB	APPROVED PAG
FIGURE NO. 11		REV



BP LLANDARCY REFINERY

CONTRACT

LLANDARCY TIP RESTORATION

CONSULTING ENGINEERS

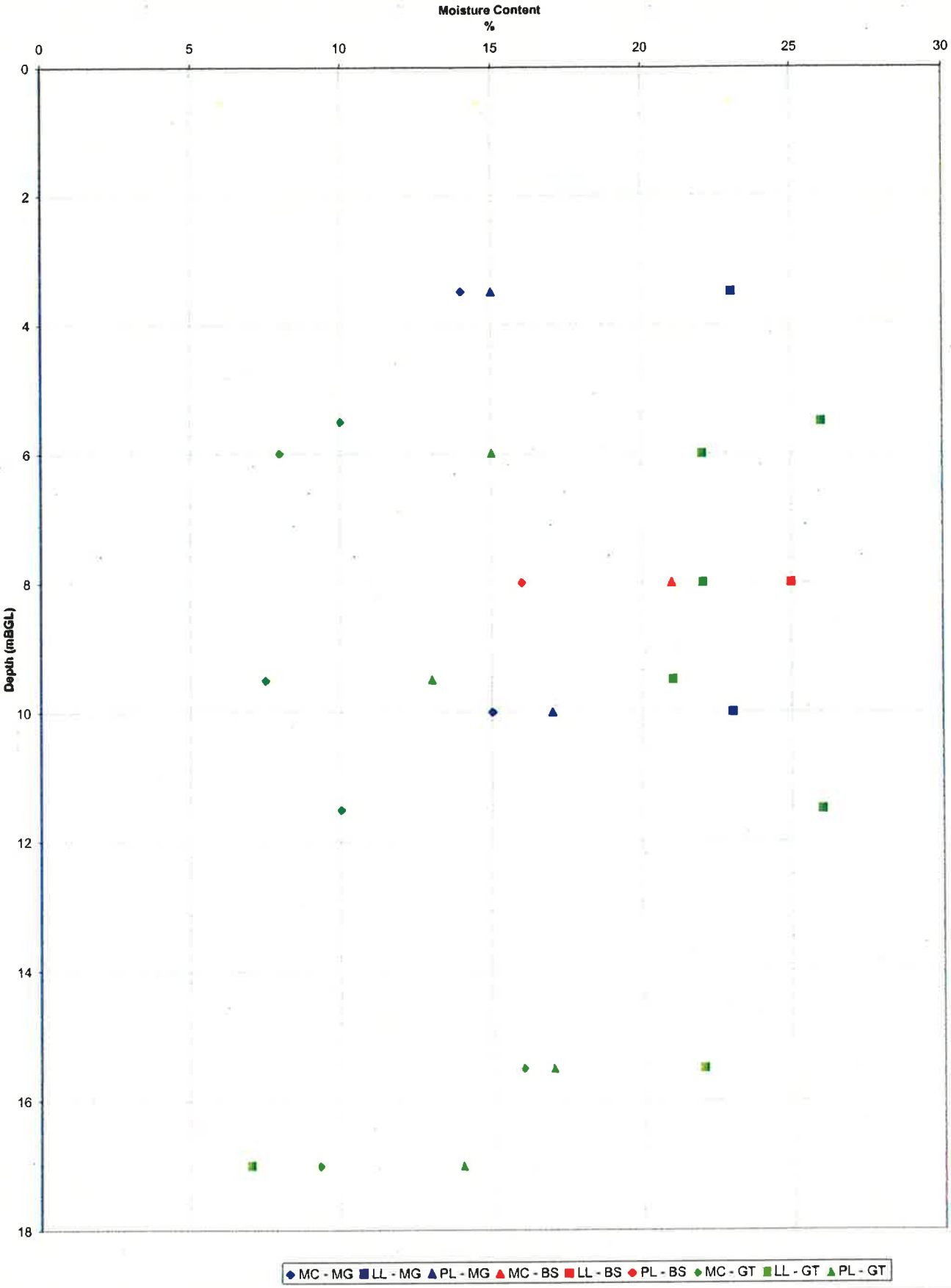
URS

URS Corporation Ltd, URS House, Horne Lane
Bedford, Bedfordshire. MK41 1TS
Tel: 01234 349641, Fax: 01234 216268

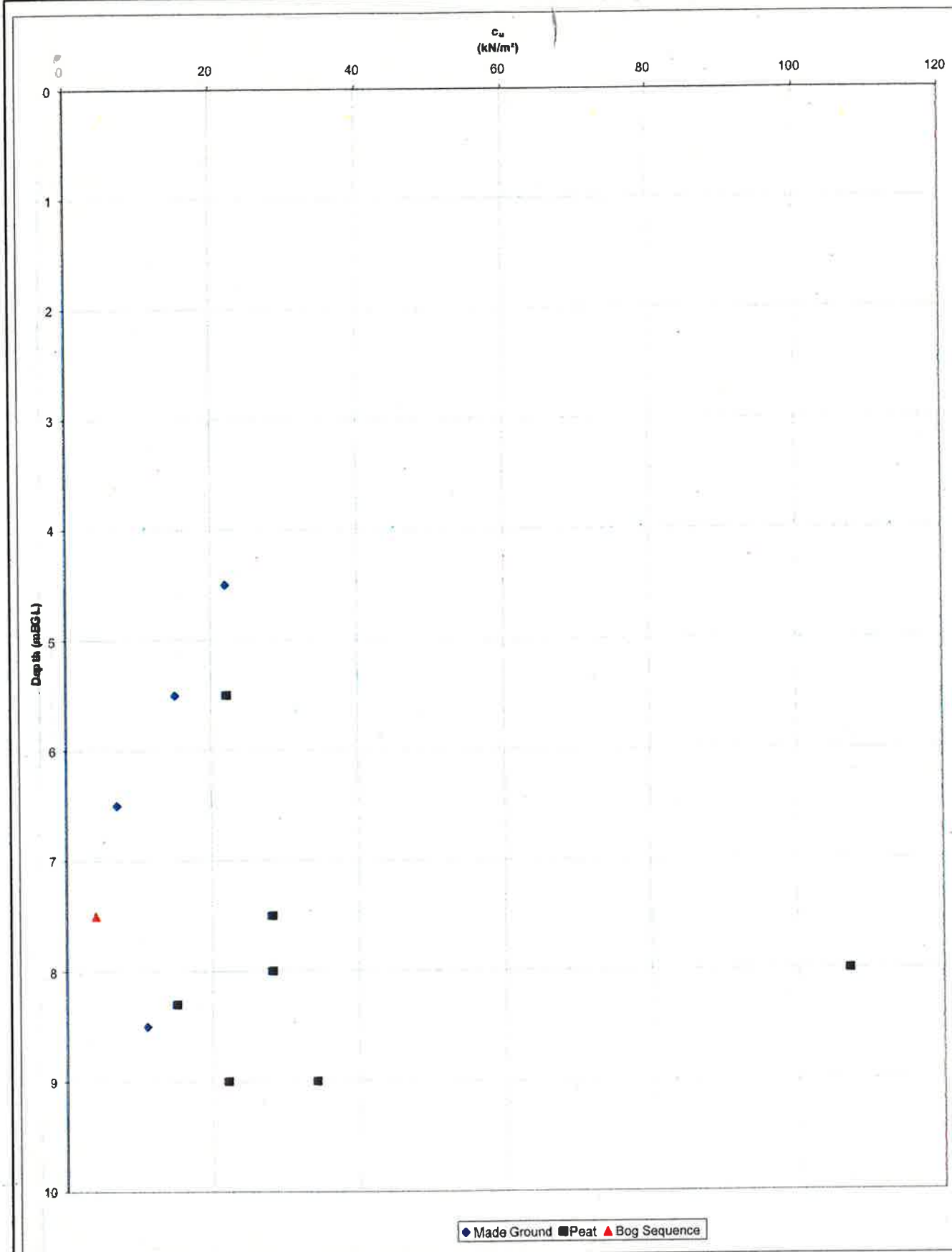
DRAWING TITLE

Casagrande Chart

DRAWN JGA	SCALE N.T.S.	DATE AUGUST'06
TRACED N/A	CHECKED CAB	APPROVED PAG
FIGURE NO. 12		REV



BP LLANDARCY REFINERY	CONSULTING ENGINEERS URS URS Corporation Ltd, URS House, Horne Lane Bedford, Bedfordshire. MK40 1TS Tel: 01234 349641, Fax: 01234 216268	DRAWING TITLE **Moisture Content, Liquid Limit and Plastic Limit vs. Depth**
CONTRACT LLANDARCY TIP RESTORATION		DRAWN PP | SCALE N.T.S. | DATE AUG'06 TRACED N/A | CHECKED CAB | APPROVED PAG FIGURE NO. 13 | REV



BP LLANDARCY REFINERY

CONTRACT

LLANDARCY TIP RESTORATION

CONSULTING ENGINEERS

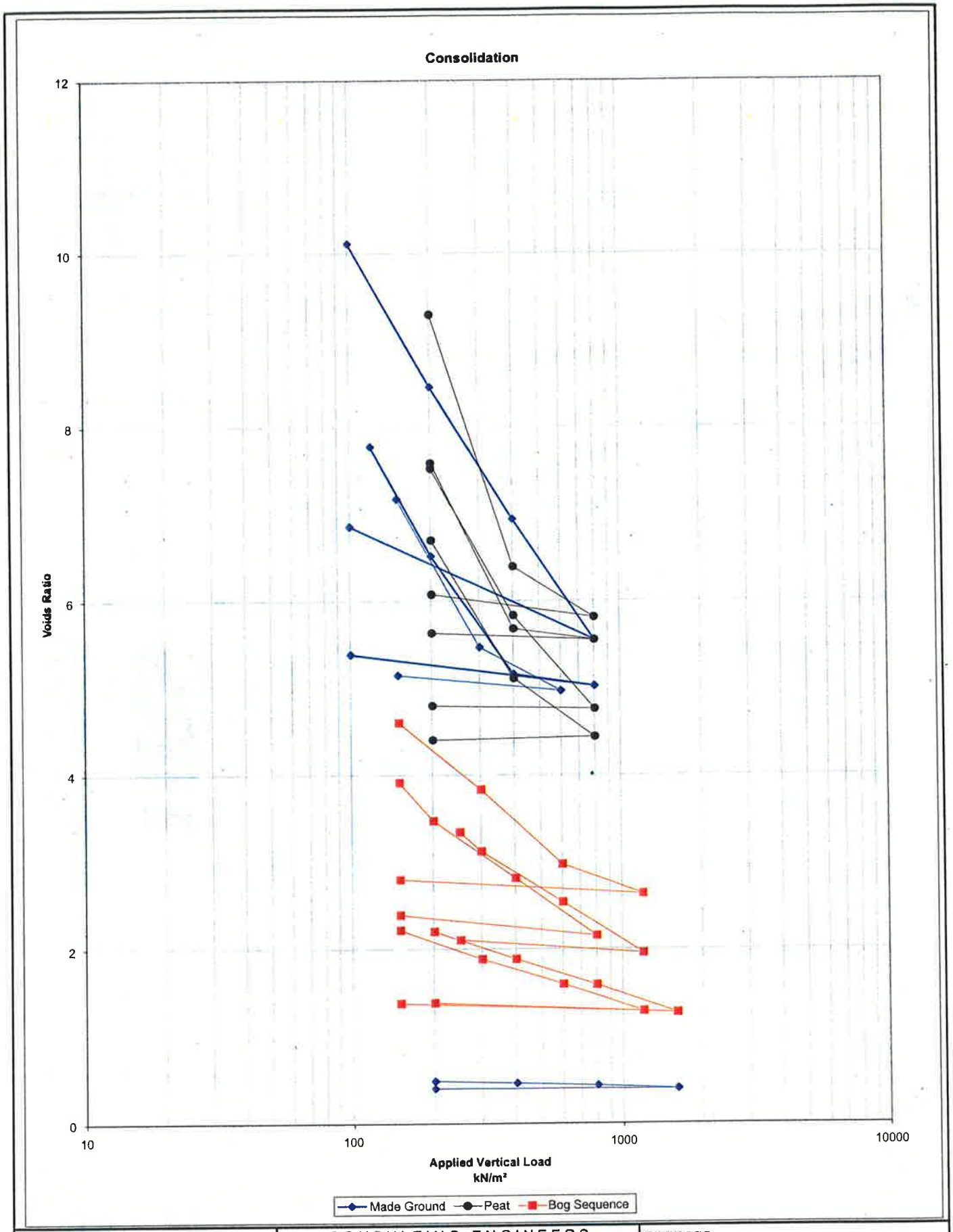
URS

URS Corporation Ltd, URS House, Home Lane
Bedford, Bedfordshire. MK41 1TS
Tel: 01234 349641, Fax: 01234 216268

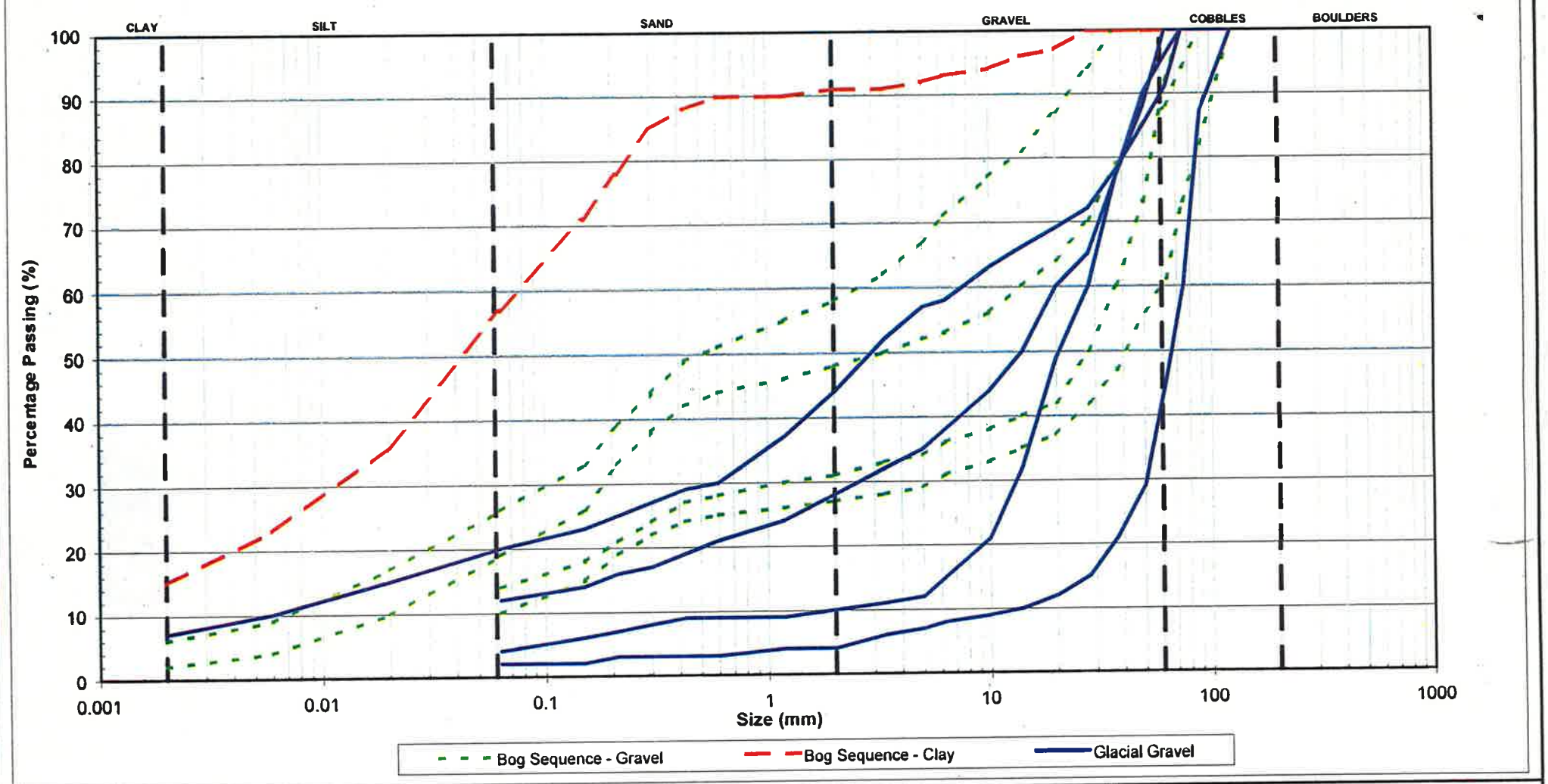
DRAWING TITLE

Undrained Shear Strength vs. Depth

DRAWN JGA	SCALE N.T.S.	DATE AUG'06
TRACED N/A	CHECKED CAB	APPROVED PAG
FIGURE NO. 14		REV



BP LLANDARCY REFINERY	CONSULTING ENGINEERS URS URS Corporation Ltd, URS House, Home Lane Bedford, Bedfordshire. MK41 1TS Tel: 01234 349641, Fax: 01234 216268	DRAWING TITLE One Dimensional Consolidation Tests
CONTRACT LLANDARCY TIP RESTORATION		DRAWN JGA · SCALE N.T.S. · DATE AUG'06 TRACED N/A · CHECKED CAB · APPROVED PAG FIGURE NO. 15 · REV



BP LLANDARCY REFINERY

CONTRACT

LLANDARCY TIP RESTORATION

CONSULTING ENGINEERS

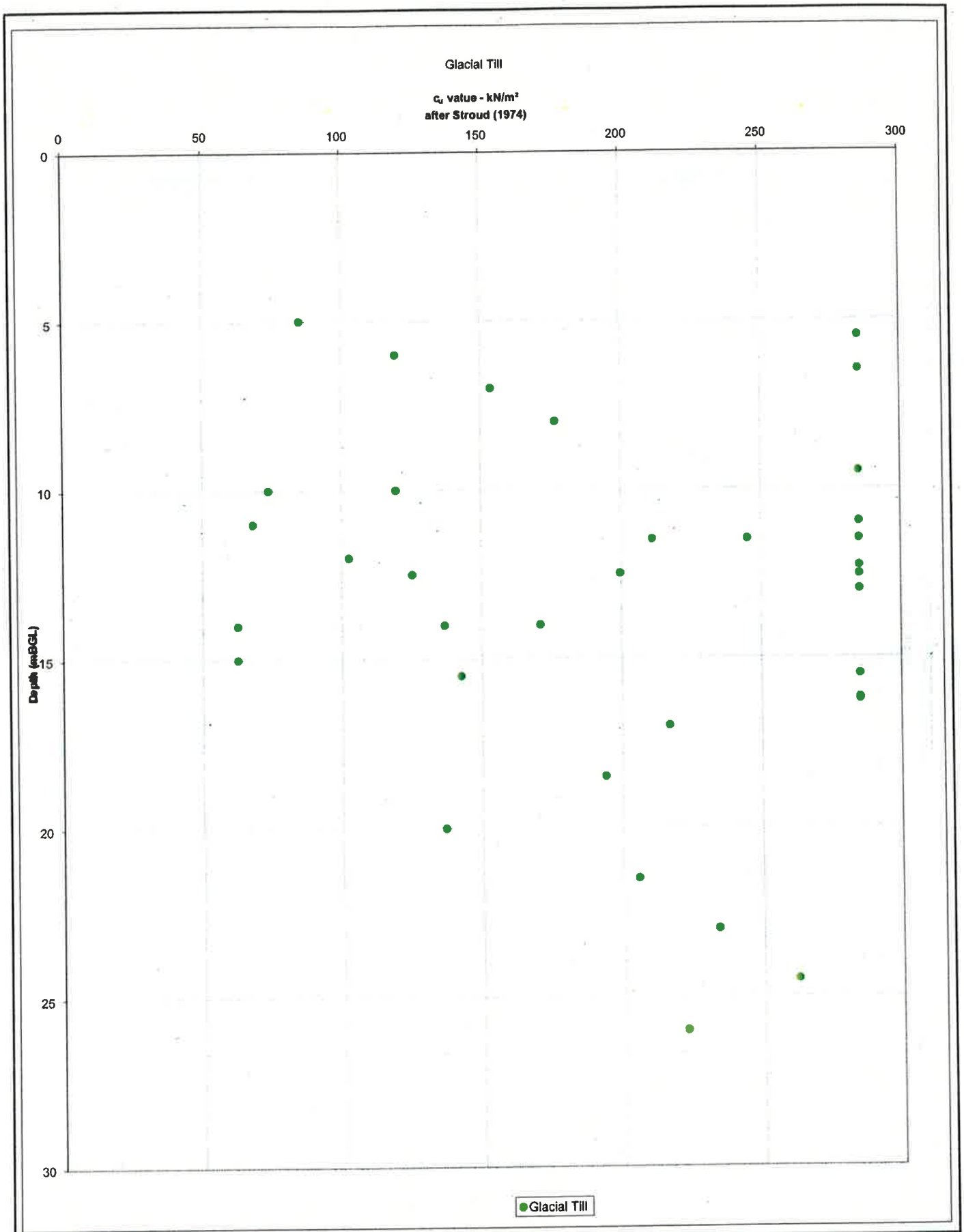
URS

URS Corporation Ltd, URS House, Horne Lane
Bedford, Bedfordshire. MK41 1TS
Tel: 01234 349641, Fax: 01234 216268

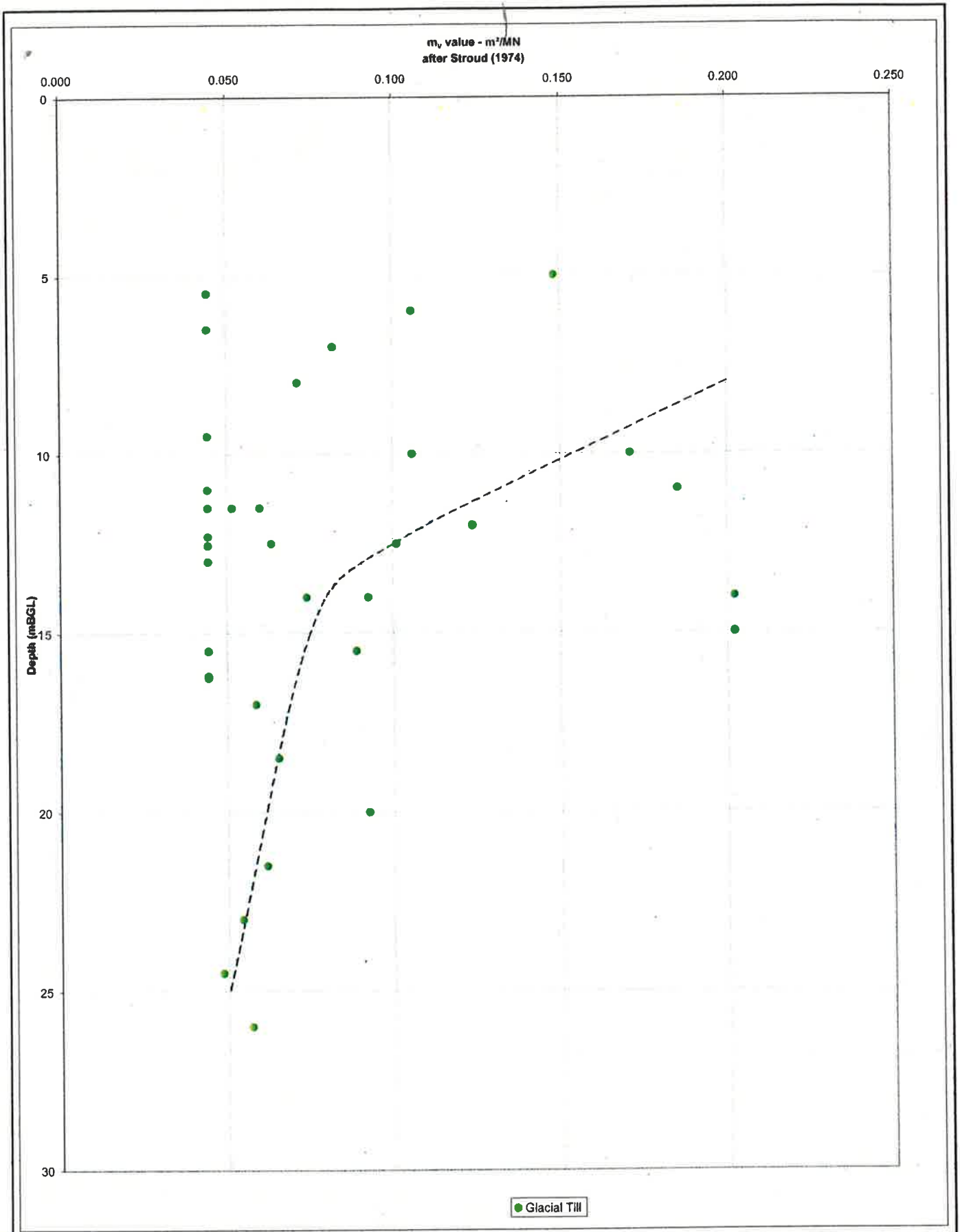
DRAWING TITLE

Particle Size Distribution

DRAWN JGA	SCALE N.T.S.	DATE AUGUST'06
TRACED N/A	CHECKED CAB	APPROVED PAG
FIGURE NO. 16		REV



BP LLANDARCY REFINERY	CONSULTING ENGINEERS URS URS Corporation Ltd, URS House, Horne Lane Bedford, Bedfordshire. MK40 1TS Tel: 01234 349641, Fax: 01234 216268	DRAWING TITLE Shear Strength from SPT N Value vs. Depth
CONTRACT LLANDARCY TIP RESTORATION		DRAWN JGA · SCALE N.T.S. · DATE AUG'06 TRACED N/A · CHECKED CAB · APPROVED PAG FIGURE NO. 17 · REV



BP LLANDARCY REFINERY	CONSULTING ENGINEERS URS URS Corporation Ltd, URS House, Home Lane Bedford, Bedfordshire. MK40 1TS Tel: 01234 349641, Fax: 01234 216268	DRAWING TITLE M_v from SPT N Value vs. Depth
CONTRACT LLANDARCY TIP RESTORATION		DRAWN JGA · SCALE N.T.S. · DATE AUG'06 TRACED N/A · CHECKED CAB · APPROVED PAG FIGURE NO. 18 · REV

Appendices

Appendix A – Borehole Logs

Borehole Log

Soil Mechanics

Drilled	RD	Start	12/06/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	14/06/2007	Dando 2000 Machine excavated trial pit GL - 1.50m. Light cable percussive methods 1.50 - 6.50m.	0.00m	6.50m	200mm	6.50m	Coordinates	-
Checked	HW								National Grid	-
									Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
0.00			12/06/2007	0800
1.50-1.80	B 1		12/06/2007 2.30	1700 damp
2.50-2.95 2.50-2.80	SPT C B 2	N=7 (3,4/2,1,2,2)	14/06/2007 2.50 2.30	0800 damp
3.50-3.95 3.50-3.80	SPT C B 3	N=22 (3,6/8,4,4,6)	3.50	
4.50-4.95 4.50-4.80	SPT C B 4	N=15 (1,4/3,4,4,4)	4.50	
5.50-5.91 5.50-5.80	SPT C B 5	50 (2,4/15,14,14,7 for 30mm)	5.50	
6.50-6.73	SPT C	50 (10,15 for 50mm/ 30,20 for 25mm)	6.50 14/06/2007 6.50	1700

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Black and brown clayey slightly sandy sub angular to sub rounded fine to coarse GRAVEL of sandstone with occasional sub angular to sub rounded cobbles of sandstone.	(1.20)		
Soft brown slightly sandy slightly gravelly CLAY with occasional sub angular to sub rounded cobbles of sandstone. (Oily sludge)	1.20 (2.30)		
Medium dense brown clayey sandy sub rounded to rounded fine to coarse GRAVEL of sandstone with many rounded cobbles of sandstone.	3.50 (1.80)		SP
Very stiff brown slightly sandy slightly gravelly CLAY with occasional rounded cobbles of sandstone. Gravel is rounded fine to coarse of sandstone.	5.30 (1.43)		
EXPLORATORY HOLE ENDS AT 6.73 m	6.73		

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
None observed (see Key Sheet)			

Depth Related Remarks *

From	to (m)	
0.60	3.50	Heavy hydrocarbon contamination below 0.60m.
0.80	2.30	Unidentified large obstruction, possibly timber, from 0.80m.
2.50	6.50	Water added to assist drilling

Chiselling

Depths (m)	Time	Tools used
0.80 -1.40	105 mins	Chisel
6.00 -6.50	60 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:55:01

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH1

Borehole Log

Soil Mechanics

Drilled JK Logged PL Checked HW	Start 15/06/2007 End 18/06/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated trial pit GL - 1.50m. Light cable percussive methods 1.50 - 13.00m	Depth from / to / Diameter / Casing Depth 0.00m / 7.50m / 200mm / 7.50m 7.50m / 13.27m / 150mm / 12.50m	Ground Level - Coordinates - National Grid - Chainage	

Samples and Tests					Strata		
Depth	Type & No	Records	Date Casing	Time Water	Description	Depth, Level (Thickness)	Legend / Backfill/ Instruments
			15/06/2007	0800	MADE GROUND: Loose black and grey slightly clayey slightly sandy angular fine to coarse GRAVEL of sandstone limestone and brick with occasional angular cobbles of sandstone.		
1.50-1.95	SPT C	N=24 (3,9/9,5,6,4)	1.50	1.10	1.50-1.95 m Medium dense	(4.50)	
3.00-3.45	SPT C	N=9 (2,3/2,3,3,1)	3.00	1.80			
4.50-4.95	SPT C	N=7 (1,2/1,2,2,2)	4.50	2.50	MADE GROUND: Obstruction (Drillers discription).	4.50	
5.50-5.95	SPT C	N=26 (4,6/5,4,12,5)	5.50	3.20		(2.40)	
6.50-6.95 6.50-6.95	SPT S D 1	N=7 (2,5/2,2,1,2)	6.50	2.50	6.60-6.95 m Soft	6.90	
			15/06/2007	1700	Soft plastic dark brown and black slightly clayey slightly sandy PEAT with rare rootlets and partially decomposed wood.		
			7.00	dry			
7.50-7.95	SPT S	N=4 (1,1/1,1,1,1)	~~7.50~~	~~dry~~			
7.50-7.95 7.50-8.00	D 2 B 3		18/06/2007 7.00	0800 dry			
8.00-8.60	U 4	22 blows				(2.30)	
9.00-9.50	B 5					9.20	
9.50-9.95 9.50-9.95 9.50-10.00	SPT S D 6 B 7	N=18 (1,3/2,4,6,6)	9.50	4.30	Medium dense grey and brown clayey sandy GRAVEL with some sub rounded to rounded cobbles of sandstone. Gravel is sub rounded to rounded fine to coarse of	(1.10)	
Depth	Type & No	Records	Date Casing	Time Water	Stratum continues to 10.30 m		

SP

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	1.10	Remained at 1.10 m after 20 minutes.	-

Depth Related Remarks *
From to (m)

Chiselling

Depths (m)	Time	Tools used
1.50 -6.90	240 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 408.24 11/01/2008 12:55:06

Project: BP Llandarcy
Project No.: H7043
Carried out for: BP Europe Ltd

Borehole
BH2
Sheet 1 of 2

Borehole Log

Soil Mechanics

Drilled	JK	Start	15/06/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	18/06/2007	Dando 2000	0.00m	7.50m	200mm	7.50m	Coordinates	-
Checked	HW			Machine excavated trial pit GL - 1.50m.	7.50m	13.27m	150mm	12.50m	National Grid	-
				Light cable percussive methods 1.50 - 13.00m					Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.50-11.00	B 8			
11.00-11.45	SPT C	N=12 (2,4/5,2,3,2)	11.00	4.10
11.50-12.00	B 9			
12.50-12.95 12.50-13.00	SPT C B 10	N=35 (2,3/3,10,12,10)	12.50	2.20
13.00-13.27	SPT C	50 (12,13 for 45mm/24,26)	12.50 18/06/2007 12.50	1700 dry

Depth	Type & No	Records	Date Casing	Time Water

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)	Legend	Backfill/ Instruments
sandstone.	10.30		
Firm becoming very stiff brown and grey slightly sandy slightly gravelly CLAY with occasional rounded cobbles of sandstone. Gravel is rounded fine to coarse of sandstone.	(2.97)		
EXPLORATORY HOLE ENDS AT 13.27 m	13.27		

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From	to (m)

Chiselling

Depths (m)	Time	Tools used
12.50 -13.00	60 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:55:07

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH2

Borehole Log

Soil Mechanics

Drilled	RD
Logged	PL
Checked	HW

Start 19/06/2007
End 21/06/2007

Equipment, Methods and Remarks
Dando 2000
Machine excavated trial pit GL - 1.50m.
Light cable percussive methods 1.50 - 12.60m

Depth from	to	Diameter	Casing Depth
0.00m	8.50m	200mm	8.50m
8.50m	12.55m	150mm	12.55m

Ground Level -
Coordinates -
National Grid -
Chainage

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			19/06/2007	0800 dry
1.50-1.95 1.50-1.80	SPT C B 1	N=16 (2,2/4,5,2,5)		1.00
2.50-2.95 2.50-2.80	SPT C B 2	N=35 (8,5/5,11,14,5)	2.50	1.00
3.50-3.91 3.50-3.80	SPT C B 3	50 (5,5/7,9,11,23 for 35mm)	3.50	1.00
4.50-4.91 4.50-4.80	SPT C B 4	50 (5,10/9,8,15,18 for 30mm)	4.50	1.00
5.50-5.62 5.50-5.80	SPT C B 5	50 (25 for 55mm/50 for 65mm)	5.50	1.00
			19/06/2007 6.30	1700 1.00
			20/06/2007 6.50 6.30	0800 1.20
6.50-6.64 6.50-6.80	SPT C B 6	50 (25 for 70mm/50 for 70mm)		
7.50-7.95 7.50-7.80	SPT C B 7	N=13 (2,4/2,4,4,3)	7.50	1.20
7.80-8.00	B 8			
8.00-8.50	U 9	45 blows		dry
8.50	D 10			
9.00-9.50	U 11	32 blows		dry
9.50	D 12			
			20/06/2007 10.00	1700 damp
Depth	Type & No	Records	Date Casing	Time Water

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Medium dense becoming very dense grey brown and red slightly clayey slightly sandy angular fine to coarse GRAVEL of sandstone concrete and brick with some angular cobbles of concrete sandstone and brick.	(7.80)		SP
7.50-7.95 m Medium dense			
Spongy dark brown and black slightly clayey slightly sandy pseudo-fibrous PEAT with many roots and rootlets.	7.80 (2.50)		
Stratum continues to 10.30 m			

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

None observed (see Key Sheet)

Depth Related Remarks *

From	to (m)	
8.00	10.00	Water added to assist drilling

Chiselling

Depths (m)	Time	Tools used
3.50 -4.50	120 mins	Chisel
4.50 -5.50	120 mins	Chisel
5.50 -6.00	60 mins	Chisel
6.00 -6.30	60 mins	Chisel
6.30 -6.60	60 mins	Chisel
6.60 -6.80	60 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:55:11

Project BP Llandarcy
Project No. H7043
Carried out for BP Europe Ltd

Borehole
BH3
Sheet 1 of 2

Borehole Log

Soil Mechanics

Drilled	RD	Start	19/06/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	21/06/2007	Dando 2000	0.00m	8.50m	200mm	8.50m	Coordinates	-
Checked	HW			Machine excavated trial pit GL - 1.50m.	8.50m	12.55m	150mm	12.55m	National Grid	-
				Light cable percussive methods 1.50 - 12.60m					Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.00-10.45	SPT C	N=13 (2,2/3,4,2,4)	10.00	dry
10.00-10.45	D 13		21/06/2007	0800
10.30-10.80	B 14		10.00	6.50
11.50-11.79	SPT C	50 (8,13/28,22 for 60mm)	11.50	
11.50-12.00	B 15			
12.55-12.71	SPT C	50 (16,9 for 15mm/50 for 70mm)	21/06/2007 12.55	1700

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)
Spongy dark brown and black slightly clayey slightly sandy pseudo-fibrous PEAT with many roots and rootlets. 10.00-10.45 m Firm	10.30
Very stiff dark brown slightly sandy slightly gravelly CLAY with occasional sub rounded to rounded cobbles of sandstone. Gravel is sub rounded to rounded fine to coarse of sandstone.	(2.41)
EXPLORATORY HOLE ENDS AT 12.71 m	12.71

Legend

Backfill/ Instruments

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

None observed (see Key Sheet)

Depth Related Remarks *

From to (m)

Chiselling

Depths (m)	Time	Tools used
11.70 -11.90	30 mins	Chisel
12.30 -12.30	30 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) EGL www.egl.co.uk 408.24 11/01/2008 12:55:13 AGS

Project: BP Llandarcy

Project No.: H7043

Carried out for: BP Europe Ltd

Borehole

BH3

Borehole Log

Soil Mechanics

Drilled RD Logged PL Checked HW	Start 22/06/2007 End 26/06/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated trial pit GL - 1.50m. Light cable percussive methods 1.50 - 18.00m.	Depth from 0.00m to 18.00m	Diameter 200mm	Casing Depth 18.00m	Ground Level - Coordinates - National Grid - Chainage

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.00-10.45	SPT C	N=0 (1,0/-,-,-,-)	10.00	damp
10.00-10.30	B 12		25/06/2007	0800
			10.00	damp
11.50-11.95	SPT C	N=43 (5,8/10,10,11,12)	11.50	8.80
11.50-11.80	B 13			
13.00-13.24	SPT C	50 (16,9 for 35mm/ 32,18 for 55mm)	13.00	damp
13.00-13.30	B 14			
14.50-14.95	SPT C	N=41 (4,4/8,10,12,11)	14.50	4.30
14.50-14.80	B 15			
			25/06/2007	1700
			15.50	6.10
			26/06/2007	0800
			15.50	6.90
16.00-16.45	SPT C	N=48 (10,15/12,10,12,12)	16.00	
16.00-16.30	B 16			
17.00-17.30	B 18			
17.50-17.71	SPT C	50 (18,7 for 10mm/ 28,22 for 50mm)	17.50	
17.50-18.00	B 17			
18.00-18.35	SPT C	50 (12,13 for 70mm/ 17,19,14 for 55mm)	18.00	
			26/06/2007	1700
			18.00	

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Very loose black slightly clayey slightly sandy sub angular to sub rounded fine to coarse GRAVEL of sandstone brick and concrete with occasional sub angular to sub rounded cobbles of sandstone.	10.00		
	(0.80)		
Black slightly clayey slightly gravelly SAND. Gravel is sub rounded fine to coarse of sandstone.	10.80		
	(0.60)		
Very stiff brown and grey slightly sandy slightly gravelly CLAY with occasional sub rounded cobbles of sandstone. Gravel is sub rounded fine to coarse of sandstone.	11.40		
	(2.80)		SB
Dense becoming very dense brown clayey sandy rounded fine to coarse GRAVEL of sandstone with some rounded cobbles of sandstone.	14.20		
	(4.15)		
EXPLORATORY HOLE ENDS AT 18.35 m	18.35		

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	10.80	Rose to 8.80 m after 20 minutes.	11.90
2	14.20	Rose to 4.30 m after 20 minutes.	-

Depth Related Remarks *

From	to (m)	
11.90	14.20	Water added to assist drilling

Chiselling

Depths (m)	Time	Tools used
11.80 -12.20	75 mins	Chisel
12.90 -13.40	90 mins	Chisel
13.90 -14.20	60 mins	Chisel
15.70 -16.30	75 mins	Chisel
17.50 -18.00	60 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:55:27

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH5

Sheet 2 of 2

Borehole Log

Soil Mechanics

Drilled RD Logged PL Checked HW	Start 05/06/2007 End 06/06/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated Inspection pit GL - 1.50m. Light cable percussive methods 1.50 - 14.56m.	Depth from / to / Diameter / Casing Depth 0.00m / 9.00m / 200mm / 9.00m 9.00m / 14.20m / 150mm / 14.20m	Ground Level - Coordinates - National Grid - Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			05/06/2007	0800
1.50-1.95 1.50-1.80	SPT C B 1	N=4 (1,0/1,1,1,1)		
2.50-2.95 2.50-2.80	SPT C B 2	N=2 (2,0/1,0,1,0)		
3.50-3.95 3.50-3.80	SPT C B 3	N=3 (1,2/0,1,1,1)	3.50	
4.50-4.95 4.50-4.80	SPT C B 4	N=1 (1,0/0,1,0,0)	4.50	
5.50-5.95 5.50-5.80	SPT C B 5	N=0 (1,0/-,-,-,-)	5.50	
6.50-6.95 6.50-6.80	SPT C B 6	N=0 (1,0/-,-,-,-)	6.50	
7.50-7.95 7.50-7.95 7.60-7.90	SPT S D 7 B 8	N=4 (3,1/1,1,1,1)	7.50	
8.00-8.30 8.00-8.30	B 18 U 9	40 blows	8.00	
8.30-8.80	U 10	29 blows	8.30	
8.80	D 11			
9.00-9.50	U 12	31 blows	9.00	
9.50	D 13			

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Black and grey clayey sandy sub angular to sub rounded fine to coarse GRAVEL of sandstone mudstone brick and concrete with occasional sub angular cobbles of sandstone and concrete.	(1.50)		
MADE GROUND: Soft brown and red slightly sandy slightly gravelly CLAY with occasional angular cobbles of limestone and sandstone. Gravel is angular fine to coarse of limestone and sandstone.	1.50 (1.00)		
MADE GROUND: Very loose black slightly silty sandy angular fine to coarse GRAVEL of coal coke mudstone and siltstone with occasional angular cobbles of mudstone and siltstone (COLLIERY SPOIL).	2.50		
3.50-7.60 m Heavy contamination	(5.10)		
Soft black and brown organic CLAY with many roots and rootlets. 7.70-7.95 m Loose	7.60 (1.90)		
Very soft brown CLAY with small fragments of wood and rare rootlets.	9.50		
Stratum continues to 11.30 m			

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	3.20	Rose to 2.80 m after 20 minutes.	-

Depth Related Remarks *
From to (m)

Chiselling
Depths (m) Time Tools used

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408 24 11/01/2008 12:55:32

AGS

Project BP Llandarcy
Project No. H7043
Carried out for BP Europe Ltd

Borehole
BH6
Sheet 1 of 2

Borehole Log

Soil Mechanics

Drilled	RD
Logged	PL
Checked	HW

Start 05/06/2007
End 06/06/2007

Equipment, Methods and Remarks
Dando 2000
Machine excavated inspection pit GL - 1.50m.
Light cable percussive methods 1.50 - 14.56m.

Depth from	to	Diameter	Casing Depth
0.00m	9.00m	200mm	9.00m
9.00m	14.20m	150mm	14.20m

Ground Level -
Coordinates -
National Grid -
Chainage

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.50-10.95 10.50-10.95 10.50-11.00	SPT S D 14 B 15	N=3 (1,0/1,1,0,1)	9.50	dry
11.50-11.86 11.50-12.00	SPT C B 16	50 (13,12 for 55mm/19,14,17)		dry
			05/06/2007 12.90	1800
13.00-13.44 13.00-13.50	SPT C B 17	50 (10,10/17,9,11,13 for 65mm)	06/06/2007 12.90	0800 8.50
14.20-14.57	SPT C	50 (10,11/20,15,15 for 65mm)		
			06/06/2007 14.20	1200 8.50

Strata

Description
(Continued from Sheet 1)

Very soft brown CLAY with small fragments of wood and rare rootlets.

(1.80)

11.30

Very dense brown slightly clayey slightly sandy gravelly sub rounded to rounded COBBLES of sandstone. Gravel is sub rounded to rounded fine to coarse of sandstone.

(3.27)

14.57

EXPLORATORY HOLE ENDS AT 14.57 m

Depth, Level (Thickness)	Legend	Backfill/ Instruments
		2

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
2	11.30	Rose to 9.10 m after 20 minutes.	-

Depth Related Remarks *
From to (m)

Chiselling

Depths (m)	Time	Tools used
11.60 -12.10	75 mins	Chisel
13.60 -14.20	90 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:55:34

Project BP Llandarcy
Project No. H7043
Carried out for BP Europe Ltd

Borehole
BH6
Sheet 2 of 2

Borehole Log

Soil Mechanics

Drilled	RD	Start	06/06/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	08/06/2007	Dando 2000	0.00m	11.00m	200mm	11.00m	Coordinates	-
Checked	HW			Machine excavated trial pit GL - 1.50m.	11.00m	14.40m	150mm	14.40m	National Grid	-
				Light cable percussive methods 1.50 - 14.540m.					Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			06/06/2007	1200
1.50-1.95 1.50-1.80	SPT C B 1	N=1 (1,0/0,0,1,0)	1.50	
2.50-2.95 2.50-2.80	SPT C B 2	N=2 (1,0/0,1,0,1)	2.50	
3.50-3.95 3.50-3.80	SPT C B 3	N=2 (1,0/0,1,0,1)	3.50	
			06/06/2007 0.00	1800
			07/06/2007 4.50 4.30	0800 1.40
4.50-4.89 4.50-4.80	SPT C B 4	50 (10,11/14,17,12,7 for 10mm)		
5.50-5.95 5.50-5.80	SPT C B 5	N=16 (4,5/6,4,4,2)	5.50	1.40
6.50-6.95 6.50-6.80	SPT C B 6	N=22 (3,4/5,5,7,5)	6.50	1.40
7.50-7.93 7.50-7.80	SPT C B 7	50 (6,7/11,14,13,12 for 55mm)	7.50	1.40
9.00-9.45 9.00-9.30	SPT C B 8	N=43 (4,4/2,12,12,17)	9.00	1.40

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Very soft dark grey slightly sandy slightly gravelly CLAY with occasional sub angular cobbles of sandstone. Garvel is sub angular fine to coarse of sandstone.	(4.00)		
Timber obstruction (Drillers discription).	4.00 (0.50)		
MADE GROUND: Medium dense and dense black clayey sandy sub angular to sub rounded fine to coarse GRAVEL of sandstone with occasional sub angular to sub rounded cobbles of sandstone. Very contaminated.	4.50		
4.50-4.89 m Very dense			
5.50-6.95 m Medium dense			
7.50-7.93 m Very dense	(6.00)		
9.00-9.45 m Dense			
Stratum continues to 10.50 m			

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From to (m)

Chiselling

Depths (m)	Time	Tools used
4.00 -4.30	45 mins	Chisel
4.30 -5.00	105 mins	Chisel
7.80 -8.40	90 mins	Chisel
9.50 -10.10	75 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12.55:39

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH7

Sheet 1 of 2

Borehole Log

Soil Mechanics

Drilled	RD	Start	06/06/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	08/06/2007	Dando 2000	0.00m	11.00m	200mm	11.00m	Coordinates	-
Checked	HW			Machine excavated trial pit GL - 1.50m.	11.00m	14.40m	150mm	14.40m	National Grid	-
				Light cable percussive methods 1.50 - 14.540m.					Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.30-10.50	B 14		07/06/2007	1800
			10.50	dry
10.50-11.00	U 9	39 blows	10.50	
			08/06/2007	0800
			10.50	8.50
11.00	D 10			
12.00-12.45	SPT S	N=14 (2,3/2,3,3,6)	12.00	
12.00-12.45	D 11			
12.00-12.50	B 12			
13.00-13.43	SPT C	50 (7,7/8,12,18,12 for 50mm)	13.00	
13.00-13.40	B 13			
14.40-14.54	SPT C	50 (25 for 45mm/ 35,15 for 20mm)	08/06/2007	1800
			14.40	
			14.40	

Depth	Type & No	Records	Date Casing	Time Water

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)
MADE GROUND: Medium dense and dense black clayey sandy sub angular to sub rounded fine to coarse GRAVEL of sandstone with occasional sub angular to sub rounded cobbles of sandstone. Very contaminated.	10.50
	(0.50)
Soft dark brown organic CLAY with wood fragments.	11.00
Firm brown sandy slightly gravelly CLAY/SILT. Gravel is subrounded to rounded fine to coarse of sandstone.	(1.50)
Very dense brown slightly clayey slightly sandy gravelly COBBLES of sandstone. Gravel is sub rounded to rounded fine to coarse of sandstone.	12.50
	(2.04)
EXPLORATORY HOLE ENDS AT 14.54 m	14.54

Legend

Backfill/ Instruments

1

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	13.10	Remained at 13.10 m after 20 minutes.	-

Depth Related Remarks *

From to (m)

Chiselling

Depths (m)	Time	Tools used
13.70 -14.20	60 mins	Chisel
14.20 -14.40	45 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 406.24 11/01/2008 12:55:41

Project BP Llandarcy

Project No. H7043

Carried out for BP Europe Ltd

Borehole

BH7

Sheet 2 of 2

Borehole Log

Soil Mechanics

Drilled	JK / MY
Logged	PL
Checked	HW

Start	25/06/2007
End	27/06/2007

Equipment, Methods and Remarks
Dando 2000
Machine excavated trial pit GL - 1.50m.
Light cable percussive methods 1.50 - 12.30m.

Depth from	to	Diameter	Casing Depth
0.00m	8.20m	200mm	8.20m
8.20m	12.42m	150mm	12.30m

Ground Level	-
Coordinates	-
National Grid	-
Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			25/06/2007	0800
4.00-4.45	SPT C	N=8 (1,1/2,2,2,2)	4.00	
4.00-4.50	B 1			
5.00-5.45	SPT C	N=5 (1,1/2,2,1,0)	5.00	
5.00-5.50	B 2			
			25/06/2007	1700
			5.80	
			26/06/2007	0800
6.00-6.45	SPT C	N=4 (1,0/1,0,2,1)	6.00	damp
6.00	B 3		5.80	
6.00-7.00	U 4	11 blows		
7.00-7.20	D 5			
7.30-7.50	D 6			
7.50-8.00	U 7	23 blows		
8.00-8.20	D 8			
8.50-8.95	SPT C	N=8 (2,2/2,2,2,2)	8.50	damp
8.50-8.95	B 9			
9.50-9.70	D 10			

Depth	Type & No	Records	Date Casing	Time Water

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: No samples taken due to obstruction.	(4.10)		
MADE GROUND: Loose black brown and grey slightly clayey slightly peaty slightly sandy sub angular to sub rounded fine to coarse GRAVEL of sandstone brick and concrete with occasional sub angular cobbles of sandstone brick and concrete.	4.10 (1.90)		
Soft black and brown spongy pseudo-fibrous PEAT with frequent roots and rootlets.	6.00 (0.50)		SP
Soft dark brown and black organic CLAY with frequent roots and rootlets.	6.50 (1.50)		
Loose dark grey and brown slightly clayey slightly gravelly SAND. Gravel is sub rounded fine to coarse of sandstone.	8.00 (1.50)		
Stiff grey and yellow sandy CLAY.	9.50 (0.50)		

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
None observed (see Key Sheet)			

Depth Related Remarks "

From	to (m)	
8.20	11.70	Water added to assist drilling

Chiselling

Depths (m)	Time	Tools used
1.20 -4.00	90 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 409.24 11/01/2008 12:55:45

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH8

Borehole Log

Soil Mechanics

Drilled	JK / MY
Logged	PL
Checked	HW

Start	25/06/2007
End	27/06/2007

Equipment, Methods and Remarks
Dando 2000
Machine excavated trial pit GL - 1.50m.
Light cable percussive methods 1.50 - 12.30m.

Depth from	to	Diameter	Casing Depth
0.00m	8.20m	200mm	8.20m
8.20m	12.42m	150mm	12.30m

Ground Level	-
Coordinates	-
National Grid	-
Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.00-10.45 10.00-10.45	SPT C B 11	N=21 (2,3/4,4,6,7)	10.00	8.00
11.50-11.95 11.50-11.95	SPT C B 12	N=37 (5,4/6,6,10,15)	11.50 26/06/2007 ~~11.70~~ ~~27/06/2007~~ 11.70	8.20 1700 ~~6.00~~ ~~0800~~ 3.00
12.30-12.42	SPT C	50 (25 for 50mm/50 for 70mm)	27/06/2007 12.00 ~~12.30~~	1700 3.00 ~~3.00~~

Depth	Type & No	Records	Date Casing	Time Water

Strata

Description (Continued from Sheet 1)

Stiff becoming very stiff brown and grey slightly sandy slightly gravelly CLAY with occasional sub rounded to rounded cobbles of sandstone. Gravel is sub rounded to rounded fine to coarse of sandstone.

EXPLORATORY HOLE ENDS AT 12.42 m

Depth, Level (Thickness)	Legend	Backfill/ Instruments
10.00		
(2.42)		
12.42		

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

None observed (see Key Sheet)

Depth Related Remarks *

From	to (m)

Chiselling

Depths (m)	Time	Tools used
11.40 -11.70	90 mins	Chisel
11.70 -11.90	60 mins	Chisel
11.90 -12.00	60 mins	Chisel
12.00 -12.30	90 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:55:47

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH8

Borehole Log

Soil Mechanics

Drilled	JK	Start	19/06/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	20/06/2007	Dando 2000 Machine excavated trial pit GL - 1.50m. Light cable percussive methods 1.50 - 11.20m	0.00m	6.00m	200mm	6.00m	Coordinates	-
Checked	HW				6.00m	11.20m	150mm	11.20m	National Grid	-
									Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			19/06/2007	0800 dry
1.50-1.95	SPT C	N=11 (2,3/3,3,3,2)	1.00	0.70
2.00-2.50	B 1			
2.50-2.95 2.50-3.00	SPT C B 2	N=22 (4,4/7,6,5,4)	1.50	1.00
3.50-3.95 3.50-4.00	SPT C B 3	N=15 (1,0/0,4,5,6)	3.50	1.90
4.50-4.95	SPT C	N=1 (1,0/0,0,0,1)	4.50	2.50
5.50-6.10	U 4	10 blows 450 mm rec	5.50	2.80
6.50-7.00 6.50-7.10	B 13 U 5	23 blows 450 mm rec	6.00	2.80
7.50-8.10	U 6	10 blows 60 mm rec	7.50	3.10
8.00-8.50	B 7			
9.00-9.50	B 8			
9.50-9.95 9.50-10.00 9.50-9.95	SPT S B 10 D 9	N=5 (1,2/1,1,2,1)	9.50	5.30

Depth	Type & No	Records	Date Casing	Time Water

Strata

Description	Depth, Level (Thickness)
MADE GROUND: Medium dense grey and brown slightly clayey slightly sandy angular to sub angular fine to coarse GRAVEL of sandstone brick and concrete with some angular cobbles of sandstone brick and concrete. Rare ragments of plastic and metal.	(5.10)
4.50-4.95 m Very loose.	
Soft black and brown slightly sandy organic CLAY with frequent roots and rootlets.	5.10 (1.90)
Soft dark brown and light grey sandy CLAY.	7.00 (3.50)
Stratum continues to 10.50 m	

Legend: 1 1 SP

Backfill/ Instruments

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	1.00	Rose to 0.70 m after 20 minutes.	-

Depth Related Remarks *

From to (m)

Chiselling

Depths (m) Time Tools used

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:55:51

AGS

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH9

Borehole Log

Soil Mechanics

Drilled	JK	Start	19/06/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	20/06/2007	Dando 2000	0.00m	6.00m	200mm	6.00m	Coordinates	-
Checked	HW			Machine excavated trial pit GL - 1.50m.	6.00m	11.20m	150mm	11.20m	National Grid	-
				Light cable percussive methods 1.50 - 11.20m					Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			19/06/2007	1700
			10.50	5.30
10.50-11.00	B 11		20/06/2007	0800
			9.50	3.20
11.00-11.20	B 12			
11.20-11.63	SPT C	50 (7,15/13,13,14,10 for 55mm)	11.00	3.00
			20/06/2007	1700
			11.00	3.00

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)	Legend	Backfill/ Instruments
Soft dark brown and light grey sandy CLAY.			
	10.50		
Dense grey brown very silty very sandy GRAVEL.	(0.50)		
	11.00		
Very dense dark brown clayey sandy sub rounded fine to coarse GRAVEL of sandstone with some sub rounded cobbles of sandstone.	(0.63)		
	11.63		
EXPLORATORY HOLE ENDS AT 11.63 m			

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From	to (m)

Chiselling

Depths (m)	Time	Tools used
11.00 -11.20	45 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12.55:52

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH9

Borehole Log

Soil Mechanics

Drilled RD Logged PL Checked HW	Start 29/05/2007 End 30/05/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated inspection pit GL - 1.50m. Light cable percussive methods 1.50 - 16.20m	Depth from / to 0.00m / 13.00m 13.00m / 16.20m	Diameter 200mm 150mm	Casing Depth 13.00m 16.20m	Ground Level - Coordinates - National Grid - Chainage

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			29/05/2007	0800
1.50-1.95 1.50-1.80	SPT C B 1	N=0 (1,0/-,-,-,-)		dry
2.50-2.95 2.50-2.80	SPT C B 2	N=0 (1,0/-,-,-,-)		dry
3.50-3.95 3.50-3.80	SPT C B 3	N=7 (3,3/3,2,1,1)	3.50	dry
4.50-4.95 4.50-4.80	SPT C B 4	N=6 (1,1/1,1,3,1)	4.50	dry
5.50-5.95 5.50-5.80	SPT C B 5	N=20 (3,6/6,6,3,5)	5.50	dry
6.50-6.90 6.50-6.80	SPT C B 6	N=26 (15,10 for 25mm/5,5,9,7)	6.50	dry
7.50-7.95 7.50-7.80	SPT C B 7	N=3 (2,0/0,0,1,2)	7.50	7.10
			29/05/2007 8.20	1700 7.10
			30/05/2007 8.20	0800 7.30
8.50-8.95 8.50-8.80	SPT C B 8	N=20 (5,5/4,7,4,5)	8.50	

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Very soft to soft brown grey slightly sandy slightly gravelly CLAY with occasional sub angular to sub rounded cobbles of sandstone and brick. Gravel is angular to sub rounded fine to medium of mudstone sandstone and brick.	(5.50)		
MADE GROUND: Medium dense dark grey and black clayey sandy sub angular to sub rounded fine to coarse GRAVEL of brick sandstone and slag with some sub angular cobbles of sandstone and slag.	5.50 (2.00)		
MADE GROUND: Very soft slightly sandy slightly gravelly CLAY with occasional sub angular cobbles of sandstone. Gravel is angular to sub rounded fine to coarse of sandstone. 7.50-8.50 m Fines washed away.	7.50 (1.00)		
MADE GROUND: Stiff dark grey to black organic slightly sandy slightly gravelly CLAY with occasional sub angular cobbles of sandstone. Gravel is sub angular to sub rounded fine to coarse of sandstone. Rare metal fragments.	8.50 (1.50)		

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	7.40	Rose to 7.10 m after 20 minutes.	-

Depth Related Remarks *
From to (m)

Chiselling

Depths (m)	Time	Tools used
6.40 -6.60	30 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:55:56

Project BP Llandarcy
Project No. H7043
Carried out for BP Europe Ltd

Borehole
BH12
Sheet 1 of 2

Borehole Log

Soil Mechanics

Drilled RD Logged PL Checked HW	Start 29/05/2007 End 30/05/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated inspection pit GL - 1.50m. Light cable percussive methods 1.50 - 16.20m	Depth from / to / Diameter / Casing Depth 0.00m / 13.00m / 200mm / 13.00m 13.00m / 16.20m / 150mm / 16.20m	Ground Level - Coordinates - National Grid - Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.00-10.45 10.00-10.30	SPT C B 9	N=14 (15,6/4,4,3,3)	10.00	
12.00-12.45 12.00-12.45 12.00-12.50	SPT S D 10 B 11	N=18 (1,2/3,4,5,6)	12.00	dry
14.00-14.45 14.00-14.45 14.00-14.50	SPT S D 12 B 13	N=11 (1,1/1,3,3,4)	14.00	dry
15.50-15.68 15.50-16.20	SPT C B 14	50 (25 for 70mm/ 32,18 for 30mm)	15.50	
16.20-16.45	SPT C	50 (18,7 for 15mm/ 23,20,7 for 10mm)	16.20 30/05/2007 16.20	12.30 1700 12.30

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Medium dense black slightly clayey slightly sandy angular fine to coarse GRAVEL of sandstone with some sub angular cobbles of sandstone.	10.00 (1.90)		
Stiff becoming very stiff dark grey and brown slightly sandy slightly gravelly CLAY with occasional sub angular to sub rounded cobbles of sandstone. Gravel is sub angular to sub rounded fine to coarse of sandstone.	11.90 (3.60)		2 2
14.00-14.45 m Firm			
Very stiff brown slightly sandy slightly gravelly CLAY with occasional subangular cobbles of sandstone. Gravel is sub angular to sub rounded fine to coarse of sandstone.	15.50 (0.95)		
EXPLORATORY HOLE ENDS AT 16.45 m	16.45		

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
2	15.10	Rose to 12.30 m after 20 minutes.	-

Depth Related Remarks *

From to (m)

Chiselling

Depths (m)	Time	Tools used
11.90 -12.40	75 mins	Chisel
15.50 -16.20	120 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 408.24 11/01/2008 12:55:59

Project BP Llandarcy

Project No. H7043

Carried out for BP Europe Ltd

Borehole

BH12

Sheet 2 of 2

Borehole Log

Soil Mechanics

Drilled	RD	Start	22/05/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	24/05/2007	Dando 2000	0.00m	11.40m	200mm	11.40m	Coordinates	-
Checked	HW			Machine excavated inspection pit GL - 1.50m. Light cable percussive methods 1.50 - 16.50m	11.40m	16.50m	150mm	16.50m	National Grid	-
									Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			22/05/2007	1200
1.50-1.95 1.50-1.80	SPT C B 1	N=5 (1,1/2,1,1,1)	1.50	dry
2.50-2.95 2.50-2.80	SPT C B 2	N=30 (4,10/10,8,6,6)	2.50	dry
3.50-3.95 3.50-3.80	SPT C B 3	N=21 (3,4/4,7,4,6)	3.50	dry
			22/05/2007	1700
			4.50	dry
4.50-4.95	SPT C	N=2 (1,0/1,0,1,0)	4.50	dry
			23/05/2007	0800
			4.50	dry
5.50-5.95 5.50-6.00	SPT C B 4	N=6 (2,2/2,1,0,3)	5.50	dry
6.50-6.95 6.50-6.90	SPT C B 5	N=12 (5,5/3,3,1,5)	6.50	dry
7.50-7.88 7.50-8.00	SPT C B 6	50 (5,15/14,19,16,1 for 5mm)	7.50	dry
8.50-8.95 8.50-9.00	SPT C B 7	N=7 (6,5/2,2,1,2)	8.50	dry
			23/05/2007	1700
			10.00	5.40

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Brown clayey slightly sandy sub angular to sub rounded fine to coarse GRAVEL of sandstone brick and mortar with occasional sub angular cobbles of sandstone.	(1.50)		
MADE GROUND: Soft becoming stiff brown slightly sandy slightly gravelly CLAY with occasional angular cobbles of sandstone. Gravel is sub angular fine to coarse of sandstone and brick.	1.50		
2.50-2.95 m Very Stiff	(3.00)		
MADE GROUND: No recovery. Apparently large masonary / brickwork (Drillers discription).	4.50 (1.00)		1
MADE GROUND: Loose black slightly silty sandy angular to sub angular fine to coarse GRAVEL of sandstone and brick with occasional angular cobbles of sandstone. Rare fragments of metal. High level of contamination.	5.50		
6.50-6.95 m Medium dense			
7.50-7.88 m Very dense			
	(5.90)		
Stratum continues to 11.40 m			

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	5.20	Remained at 5.20 m after 20 minutes.	-

Depth Related Remarks *

From	to (m)	
3.00		Contamination below 3.00m

Chiselling

Depths (m)	Time	Tools used
6.30 -7.50	90 mins	Chisel
7.50 -8.20	105 mins	Chisel
9.40 -10.00	90 mins	Chisel
10.00 -11.40	195 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 408.24 11/01/2008 12:56:03

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH13

Sheet 1 of 2

Borehole Log

Soil Mechanics

Drilled	RD	Start	22/05/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	24/05/2007	Dando 2000	0.00m	11.40m	200mm	11.40m	Coordinates	-
Checked	HW			Machine excavated inspection pit GL - 1.50m. Light cable percussive methods 1.50 - 16.50m	11.40m	16.50m	150mm	16.50m	National Grid	-
									Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.00-10.35 10.00-10.50	SPT C B 8	50 (7,11/10,19,21 for 50mm)	10.00 24/05/2007 10.00	5.40 0800 5.30
11.50-11.95 11.50-11.80 11.50-11.95	SPT S B 10 D 9	N=25 (7,8/10,5,5,5)	11.50	damp
			24/05/2007 13.00	1700
13.00-13.45 13.00-13.45 13.00-13.50	SPT S D 11 B 12	N=27 (2,2/2,6,8,11)	13.00 25/05/2007 13.00	damp 0800 5.40
15.00-15.38 15.00-15.50	SPT C B 13	50 (5,11/12,16,20,2 for 5mm)	15.00	damp
16.50-16.70	SPT C	50 (20,5 for 15mm/ 32,18 for 35mm)	16.50 25/05/2007 16.50	damp 1700 5.40

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)
MADE GROUND: Loose black slightly silty sandy angular to sub angular fine to coarse GRAVEL of sandstone and brick with occasional angular cobbles of sandstone. Rare fragments of metal. High level of contamination. 10.00-10.35 m Very dense	11.40
Stiff brown and black slightly sandy slightly gravelly organic CLAY with many wood fragments and peat lenses (30mm x 40mm). Gravel is sub rounded fine to coarse of sandstone.	(1.40)
Medium dense becoming very dense brown slightly clayey slightly sandy sub rounded to rounded fine to coarse GRAVEL of sandstone with some sub rounded to rounded cobbles of sandstone.	12.80 (3.90)
EXPLORATORY HOLE ENDS AT 16.70 m	16.70

Legend

Backfill/ Instruments

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From	to (m)

Chiselling

Depths (m)	Time	Tools used
10.00 -11.40	195 mins	Chisel
11.90 -12.80	150 mins	Chisel
15.40 -15.40	150 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 408.24 11/01/2008 12:56:05

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH13

Borehole Log

Soil Mechanics

Drilled RD Logged PL Checked HW	Start 17/05/2007 End 21/05/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated inspection pit GL - 1.50m. Light cable percussive methods 1.50m - 16.25m	Depth from / to / Diameter / Casing Depth 0.00m / 13.50m / 200mm / 13.50m 13.50m / 16.25m / 150mm / 16.25m	Ground Level - Coordinates - National Grid - Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			17/05/2007	1200
1.10	B 16			
1.50-1.95 1.50-1.80	SPT C B 1	N=6 (1,1/1,1,2,2)		dry
			17/05/2007	1700
			2.50	2.20
			~~2.50~~	~~2.20~~
2.50-2.95 2.50-2.80	SPT C B 2	N=9 (1,2/1,2,2,4)	18/05/2007	0800
			2.50	damp
3.50-3.95 3.50-3.95	SPT C B 3	N=15 (5,5/2,5,5,3)	3.50	damp
4.50-4.95 4.50-4.80	SPT C B 4	N=4 (1,0/1,1,1,1)	4.50	damp
5.50-5.95 5.50-5.80	SPT C B 5	N=6 (1,1/2,1,2,1)	5.50	damp
6.50-6.95 6.50-6.80	SPT C B 6	N=6 (1,1/2,1,2,1)	6.50	damp
7.50-7.95 7.50-7.80	SPT C B 7	N=4 (1,1/1,1,1,1)	7.50	damp
8.50-8.95 8.50-8.80	SPT C B 8	N=6 (2,2/1,2,1,2)	8.50	damp

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Grey black and red slightly clayey sandy angular fine to coarse GRAVEL of brick sandstone and mortar with occasional angular cobbles of brick mortat and sandstone. Rare fragments of metal and cardboard.	(1.50)		
MADE GROUND: Loose black brown and grey clayey slightly sandy sub angular to sub rounded fine to coarse GRAVEL of sandstone brick mudstone mortar coal and coke with occasional sub angular cobbles of sandstone and brick.	1.50		1 ▽ 1 ▼
3.50-3.95 m Medium dense			
	(11.40)		
Stratum continues to 12.90 m			

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth seated (m)
1	2.50	Rose to 2.20 m after 20 minutes.	-

Depth Related Remarks *

From	to (m)	
1.50	12.90	Samples were heavily contaminated with hydrocarbons

Chiselling

Depths (m)	Time	Tools used

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12.56.10

AGS

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH14

Borehole Log

Soil Mechanics

Drilled RD Logged PL Checked HW	Start 17/05/2007 End 21/05/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated inspection pit GL - 1.50m. Light cable percussive methods 1.50m - 16.25m	Depth from / to / Diameter / Casing Depth 0.00m / 13.50m / 200mm / 13.50m 13.50m / 16.25m / 150mm / 16.25m	Ground Level - Coordinates - National Grid - Chainage			

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.00-10.45 10.00-10.30	SPT C B 9	N=5 (2,2/1,2,1,1)	10.00	damp
11.50-11.95 11.50-11.80 11.80-12.10	SPT C B 10 B 17	N=20 (2,2/9,3,4,4)	11.50	damp
12.50-12.80	B 18			
12.90 13.00-13.45 13.00-13.45	D 11 SPT S D 12	N=20 (2,3/4,4,5,7)	13.00	damp
13.80 14.00-14.45 14.00-14.30	D 13 SPT C B 19	N=30 (5,6/5,9,7,9)	14.00	damp
15.50-15.59 15.50-15.75 15.50-16.25 15.60	SPT C B 14 B 15 B 20	50 (25 for 40mm/50 for 50mm)	18/05/2007 15.50 ~~15.50~~ 21/05/2007 15.50	1700 damp ~~damp~~ 0800 10.70
16.25-16.45	SPT C	50 (13,12 for 45mm/50)	21/05/2007 16.25	1030 10.70

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Loose black brown and grey clayey slightly sandy sub angular to sub rounded fine to coarse GRAVEL of sandstone brick mudstone mortar coal and coke with occasional sub angular cobbles of sandstone and brick.			
11.50-11.95 m Medium dense			
Stiff black and brown spongy pseudo-fibrous very organic CLAY with wood fragments and mild decomposing odour.	12.90 (0.90)		
Stiff becoming very stiff brown and grey slightly sandy slightly gravelly CLAY with occasional sub rounded to rounded cobbles of sandstone. Gravel is sub rounded to rounded fine to coarse of sandstone.	13.80 (2.65)		
EXPLORATORY HOLE ENDS AT 16.45 m	16.45		

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From to (m)

Chiselling

Depths (m)	Time	Tools used
15.50 -16.25	150 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 408.24 11/01/2008 12:56:12

Project BP Llandarcy

Project No. H7043

Carried out for BP Europe Ltd

Borehole

BH14

Borehole Log

Soil Mechanics

Drilled	RD	Start	14/05/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	17/05/2007	Dando 2000 Machine excavated inspection pit GL - 1.50m. Light cable percussive methods 1.50 - 16.20m.	0.00m	14.00m	200mm	14.00m	Coordinates	-
Checked	HW				14.00m	16.20m	150mm	16.20m	National Grid	-
									Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			14/05/2007	0800
1.50-1.95 1.50-1.80	SPT C B 1	N=8 (3,4/2,1,1,4)		
2.30-3.80	B 15			
2.50-2.95 2.50-2.80	SPT C B 2	N=5 (3,2/1,1,1,2)		
3.50-3.95 3.50-3.80	SPT C B 3	N=4 (1,1/1,1,1,1)	3.00	
4.50-4.95 4.50-4.80	SPT C B 4	N=6 (1,0/1,1,1,3)	3.00	
			14/05/2007 5.00	1730 dry
			15/05/2007 5.00	0800 dry
5.50-5.95 5.50-5.80	SPT C B 5	N=5 (1,1/2,1,1,1)	5.00	
6.50-6.95 6.50-6.80	SPT C B 6	N=5 (1,1/2,1,1,1)	6.50	
7.50-7.95 7.50-7.80	SPT C B 7	N=5 (1,2/1,2,1,1)	7.50	
8.50-8.95 8.50-8.80	SPT C B 8	N=3 (1,1/1,1,0,1)	8.50	

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Loose black and brown clayey slightly sandy sub-angular to sub-rounded fine to coarse GRAVEL of brick mortar and sandstone with occasional sub-angular to sub-rounded cobbles of brick sandstone and mortar.	(4.50)		
MADE GROUND: Soft black and brown slightly sandy slightly gravelly CLAY with occasional sub-angular to sub-rounded cobbles of brick and sandstone. Gravel is sub-angular to sub-rounded fine to coarse of brick sandstone and mortar. Strong hydrocarbon odour.	4.50 (2.00)		
MADE GROUND: Loose black slightly silty slightly sandy angular fine to coarse GRAVEL of mudstone siltstone coal and coke with occasional angular cobbles of mudstone and siltstone. (COLLIERY SPOIL)	6.50 (5.10)		1
Stratum continues to 11.60 m			

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From	to (m)	
7.50	12.50	Water added to assist drilling

Chiselling Depths (m)	Time	Tools used

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:56:16

AGS

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH15

Borehole Log

Soil Mechanics

Drilled	MY	Start	23/05/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	25/05/2007	Dando 2000	0.00m	5.00m	200mm	5.00m	Coordinates	-
Checked	HW			Machine excavated inspection pit GL - 1.50m.	5.00m	11.00m	150mm	11.00m	National Grid	-
				Light cable percussive methods 1.50 - 11.00m					Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
11.00-11.41	SPT S	50 (5,8/14,13,13,10 for 35mm)	11.00	4.10
11.00	D 10		25/05/2007	1700
			11.00	4.10

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)	Legend	Backfill/ Instruments
Stiff becoming very stiff brown mottled grey slightly sandy slightly gravelly CLAY with occasional sub rounded to rounded cobbles of sandstone. Gravel is sub rounded to rounded fine to coarse of sandstone.			
EXPLORATORY HOLE ENDS AT 11.41 m	11.41		

Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From to (m)

Chiselling

Depths (m)	Time	Tools used
10.30 -10.50	30 mins	Chisel
10.80 -11.00	30 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 408.24 11/01/2008 12:56:25

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH16

Borehole Log

Soil Mechanics

Drilled	Start	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
MY	15/05/2007	Dando 2000	0.00m	12.50m	200mm	12.50m	Coordinates	-
Logged PL	End	Machine excavated inspection pit GL - 1.50m.	12.50m	26.00m	150mm	26.00m	National Grid	-
Checked HW	22/05/2007	Light cable precussive methods 1.50m - 26.00m.					Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			11/05/2007	0800
1.50-1.95 1.50-1.95	SPT C B 1	N=1 (1,0/1,0,0,0)		dry
2.00-2.45 2.00-2.45	SPT C B 2	N=2 (1,0/1,0,1,0)	2.00	dry
3.00-3.45 3.00-3.45	SPT C B 3	N=2 (1,0/1,0,1,0)	3.00	dry
4.00-4.45 4.00-4.45	SPT C B 4	N=2 (1,1/1,0,1,0)	4.00	dry
			11/05/2007 4.50	1700 dry
			14/05/2007 4.50	0800 dry
5.00-5.45 5.00-5.45	SPT C B 5	N=2 (1,0/1,0,1,0)	5.00	dry
6.00-6.45 6.00-6.45	SPT C B 6	N=5 (2,2/2,1,2,0)	6.00	dry
7.00-7.45 7.00-7.45	SPT C B 7	N=1 (1,0/1,0,0,0)	7.00	dry
8.00-8.45 8.00-8.45	SPT C B 8	N=2 (1,0/1,0,0,1)	8.00	dry
9.50-9.95 9.50-9.95	SPT C B 9	N=3 (1,1/1,0,1,1)	9.50	dry
Depth	Type & No	Records	Date Casing	Time Water

Strata

Description	Depth, Level (Thickness)	Legend	Backfill/ Instruments
MADE GROUND: Loose black slightly silty sandy angular fine to coarse GRAVEL of mudstone siltstone coal coke and sandstone with occasional angular cobbles of sandstone and mudstone. (COLLIERY SPOIL).	(11.80)		
6.00-6.45 m Loose			
Stratum continues to 11.80 m			

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From	to (m)

Chiselling

Depths (m)	Time	Tools used

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 408.24 11/01/2008 12:56:29

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH17

Borehole Log

Soil Mechanics

Drilled	MY	Start	15/05/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	22/05/2007	Dando 2000	0.00m	12.50m	200mm	12.50m	Coordinates	-
Checked	HW			Machine excavated inspection pit GL - 1.50m.	12.50m	26.00m	150mm	26.00m	National Grid	-
				Light cable precussive methods 1.50m - 26.00m.					Chainage	

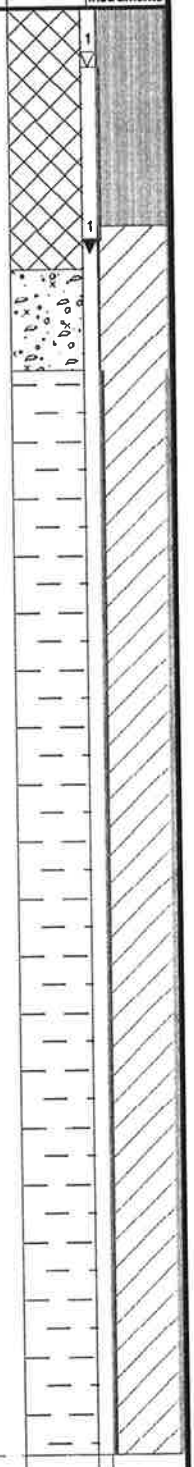
Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
11.00-11.45 11.00-11.45	SPT C B 10	N=3 (1,1/1,0,1,1)	11.00 14/05/2007 11.40 15/05/2007 11.40	dry 1700 dry 0800 10.40
12.50-12.95 12.50-12.95	SPT C B 11	N=22 (2,2/4,5,5,8)	12.50	10.40
14.00-14.45 14.00-14.45	SPT C B 12	N=24 (3,4/5,7,7,5)	14.00	10.90
15.50-15.95 15.50-15.95	SPT C B 13	N=25 (10,4/5,5,7,8)	15.50 15/05/2007 15.50 16/05/2007 15.50	10.90 1700 10.40 0800 14.70
17.00-17.45 17.00-17.45	SPT C B 14	N=38 (7,8/13,7,11,7)	17.00	14.70
18.50-18.95 18.50-18.95	SPT C B 15	N=34 (7,6/9,8,9,8)	18.50 16/05/2007 18.70 21/05/2007 18.70	14.70 1700 14.70 0800 11.70

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)
MADE GROUND: Loose black slightly silty sandy angular fine to coarse GRAVEL of mudstone siltstone coal coke and sandstone with occasional angular cobbles of sandstone and mudstone. (COLLIERY SPOIL).	
Medium dense brown sandy silt and gravel (Drillers discription).	11.80 (0.70)
Stiff becoming very stiff brown mottled grey slightly sandy slightly gravelly CLAY with occasional sub rounded to rounded cobbles of sandstone. Gravel is sub rounded to rounded fine to coarse of sandstone.	12.50 (13.92)
Stratum continues to 26.42 m	

Legend / Backfill/Instruments



Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	11.60	Rose to 10.40 m after 20 minutes.	-

Depth Related Remarks *

From to (m)

Chiselling

Depths (m)	Time	Tools used
11.00 -11.80	90 mins	Chisel
13.00 -14.20	150 mins	Chisel
14.20 -14.80	60 mins	Chisel
15.50 -16.10	90 mins	Chisel
16.20 -16.70	60 mins	Chisel
16.80 -17.00	45 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:56:31

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH17

Borehole Log

Soil Mechanics

Drilled	Start	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
MY	15/05/2007	Dando 2000	0.00m	12.50m	200mm	12.50m	Coordinates	-
Logged PL	End	Machine excavated inspection pit GL - 1.50m.	12.50m	26.00m	150mm	26.00m	National Grid	-
Checked HW	22/05/2007	Light cable precussive methods 1.50m - 26.00m.					Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
20.00-20.45 20.00-20.45	SPT C B 16	N=24 (7,10/6,6,6,6)	20.00	10.40
21.50-21.95 21.50-21.95	SPT C B 17	N=36 (6,7/8,7,9,12)	21.50	10.40
23.00-23.42 23.00-23.45	SPT C B 18	N=41 (14,11 for 45mm/19,7,8,7)	23.00	10.40
24.50-24.95 24.50-24.95	SPT C B 19	N=46 (7,10/8,5,16,17)	24.50 21/05/2007 ~~24.70~~ 22/05/2007 24.70	11.40 1700 ~~11.40~~ 0800 12.20
26.00-26.42 26.00	SPT C B 20	39 (5,6/6,6,11,16 for 44mm)	26.00 22/05/2007 26.00	12.20 1700 12.20

Depth	Type & No	Records	Date Casing	Time Water

Strata

Description (Continued from Sheet 2)	Depth, Level (Thickness)	Legend	Backfill/ Instruments
Stiff becoming very stiff brown mottled grey slightly sandy slightly gravelly CLAY with occasional sub rounded to rounded cobbles of sandstone. Gravel is sub rounded to rounded fine to coarse of sandstone.			
EXPLORATORY HOLE ENDS AT 26.42 m	26.42		

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From	to (m)

Chiselling

Depths (m)	Time	Tools used
22.20 -23.00	90 mins	Chisel
23.60 -24.10	90 mins	Chisel
24.70 -25.00	30 mins	Chisel
25.00 -25.50	60 mins	Chisel
25.50 -26.00	60 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:56:33

AGS

Project: BP Llandarcy

Project No.: H7043

Carried out for: BP Europe Ltd

Borehole

BH17

Borehole Log

Soil Mechanics

Drilled RD Logged PL Checked HW	Start 12/06/2007 End 14/06/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated trial pit GL - 1.50m. Light cable percussive methods 1.50 - 14.00m.	Depth from / to / Diameter / Casing Depth 0.00m / 6.00m / 200mm / 6.00m 6.00m / 14.00m / 150mm / 14.00m			Ground Level - Coordinates - National Grid - Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			12/06/2007	0800
1.50-1.95 1.50-1.80	SPT C B 1	N=16 (1,1/2,4,5,5)	1.50	0.20
2.50-2.95 2.50-2.80	SPT S B 2	N=16 (2,4/4,5,3,4)	2.50	0.20
3.50-3.80	B 3			
			12/06/2007 4.40	1700 damp
4.50-4.95	SPT C	N=50 (3,9/12,12,13,13)	4.50 13/06/2007 4.40	damp 0800 4.00
6.00-6.45 6.00-6.30	SPT S B 4	N=3 (1,0/0,1,1,1)	6.00	
7.00-7.45 7.00-7.30	SPT S B 5	N=3 (1,0/0,1,1,1)	7.00	
8.00-8.45 8.00-8.30	SPT S B 6	N=19 (3,3/4,5,5,5)	8.00	
9.50-9.95 9.50	SPT C B 7	N=36 (8,10/10,7,8,11)	9.50	7.00

Depth	Type & No	Records	Date Casing	Time Water

Strata

Description	Depth, Level (Thickness)
MADE GROUND: Brown and red slightly clayey slightly sandy slightly gravelly COBBLES of sandstone brick and concrete. Gravel is angular fine to coarse of brick sandstone and concrete.	(1.50)
MADE GROUND: Medium dense black slightly silty sandy sub angular to sub rounded fine to coarse GRAVEL of coke coal slag and mudstone. (COLLIERY SPOIL).	1.50
4.50-4.95 m Very dense	(4.00)
Very soft spongy black and brown slightly clayey slightly sandy pseudo-fibrous PEAT with rare wood fragments.	5.50
Medium dense dark grey slightly clayey sandy sub rounded to rounded fine to coarse GRAVEL of sandstone with occasional rounded cobbles of sandstone.	(1.90) 7.40
Dense and medium dense brown and grey clayey sandy angular fine to coarse	(2.10) 9.50
Stratum continues to 14.45 m	

Legend: SP

Backfill/ Instruments: 1

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	9.50	Rose to 7.00 m after 20 minutes.	-

Depth Related Remarks *

From	to (m)	
3.10	4.40	Water added to assist drilling
3.30		Large obstruction
4.40	9.00	Water added to assist drilling

Chiselling

Depths (m)	Time	Tools used
2.90 -3.30	60 mins	Chisel
3.30 -3.60	90 mins	Chisel
4.40 -5.20	105 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:56:38

Project: BP Llandarcy

Project No.: H7043

Carried out for: BP Europe Ltd

Borehole: **BH18**

Borehole Log

Soil Mechanics

Drilled	RD	Start	12/06/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	14/06/2007	Dando 2000	0.00m	6.00m	200mm	6.00m	Coordinates	-
Checked	HW			Machine excavated trial pit GL - 1.50m.	6.00m	14.00m	150mm	14.00m	National Grid	-
				Light cable percussive methods 1.50 - 14.00m.					Chainage	

Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
11.00-11.45	SPT C	N=22 (2,3/5,6,5,6)	13/06/2007	1700
11.00-11.50	B 8		11.00	7.00
			11.00	
			14/06/2007	0800
			11.00	7.00
12.50-12.95	SPT C	N=13 (2,1/2,3,4,4)	12.50	8.00
14.00-14.45	SPT C	N=42 (3,6/6,8,10,18)	14.00	9.10
			14/06/2007	1700
			14.00	9.10

Depth	Type & No	Records	Date Casing	Time Water

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)	Legend	Backfill/ Instruments
GRAVEL of sandstone with occasional angular to rounded cobbles of sandstone.	(4.95)		
14.00-14.45 m Very dense	14.45		
EXPLORATORY HOLE ENDS AT 14.45 m			

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)

Depth Related Remarks *

From to (m)

Chiselling

Depths (m)	Time	Tools used
10.50 -11.00	45 mins	Chisel
13.50 -14.00	60 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 409.24 11/01/2008 12.56.40

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH18

Sheet 2 of 2

Borehole Log

Soil Mechanics

Drilled RD Logged PL Checked HW	Start 31/05/2007 End 04/06/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated inspection pit GL - 1.50m, Light cable percussive methods 1.50 - 17.95m. Borehole was very heavily contaminated.	Depth from 0.00m 13.50m	to 13.50m 17.80m	Diameter 200mm 150mm	Casing Depth 13.50m 17.80m	Ground Level - Coordinates - National Grid - Chainage	

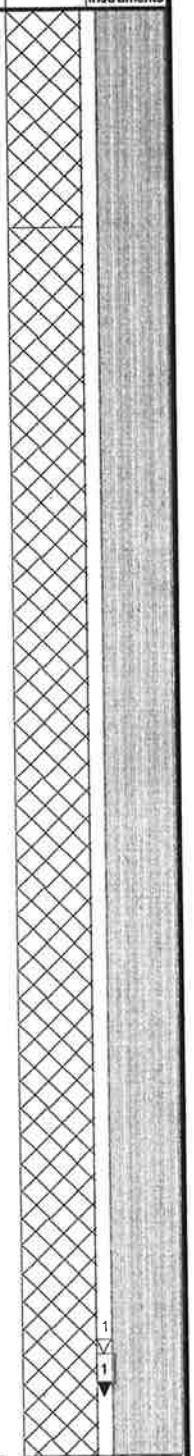
Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
			31/05/2007	0800
1.50-1.95 1.50-1.80	SPT C B 1	N=0 (1,0/-,-,-,-)		dry
2.50-2.64 2.50-2.80	SPT C B 2	50 (25/50 for 60mm)		dry
3.50-3.95 3.50-3.80	SPT C B 3	N=10 (1,1/2,4,2,2)	3.50	dry
4.50-4.95 4.50-4.80	SPT C B 4	N=5 (1,2/1,1,2,1)	3.90	dry
6.50-6.95 6.50-6.80	SPT C B 5	N=3 (1,0/1,0,1,1)	6.10	dry
7.50-7.95 7.50-7.80	SPT C B 6	N=6 (1,1/1,1,2,2)	7.50	dry
9.00-9.45 9.00-9.30	SPT C B 7	N=0 (1,0/-,-,-,-)	9.00	dry
			31/05/2007 10.00	1700 9.00

Strata

Description	Depth, Level (Thickness)
MADE GROUND: Black slightly clayey sandy sub angular fine to coarse GRAVEL of sandstone brick coal and mudstone with occasional sub angular cobbles of sandstone.	(1.50)
MADE GROUND: Very soft and soft brown and grey slightly sandy gravelly CLAY with occasional sub angular to sub rounded cobbles of sandstone brick and mudstone.	1.50
2.50-2.64 m Very stiff	
3.50-3.95 m Firm	
	(10.00)
Stratum continues to 11.50 m	

Legend / Backfill/Instruments



Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	9.50	Rose to 9.30 m after 20 minutes.	-

Depth Related Remarks *

From	to (m)	
9.50	10.00	Water added to assist drilling

Chiselling

Depths (m)	Time	Tools used
2.50 -2.80	30 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:56:45

Project: BP Llandarcy

Project No.: H7043

Carried out for: BP Europe Ltd

Borehole

BH19

Sheet 1 of 2

Borehole Log

Soil Mechanics

Drilled	RD	Start	31/05/2007	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level	-
Logged	PL	End	04/06/2007	Dando 2000 Machine excavated Inspection pit GL - 1.50m, Light cable percussive methods 1.50 - 17.95m. Borehole was very heavily contaminated.	0.00m	13.50m	200mm	13.50m	Coordinates	-
Checked	HW				13.50m	17.80m	150mm	17.80m	National Grid	-
									Chainage	

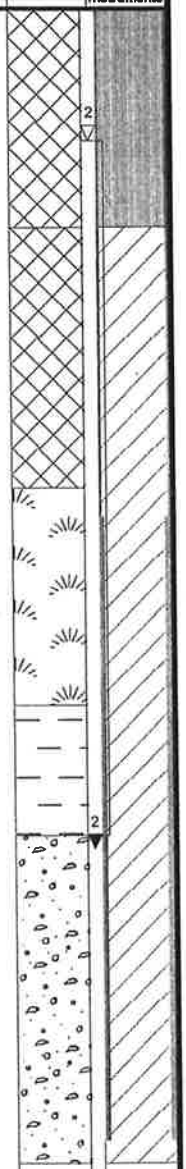
Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
10.00-10.45 10.00-10.30	SPT C B 8	N=9 (1,1/2,2,2,3)	10.00 01/06/2007 10.00	dry 0800 8.80
12.00-12.45 12.00-12.45 12.00-12.45	SPT S B 10 D 9	N=24 (4,5/7,5,6,6)	12.00	
13.50-13.95 13.50-13.95 13.50-14.00	SPT S D 11 B 12	N=35 (2,5/5,7,9,14)	13.50	
15.00-15.45 15.00-15.45 15.00 15.00-15.90	SPT S D 13 B 14 B 16	N=11 (1,1/2,3,3,3)	15.00	
16.50-16.89 16.50-17.00 16.50-17.00	SPT C B 15 B 17	50 (8,10/11,16,14,9 for 15mm)	16.50 01/06/2007 17.20 04/06/2007 17.20	1700 damp 0800 10.60
17.80-17.96	SPT C	50 (25/42,8 for 5mm)	04/06/2007 17.80	1200 10.60

Strata

Description (Continued from Sheet 1)	Depth, Level (Thickness)
MADE GROUND: Very soft and soft brown and grey slightly sandy gravelly CLAY with occasional sub angular to sub rounded cobbles of sandstone brick and mudstone.	10.00-10.45 m Firm
MADE GROUND: Medium dense black slightly silty sandy angular fine to coarse GRAVEL of mudstone siltstone coal and coke with occasional angular cobbles of mudstone.(COLLIERY SPOIL)	11.50 (1.80)
Very stiff brown and black fibrous PEAT with many fragments of wood.	13.30 (1.50)
Firm brown slightly sandy slightly gravelly CLAY with occasional sub rounded to rounded cobbles of sandstone. Gravel is sub rounded to rounded fine to coarse of sandstone.	14.80 (0.90)
Very dense brown slightly clayey slightly sandy sub rounded to rounded fine to coarse GRAVEL of sandstone with some rounded cobbles of sandstone.	15.70 (2.26)
EXPLORATORY HOLE ENDS AT 17.96 m	17.96

Legend: Backfill/Instruments



Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
2	15.70	Rose to 10.90 m after 20 minutes.	-

Depth Related Remarks *

From	to (m)	
13.50	17.20	Water added to assist drilling

Chiselling

Depths (m)	Time	Tools used
16.70 -17.20	60 mins	Chisel
17.20 -17.80	75 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk
408.24 11/01/2008 12:56:46

Project	BP Llandarcy
Project No.	H7043
Carried out for	BP Europe Ltd

Borehole

BH19

Sheet 2 of 2

Borehole Log

Soil Mechanics

Drilled RD Logged PL Checked HW	Start 04/06/2007 End 11/06/2007	Equipment, Methods and Remarks Dando 2000 Machine excavated inspection pit GL - 1.50m. Light cable percussive methods 1.50 - 8.80m	Depth from / to / Diameter / Casing Depth 0.00m / 6.00m / 200mm / 6.00m 6.00m / 8.80m / 150mm / 8.80m	Ground Level - Coordinates - National Grid - Chainage			

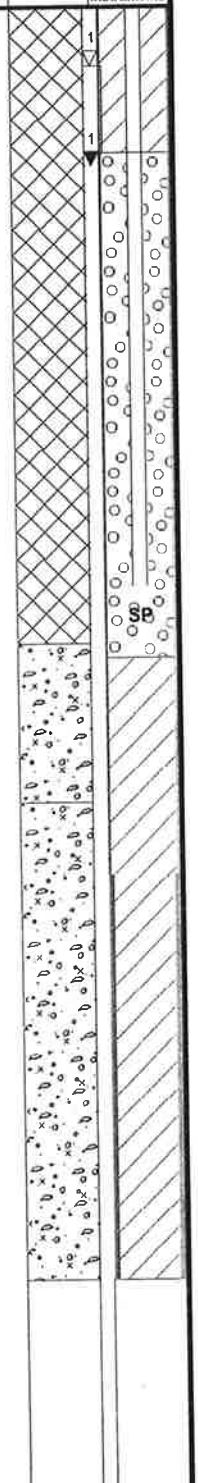
Samples and Tests

Depth	Type & No	Records	Date Casing	Time Water
0.00-1.50	B 1		04/06/2007	1200
			04/06/2007	1700
			1.50	0.40
1.50-1.95	SPT C	N=2 (1,0/0,1,0,1)	~~1.50~~	
1.50-1.80	B 2		07/06/2007	0800
			1.50	0.40
2.50-2.95	SPT C	N=14 (3,3/2,3,4,5)	2.50	
2.50-2.80	B 3			
3.50-3.95	SPT C	N=10 (1,2/2,2,3,3)	3.50	
3.50-3.80	B 4			
4.50-4.95	SPT C	N=9 (1,0/1,3,2,3)	4.50	
4.50-4.80	B 5			
5.50-5.95	SPT S	N=20 (13,8/6,4,4,6)	5.50	
5.50-5.95	D 6			
5.50-5.80	B 7			
6.50-6.95	SPT C	N=31 (2,3/6,9,8,8)	6.50	
6.50-7.00	B 11		07/06/2007	1800
6.50-6.80	D 8		6.80	
			08/06/2007	0800
			6.80	2.00
7.50-7.95	SPT C	N=27 (2,2/2,5,9,11)	7.50	
7.50-8.00	B 9			
			08/06/2007	1800
			8.50	2.00
8.50-8.65	SPT C	50 (25 for 70mm/50)	~~8.50~~	
8.50-8.80	B 10		11/06/2007	1200
			8.80	0800
			~~8.50~~	~~1.20~~

Strata

Description	Depth, Level (Thickness)
MADE GROUND: Very soft becoming firm brown slightly sandy slightly gravelly CLAY with occasional sub rounded to rounded cobbles of sandstone. Gravel is sub angular to sub rounded fine to coarse of sandstone and brick.	(4.40)
Loose brown and grey silty very sandy GRAVEL with some sub rounded cobbles of sandstone. Gravel is sub angular to subrounded fine to coarse of sandstone.	4.40 (1.10)
Medium dense becoming very dense brown very silty very sandy sub-rounded to rounded fine to coarse GRAVEL of sandstone with some rounded cobbles of sandstone. 6.50-6.95 m Dense	5.50 (3.30)
EXPLORATORY HOLE ENDS AT 8.80 m	8.80

Legend / Backfill/Instruments



Depth	Type & No	Records	Date Casing	Time Water

Groundwater Entries

No.	Struck (m)	Post strike behaviour	Depth sealed (m)
1	1.00	Rose to 0.40 m after 20 minutes.	-

Depth Related Remarks *

From	to (m)	
2.00	6.80	Water added to assist drilling

Chiselling

Depths (m)	Time	Tools used
6.30 -6.80	60 mins	Chisel
8.50 -8.80	45 mins	Chisel

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) ESGL www.esgl.co.uk 408.24 11/01/2008 12:56:51

Project: BP Llandarcy

Project No.: H7043

Carried out for: BP Europe Ltd

Borehole

BH20

Sheet 1 of 1

Appendix B – Laboratory Test Results

Project Name

BP Landarcy

Project No.

H7043

Details of Report Contents

*Tests in the following list marked * are not UKAS accredited*

ITEM		Sheet Nos	Comments
Contents	page(s)	1 to 1	

SOIL TESTS

Index Properties - Summary of Results	INDX	1 to 1	
UU triaxial compression test - Summary of Results	UUSUM	1 to 1	
Particle Size Distribution Analyses	PSD	1 to 9	
One Dimensional Consolidation test - Oedometer	OED	1 to 13	
END OF REPORT			

Soil Mechanics

Total number of pages in this report 25

INDEX PROPERTIES - SUMMARY OF RESULTS

Project No	Project Name
H7043	BP Llandarcy

Hole No.	Sample No.	Depth (m) from	Depth (m) to	type	Soil Description	ρ Mg/m³	ρ_d Mg/m³	w %	< 425 µm sieve %	W_L %	W_P %	I_P	ρ_s Mg/m³	Remarks
BH1	5	5.50	5.80	B	Brown slightly clayey sandy GRAVEL with cobbles			10	62 s	22 a	NP			Not plastic - sandy.
BH2	3	7.50	8.00	B	Brown black slightly sandy PEAT			401						
BH5	7	6.00		D	Brown black slightly sandy PEAT with a little wood			631						
BH5	13	11.50	11.80	B	Brown slightly clayey sandy GRAVEL with cobbles			10	36 s	26 a	NP			Sample not plastic
BH6	15	10.50	11.00	B	Grey brown slightly gravelly very silty PEAT with pieces of wood			108	83 s	b				Sample dilated - not plastic
BH8	11	10.00	10.45	B	Brown sandy clayey GRAVEL			15	67 s	23 a	17	6		
BH12	11	12.00	12.50	B	Black grey slightly sandy clayey PEAT with frequent wood			191						
BH12	14	15.50	16.20	B	Brown sandy clayey GRAVEL			16	43 s	26 a	17	9		
BH16	6	6.00	6.45	B	Brown sandy clayey GRAVEL			8.0	39 s	22 a	15	7		
BH16	9	9.50	9.92	B	Brown sandy clayey GRAVEL			7.5	50 s	22 a	13	9		
BH17	14	17.00	17.45	B	Brown sandy clayey GRAVEL			9.3	41 s	21 a	14	7		
BH18	6	8.00	8.30	B	Brown sandy clayey GRAVEL			21	58 s	25 a	16	9		
BH20	4	3.50	3.80	B	Brown slightly sandy slightly clayey gravelly COBBLES			14	36 s	23 a	15	8		

General notes: All above tests carried out to BS1377 : 1990 definitive method in all cases unless annotated otherwise. See individual test reports for further details.

Key :

ρ	bulk density, linear	W_L Liquid limit	W_P	Plastic limit	<425um preparation	ρ_s particle density
ρ_d	dry density	a 4 point cone test	NP	non - plastic	n from natural soil	-g = gas jar
w	moisture content	b 1 point cone test	I_P	Plasticity Index	s sieved specimen	-p = small pyknometer

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TESTS WITHOUT MEASUREMENT OF PORE PRESSURE - SUMMARY OF RESULTS

Project No	Project Name
H7043	BP Llandarcy

Hole No.	Sample No.	Depth (m) from	Depth (m) to	type	Soil Description	Density bulk Mg/m³	Density dry Mg/m³	w %	Test type	Dia. mm	σ_3 kPa	At failure / end of stage: Axial strain %	$\sigma_1 - \sigma_3$ kPa	C_u kPa	MODE	Remarks
BH2	4	8.00	8.60	U	Black PEAT	1.15	0.34	240	UU	103.8	160	11.4	56	28	P	
BH3	9	8.00	8.50	U	Brown PEAT	1.03	0.43	140	UU	102.0	160	19.0	213	107	P	
BH3	11	9.00	9.50	U	Brown black PEAT	1.09	0.27	310	UU	102.0	180	11.0	44	22	P	
BH5	4	4.50		U	Brown PEAT with wood pieces	0.99	0.18	460	UU	102.4	90	16.7	44	22	P	Centre of sample mainly single piece of wood.
BH5	6	5.50		U	Brown PEAT	1.04	0.22	370	UU	101.8	110	14.3	30	15	P	
BH5	8	6.50		U	Soft dark brown organic CLAY	1.06	0.21	400	UU	101.4	130	17.6	14	7	P	
BH5	11	8.50		U	Soft brown CLAY	2.01	1.59	27	UU	99.9	170	12.8	22	11	P	
BH6	10	8.30	8.80	U	Very soft dark brown organic CLAY	1.02	0.23	340	UU	100.0	160	8.5	30	15	C	
BH6	12	9.00	9.50	U	Soft dark brown organic CLAY	1.05	0.23	360	UU	101.4	180	13.6	67	34	P	
BH7	9	10.50	11.00	U	Soft dark brown organic CLAY with wood	1.06	0.21	410	UU	102.4						
BH8	7	7.50	8.00	U	Soft dark brown organic CLAY	1.27	0.35	260	UU	101.5	150	12.5	56	28	P	
BH9	4	5.50	6.10	U	Soft dark brown organic CLAY	1.08	0.28	290	UU	102.8	110	7.6	44	22	C	
BH9	6	7.50	8.10	U	Soft dark brown organic CLAY	1.31	0.51	160	UU	102.4	150	8.6	8	4	P	

General notes: Tests carried out in accordance with BS1377: Part 7: 1990, clause 8 for single stage, clause 9 for multistage tests. Specimens nominally 2:1 height diameter ratio and tested at a rate of strain of 2%/minute, unless annotated otherwise. See individual test reports for further details.

Legend

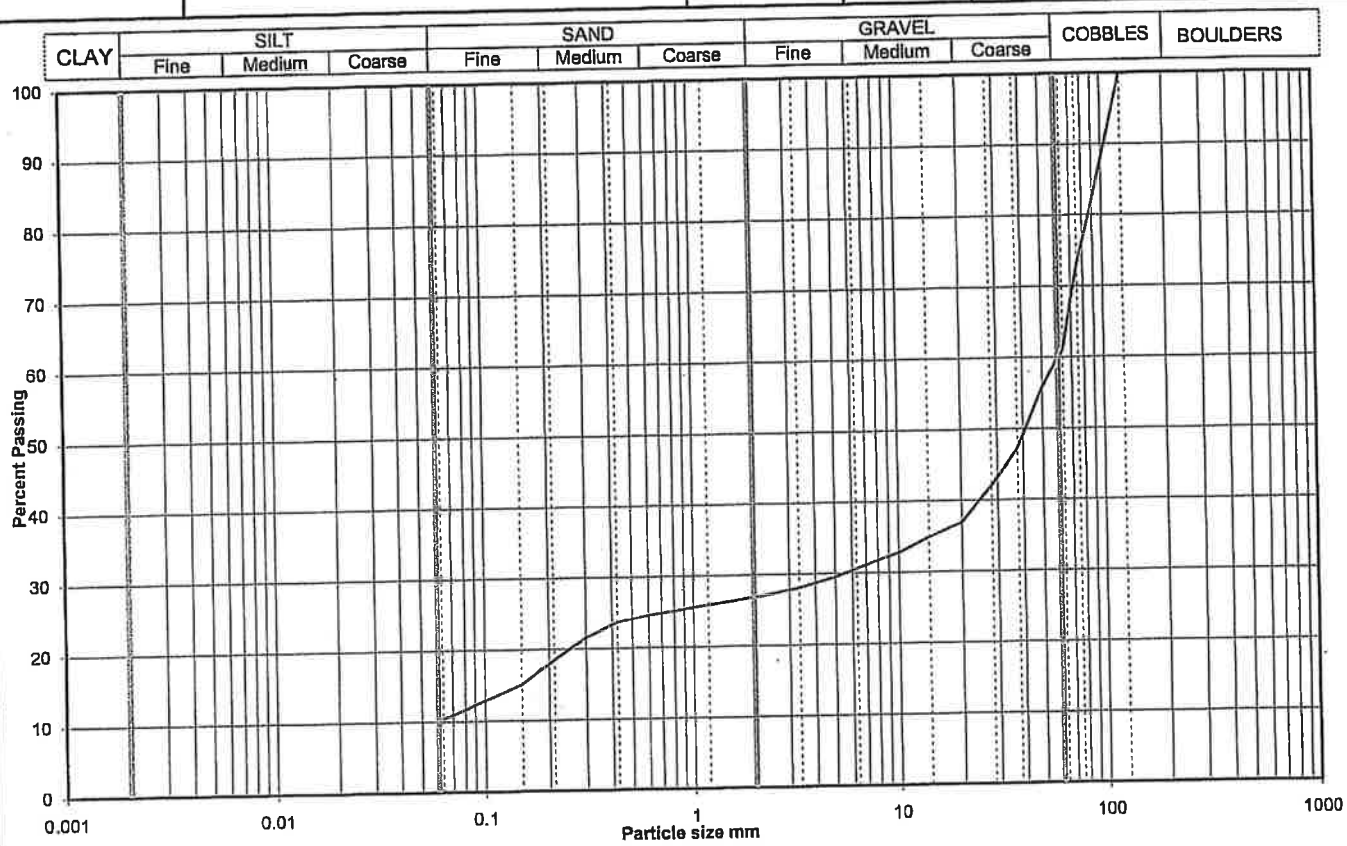
UU - single stage test (may be in sets of specimens)
UUM - multistage test on a single specimen
suffix R - remoulded or recompacted

σ_3 cell pressure
$\sigma_1 - \sigma_3$ deviator stress
C_u undrained shear strength

Mode of failure: P plastic; B brittle; C compound

Particle Size Distribution Analysis

Project No	H7043	Sample Details:	Hole No	BH1		
Project Name	BP Llandarcy		Depth (m BGL)	4.50		
			Samp No	4	Type	B
			ID	ESGH704320070620000000136		
			Spec Ref			



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	82		
75	73		
63	61		
50	56		
37.5	47		
28	42		
20	37		
14	35		
10	33		
6.3	31		
5.0	29		
3.35	28		
2.00	27		
1.18	26		
0.600	25		
0.425	24		
0.300	22	Dry mass of sample, kg	
0.212	19		
0.150	15	8.0	
0.063	10		

Soil description	Brown clayey very sandy GRAVEL with many cobbles		
Preparation / Pretreatment	Sieve: natural material		
Remarks			
Sample Proportions *<60mm values to aid description only		Whole	*<60mm
	Cobbles / boulders	40	0
	Gravel	33	55
	Sand	16	27
	Silt	silt+clay =	
	Clay	11	18

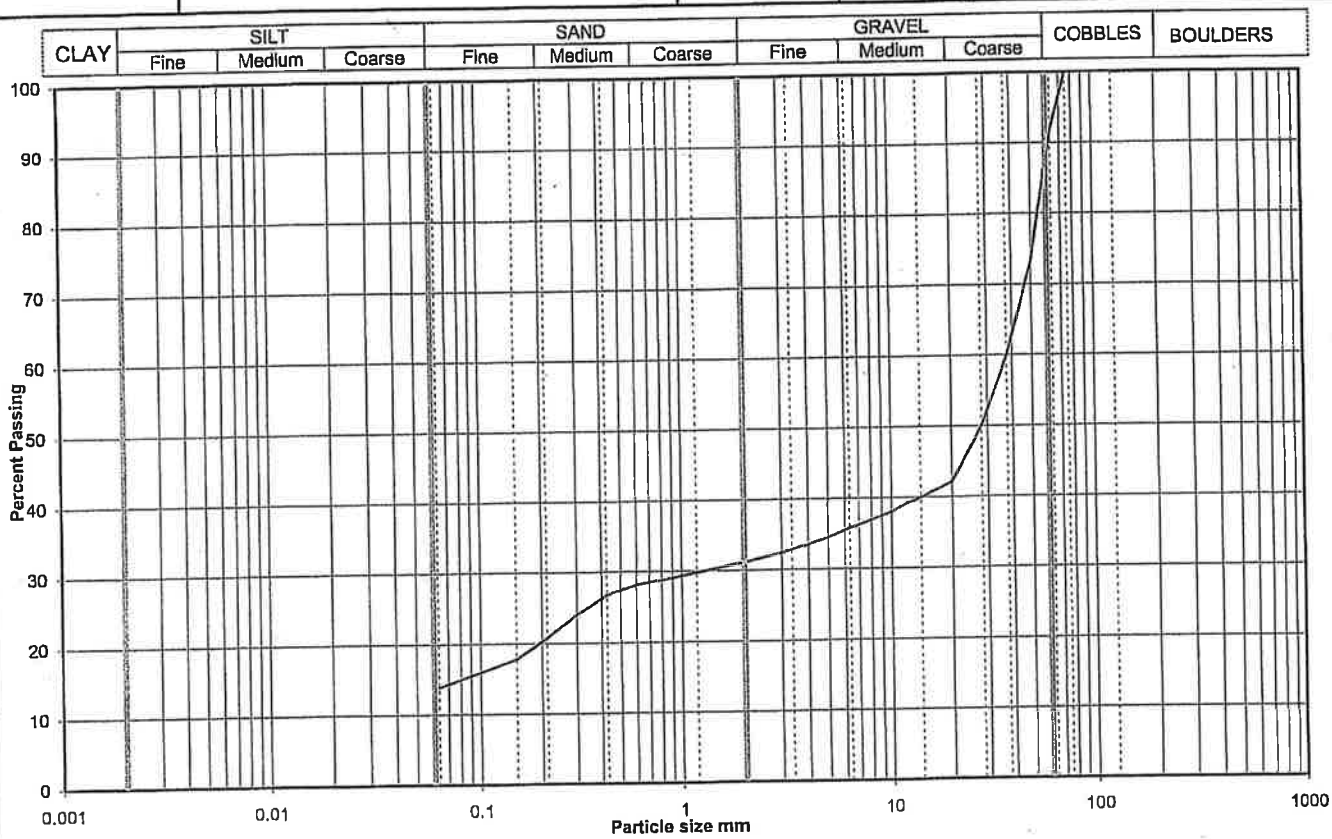
Uniformity Coefficient	D_{60} / D_{10}	#N/A

Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	none

QA Ref SLR 2.9 Rev 72 Jul 07	Soil Mechanics	UKAS TESTING 4089	Printed:10/01/2008 09:53	Figure **PSD 1**

Particle Size Distribution Analysis

Project No	H7043	Sample Details:	Hole No	BH2		
Project Name	BP Llandarcy		Depth (m BGL)	9.50		
			Samp No	7	Type	B
			ID	ESGH704320070625000000160		
			Spec Ref			



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	92		
50	73		
37.5	60		
28	50		
20	42		
14	40		
10	38		
6.3	36		
5.0	34		
3.35	33		
2.00	31		
1.18	30		
0.600	28		
0.425	27		
0.300	24	Dry mass of sample, kg	
0.212	21		
0.150	18	6.2	
0.063	14		

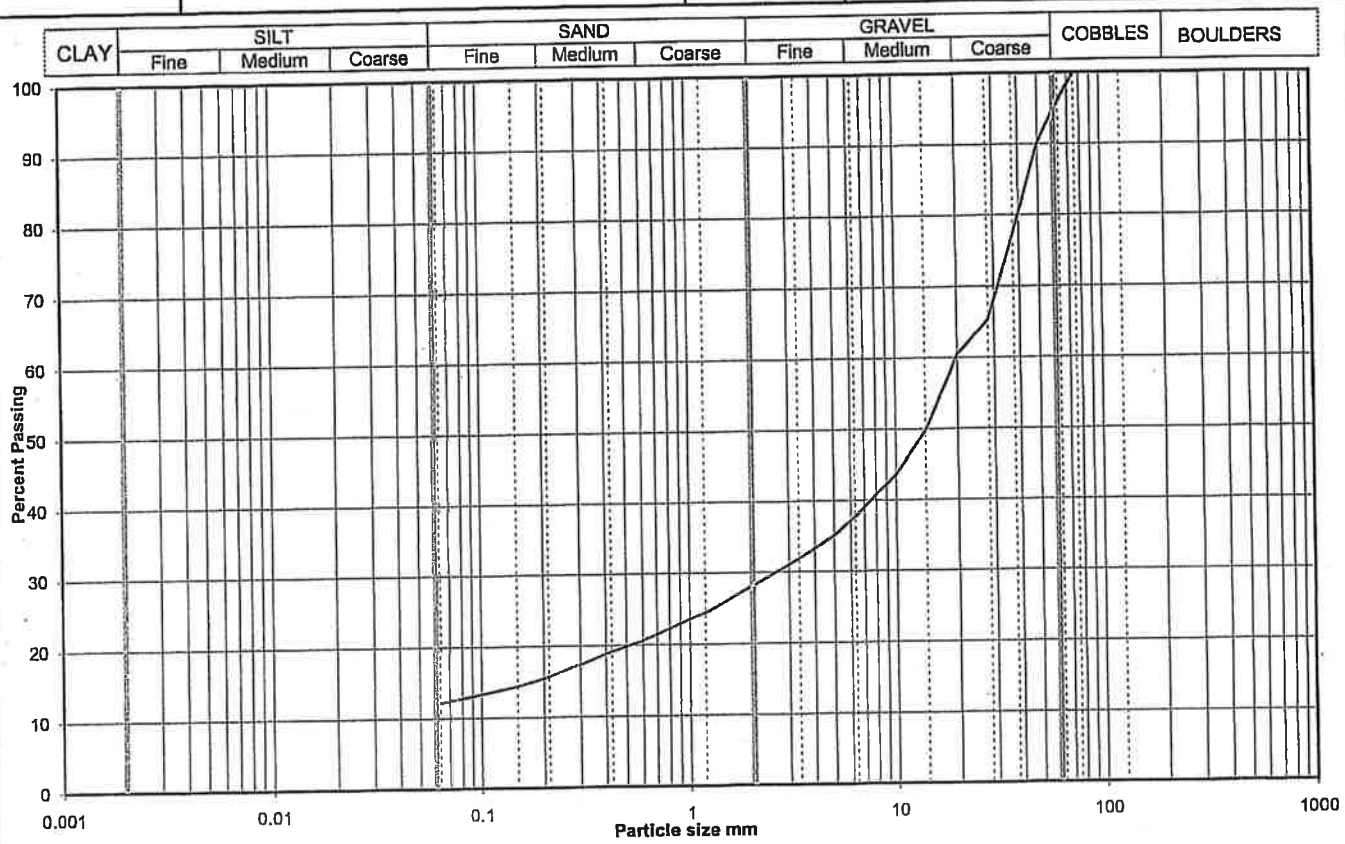
Soil description	Grey sandy clayey GRAVEL with some cobbles		
Preparation / Pretreatment	Sieve: natural material		
Remarks			
Sample Proportions *<60mm values to aid description only		Whole	*<60mm
	Cobbles / boulders	12	0
	Gravel	57	65
	Sand	17	19
	Silt	silt+clay =	
	Clay	14	16

Uniformity Coefficient	D_{60} / D_{10}	#N/A

Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	none

Particle Size Distribution Analysis

Project No	H7043	Sample Details:	Hole No	BH5		
Project Name	BP Llandarcy		Depth (m BGL)	14.50		
			Samp No	15	Type	B
			ID	ESGH704320070702000000191		
			Spec Ref			



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	96		
50	90		
37.5	77		
28	65		
20	60		
14	50		
10	44		
6.3	38		
5.0	35		
3.35	32		
2.00	28		
1.18	24		
0.600	21		
0.425	19		
0.300	17	Dry mass of sample, kg	
0.212	16		
0.150	14	10.5	
0.063	12		

Soil description	Brown sandy clayey GRAVEL with some cobbles		
Preparation / Pretreatment	Sieve: natural material		
Remarks			
Sample Proportions *<60mm values to aid description only		Whole	*<60mm
	Cobbles / boulders	5	0
	Gravel	67	71
	Sand	16	17
	Silt	silt+clay =	
	Clay	12	13

Uniformity Coefficient	D_{60} / D_{10}	#N/A

Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	none

QA Ref SLR 2.9 Rev 72 Jul 07

Soil Mechanics

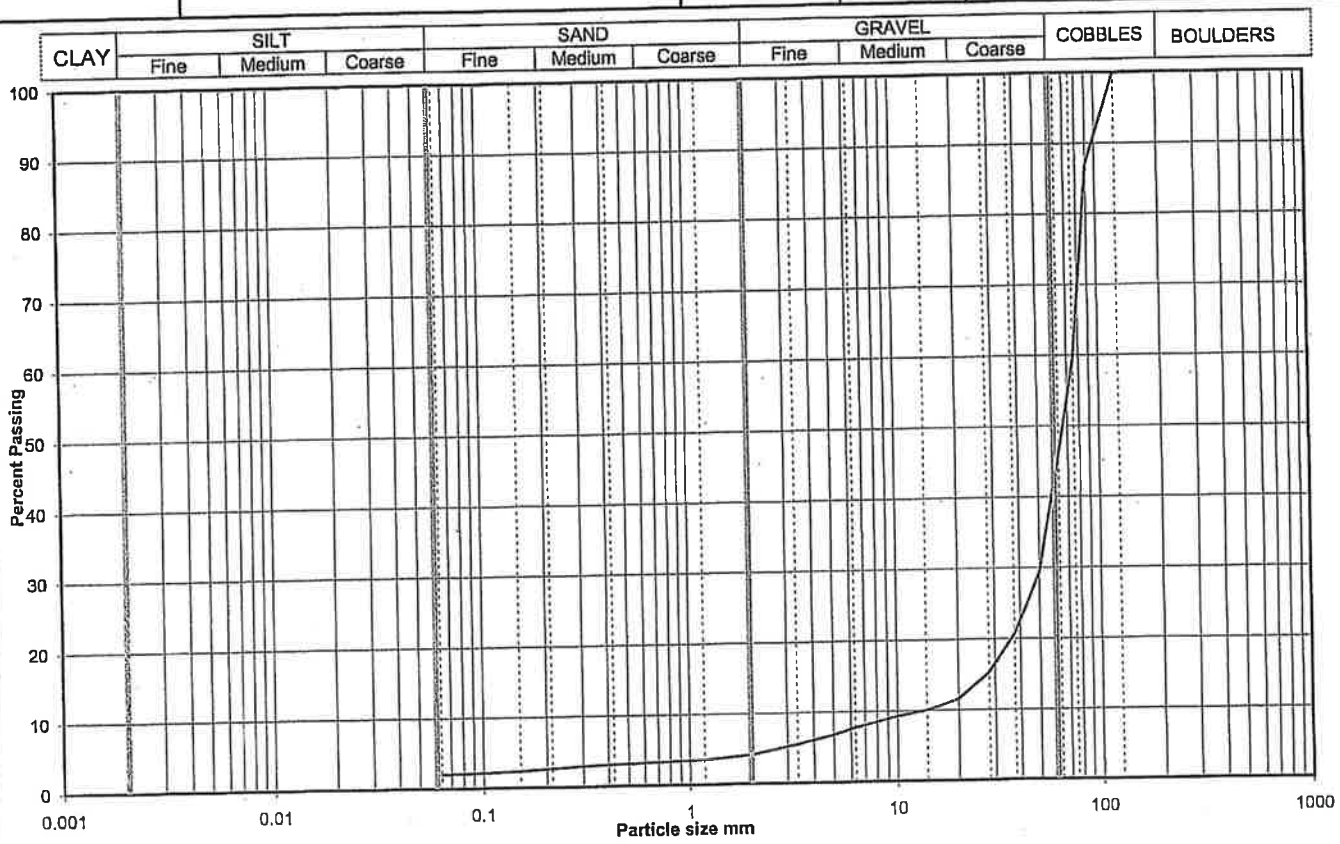
UKAS 4059

Printed:10/01/2008 09:53

Figure **PSD 3**

Particle Size Distribution Analysis

Project No	H7043	Sample Details:	Hole No	BH6		
Project Name	BP Llandarcy		Depth (m BGL)	13.00		
			Samp No	17	Type	B
			ID	ESGH704320070618000000118		
			Spec Ref			



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	87		
75	60		
63	46		
50	29		
37.5	21		
28	15		
20	12		
14	10		
10	9		
6.3	8		
5.0	7		
3.35	6		
2.00	4		
1.18	4		
0.600	3		
0.425	3		
0.300	3	Dry mass of sample, kg	
0.212	3		
0.150	2	8.0	
0.063	2		

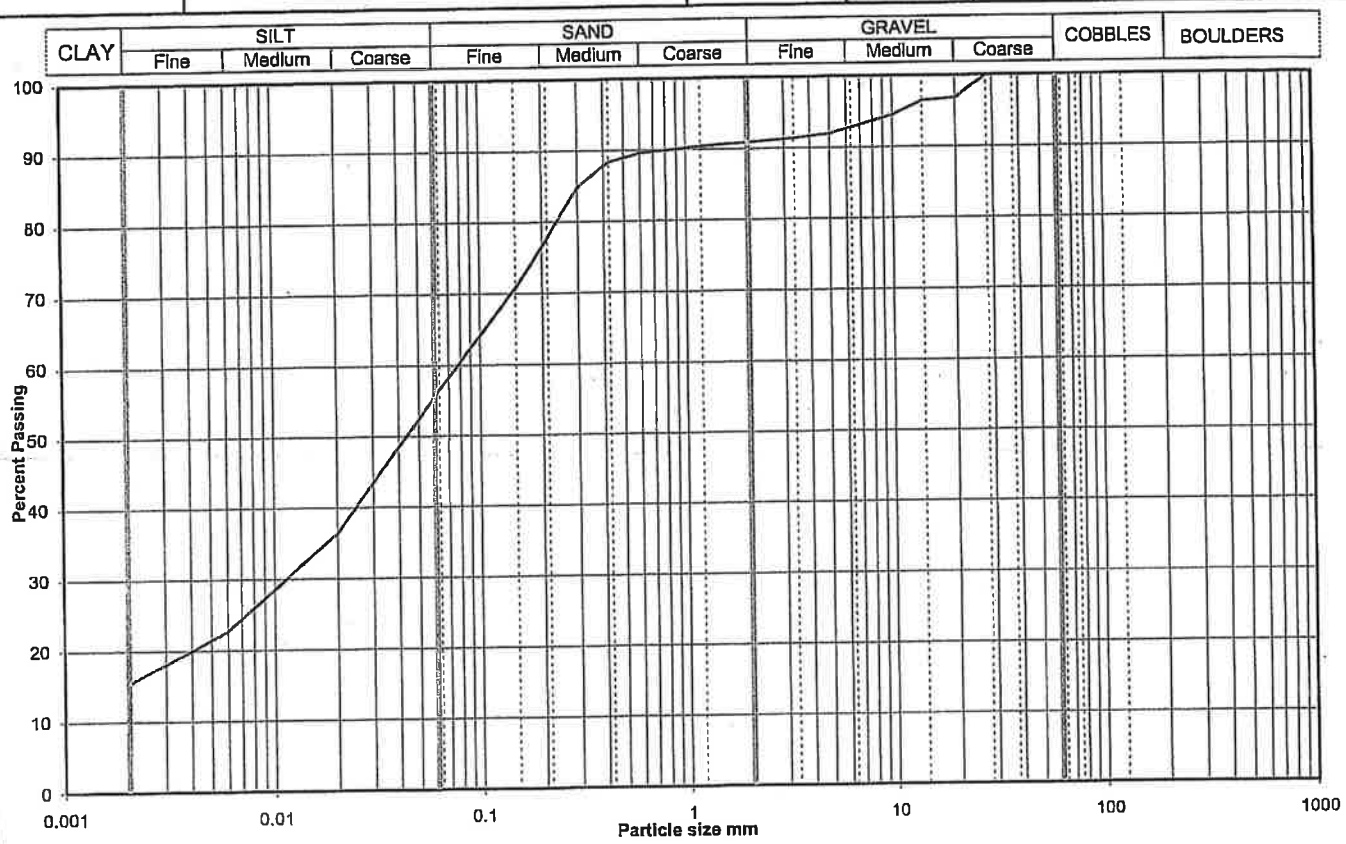
Soil description	COBBLES with slightly clayey slightly sandy GRAVEL		
Preparation / Pretreatment	Sieve: natural material		
Remarks			
Sample Proportions *<60mm values to aid description only		Whole	*<60mm
	Cobbles / boulders	57	0
	Gravel	39	91
	Sand	2	5
	Silt	silt+clay =	
	Clay	2	5

Uniformity Coefficient	D_{60} / D_{10}	6

Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	none

Particle Size Distribution Analysis

Project No	H7043	Sample Details:	Hole No	BH7		
Project Name	BP Llandarcy		Depth (m BGL)	12.00		
			Samp No	12	Type	B
			ID	ESGH704320070619000000131		
			Spec Ref			



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0201	36
90	100	0.0060	23
75	100	0.0020	15
63	100		
50	100		
37.5	100		
28	100		
20	97		
14	96		
10	94		
6.3	93		
5.0	92		
3.35	91		
2.00	91		
1.18	90	Particle density, Mg/m3	
0.600	90	2.65	assumed
0.425	88	Dry mass of sample, kg	
0.300	85	1.1	
0.212	78		
0.150	71		
0.063	57		

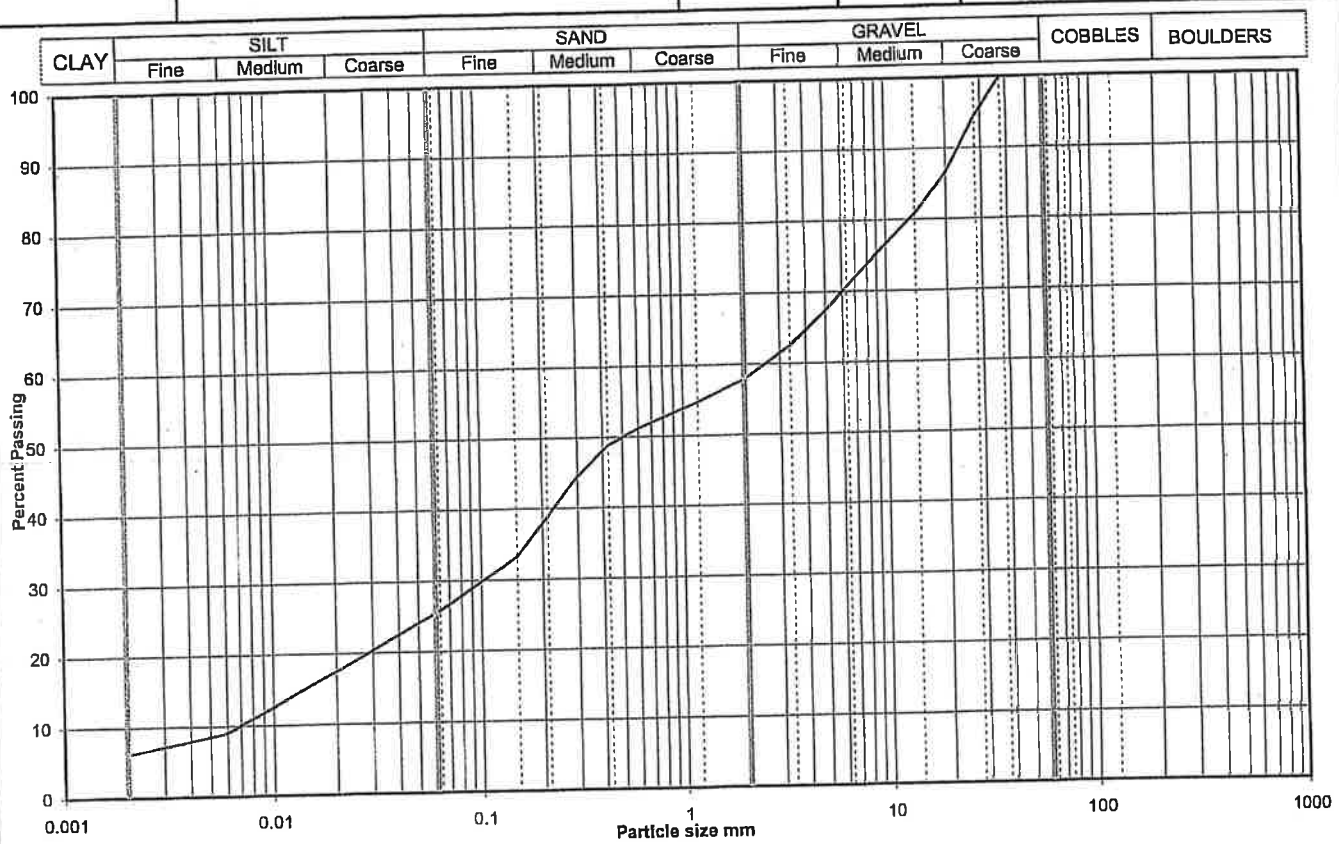
Soil description	Brown slightly gravelly sandy SILT		
Preparation / Pretreatment	Sieve: natural material Pipette: as BS1377		
Remarks			
Sample Proportions *<60mm values to aid description only		Whole	*<60mm
	Cobbles / boulders	0	0
	Gravel	9	9
	Sand	35	35
	Silt	41	41
	Clay	15	15

Uniformity Coefficient	D_{60} / D_{10}	#N/A

Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	9.4 pipette

Particle Size Distribution Analysis

Project No	H7043	Sample Details:	Hole No	BH9	
Project Name	BP Llandarcy		Depth (m BGL)	10.50	
			Samp No	11	Type B
			ID	ESGH704320070627000000186	
			Spec Ref		



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0201	17
90	100	0.0060	9
75	100	0.0020	6
63	100		
50	100		
37.5	100		
28	94		
20	87		
14	81		
10	77		
6.3	71		
5.0	67		
3.35	62		
2.00	58		
1.18	55	Particle density, Mg/m3	
0.600	51	2.65 assumed	
0.425	49		
0.300	44	Dry mass of sample, kg	
0.212	39	5.2	
0.150	33		
0.063	26		

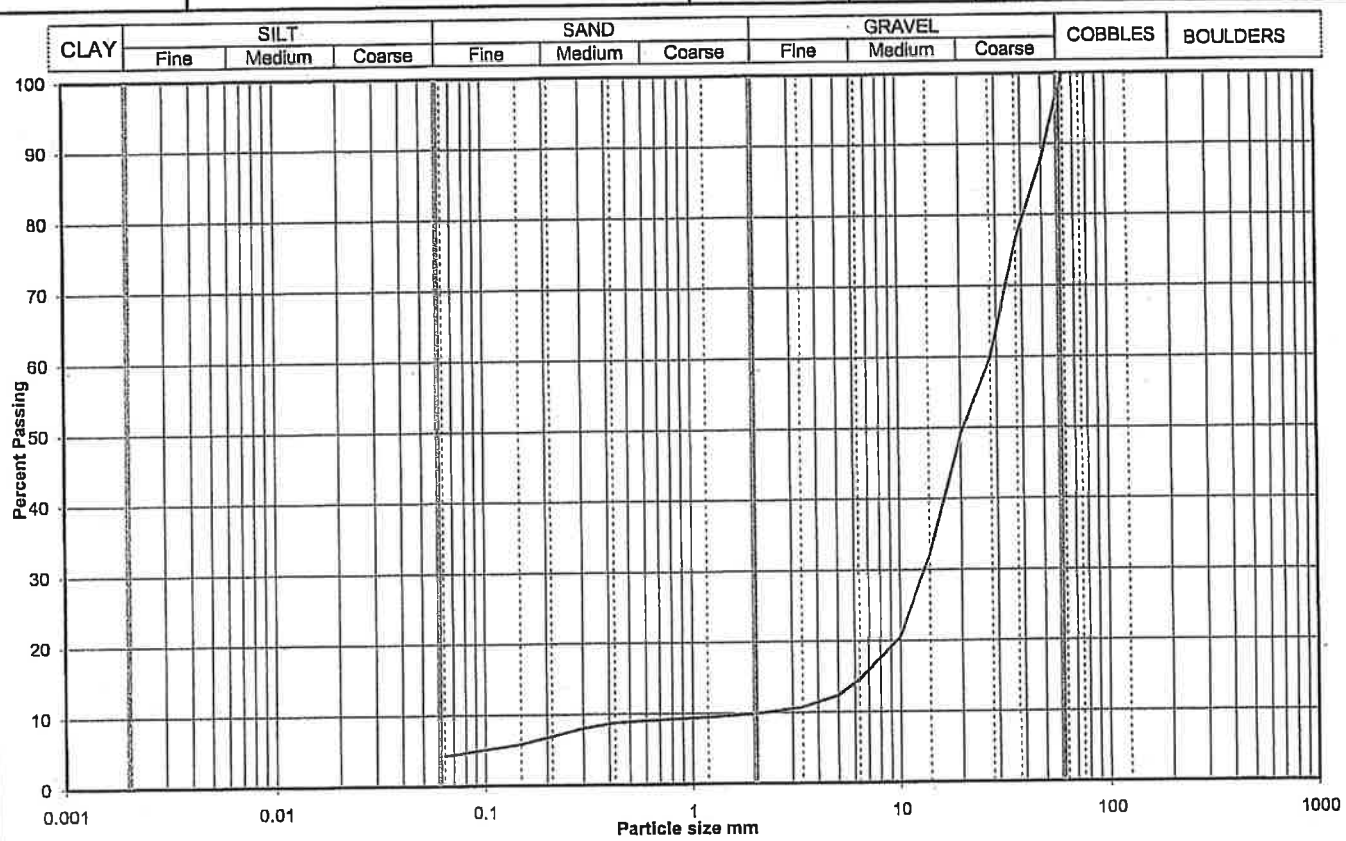
Soil description	Grey brown very silty very sandy GRAVEL		
Preparation / Pretreatment	Sieve: natural material Pipette: as BS1377		
Remarks			
Sample Proportions *<60mm values to aid description only		Whole	*<60mm
	Cobbles / boulders	0	0
	Gravel	42	42
	Sand	32	32
	Silt	20	20
	Clay	6	6

Uniformity Coefficient	D_{60} / D_{10}	366

Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	9.4 pipette

Particle Size Distribution Analysis

Project No	H7043	Sample Details:	Hole No	BH18		
Project Name	BP Llandarcy		Depth (m BGL)	9.50		
			Samp No	7	Type	B
			ID	ESGH704320070620000000144		
			Spec Ref			



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	88		
37.5	77		
28	60		
20	49		
14	32		
10	21		
6.3	15		
5.0	12		
3.35	11		
2.00	10		
1.18	9		
0.600	9		
0.425	9		
0.300	8	Dry mass of sample, kg	
0.212	7		
0.150	6	3.0	
0.063	4		

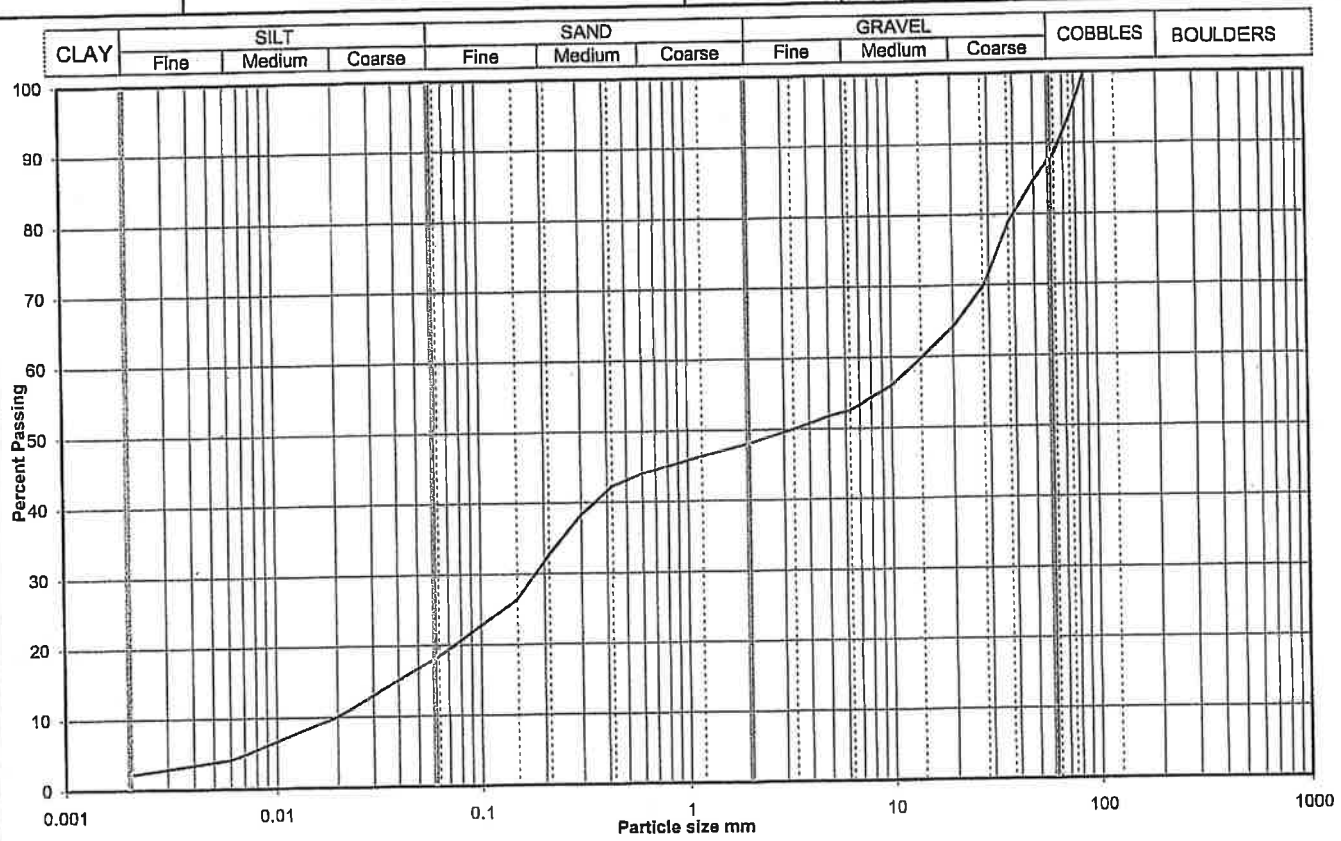
Soil description	Brown slightly clayey sandy GRAVEL with occasional cobbles		
Preparation / Pretreatment	Sieve: natural material		
Remarks			
Sample Proportions *<60mm values to aid description only		Whole	*<60mm
	Cobbles / boulders	3	0
	Gravel	87	90
	Sand	6	6
	Silt	silt+clay =	
	Clay	4	4

Uniformity Coefficient	D_{60} / D_{10}	13

Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	none

Particle Size Distribution Analysis

Project No	H7043	Sample Details:	Hole No	BH20	
Project Name	BP Llandarcy		Depth (m BGL)	4.50	
			Samp No	5	Type B
			ID	ESGH704320070621000000150	
			Spec Ref		



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0201	10
90	100	0.0060	4
75	94	0.0020	2
63	88		
50	85		
37.5	79		
28	70		
20	64		
14	60		
10	56		
6.3	53		
5.0	52		
3.35	50		
2.00	48		
1.18	46	Particle density, Mg/m3	
0.600	44	2.65 assumed	
0.425	42		
0.300	38	Dry mass of sample, kg	
0.212	33	9.5	
0.150	26		
0.063	19		

Soil description	Brown very silty very sandy GRAVEL with some cobbles
Preparation / Pretreatment	Sieve: natural material Pipette: as BS1377
Remarks	

Sample Proportions		Whole	*<60mm
*<60mm values to aid description only	Cobbles / boulders	12	0
	Gravel	40	45
	Sand	30	34
	Silt	16	18
	Clay	2	2

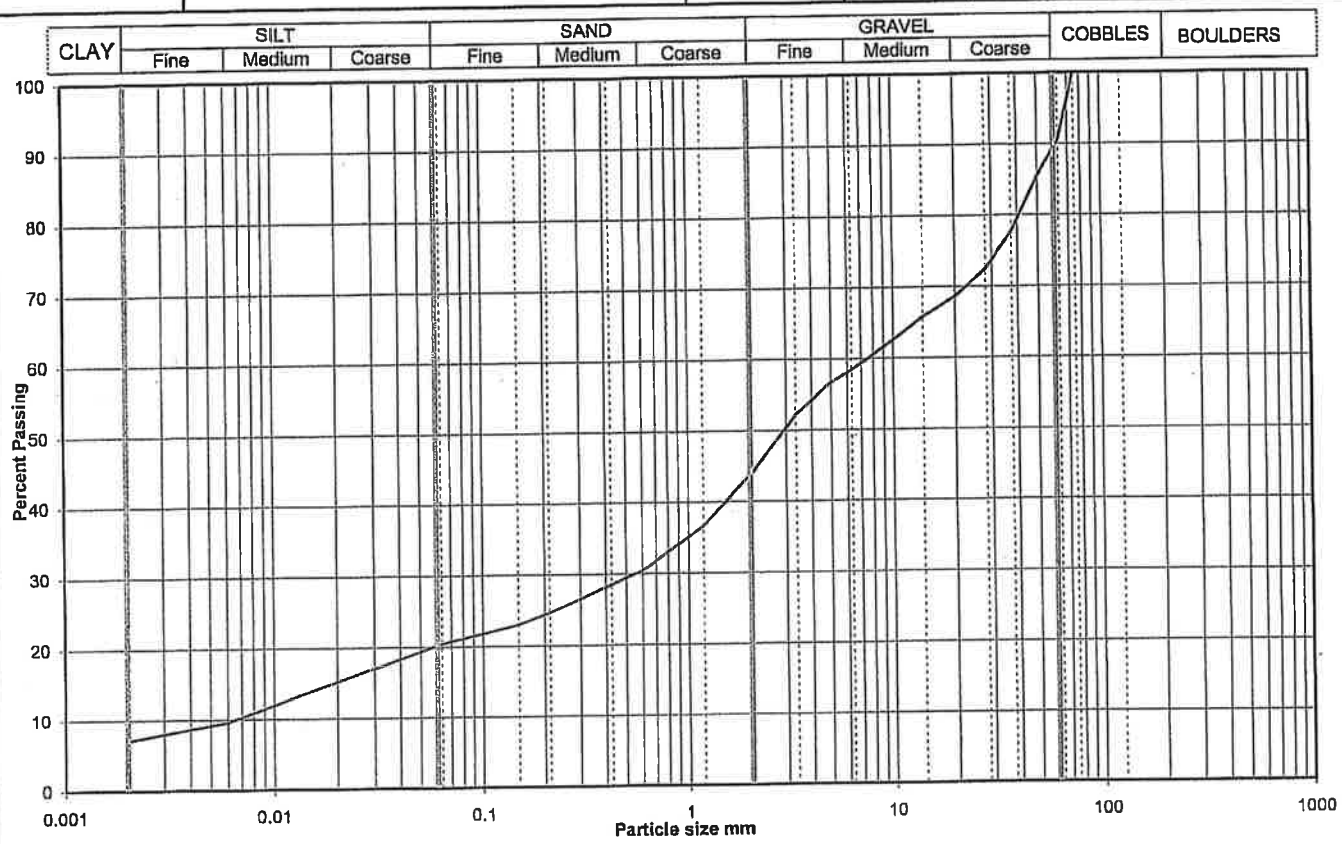
Uniformity Coefficient	D_{60} / D_{10}	714

Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	9.4 pipette

QA Ref SLR 2.9 Rev 72 Jul 07	Soil Mechanics	UKAS TESTING 4089	Printed:10/01/2008 09:53	Figure PSD 8

Particle Size Distribution Analysis

Project No	H7043	Sample Details:	Hole No	BH20		
Project Name	BP Llandarcy		Depth (m BGL)	7.50		
			Samp No	9	Type	B
			ID	ESGH704320070621000000154		
			Spec Ref			



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100	0.0201	15
90	100	0.0060	10
75	100	0.0020	7
63	91		
50	85		
37.5	78		
28	72		
20	69		
14	66		
10	63		
6.3	58		
5.0	57		
3.35	52		
2.00	44		
1.18	37	Particle density, Mg/m3	
0.600	30	2.65 assumed	
0.425	29		
0.300	27	Dry mass of sample, kg	
0.212	25		
0.150	23	11.7	
0.063	20		

Soil description	Brown very silty very sandy GRAVEL with some cobbles		
Preparation / Pretreatment	Sieve: natural material Pipette: as BS1377		
Remarks			
Sample Proportions *<60mm values to aid description only		Whole	*<60mm
	Cobbles / boulders	11	0
	Gravel	45	51
	Sand	24	27
	Silt	13	15
	Clay	7	8

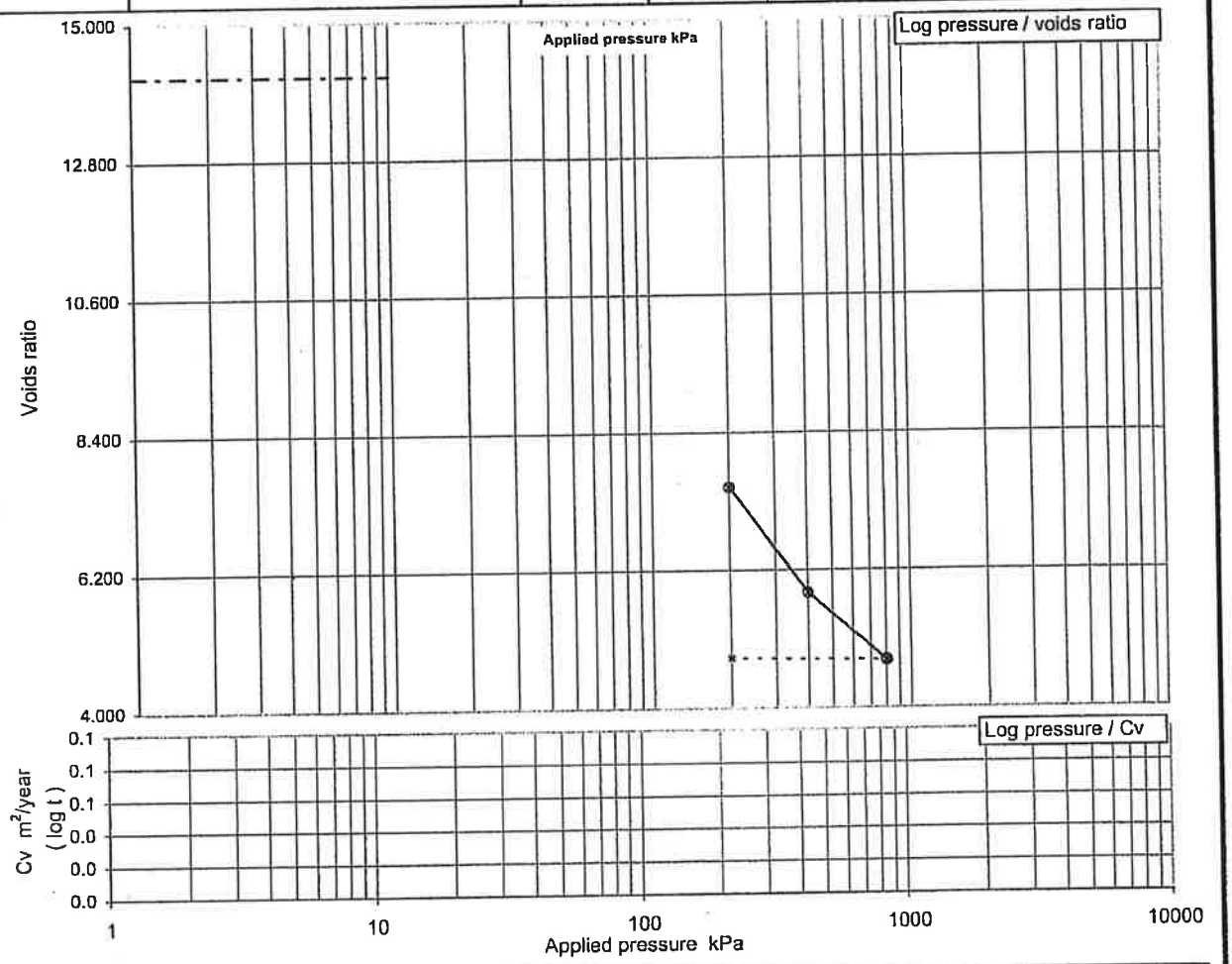
Uniformity Coefficient	D_{60} / D_{10}	1147

Test Method	BS 1377 : Part 2 : 1990	
	Sieving	9.2 wet sieve
	Sedimentation	9.4 pipette

QA Ref SLR 2.9 Rev 72 Jul 07	Soil Mechanics	UKAS TESTING 4089	Printed:10/01/2008 09:53	Figure **PSD 9**

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH2	
Project Name	BP Llandarcy		Depth (m BGL)	8.00	
			Samp No	4	Type U
			ID	ESGH704320070625000000157	
			Spec Ref		



Soil description: Black PEAT — Liquid limit %:
Preparation: — Plastic limit %:

Specimen details	Initial	Final	
Particle density	2.65	assumed	Mg/m³
Diameter	74.86		mm
Height	19.25	7.37	mm
Voids ratio	14.140	4.794	
Moisture content	457	190	%
Bulk density	0.97	1.33	Mg/m³
Dry density	0.18	0.46	Mg/m³
Saturation	86	105	%
Average temperature for test	20		°C

Swelling pressure: not measured kPa

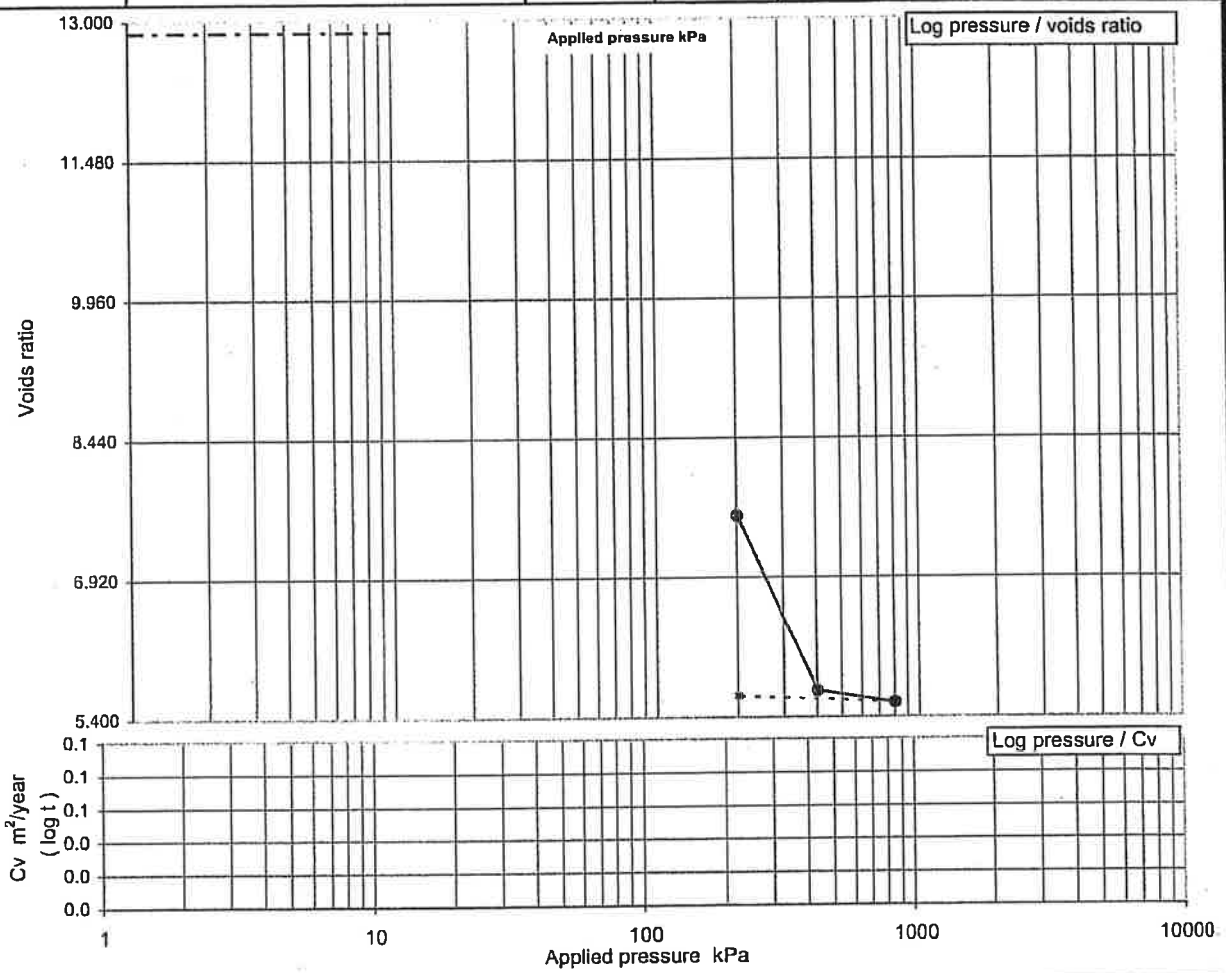
Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50, log}$) m²/year	C_v ($t_{90, root}$) m²/year	
0	14.1400				
200	7.5216	2.186	-	12	
400	5.8307	0.992	-	0.76	
800	4.7571	0.393	-	0.58	
200	4.7941	0.011	-	-	

Notes : Consol frame reached extent of travelling during third loading stage. Proceeded to unloading stage.

Specimen taken 425 mm from base of sample

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH3		
Project Name	BP Llandarcy		Depth (m BGL)	8.00		
			Samp No	9	Type	U
			ID	ESGH704320070709000000214		
			Spec Ref			



Soil description	Brown PEAT	Liquid limit %	
Preparation		Plastic limit %	

Specimen details	Initial	Final	
Particle density	2.65	assumed	Mg/m³
Diameter	74.87		mm
Height	18.96	9.06	mm
Voids ratio	12.877	5.629	
Moisture content	434	204	%
Bulk density	1.02	1.22	Mg/m³
Dry density	0.19	0.40	Mg/m³
Saturation	89	96	%
Average temperature for test	20		°C

Swelling pressure: not measured kPa

Notes : Consol frame reached extent of travel during third loading stage. Proceeded to unloading stage.

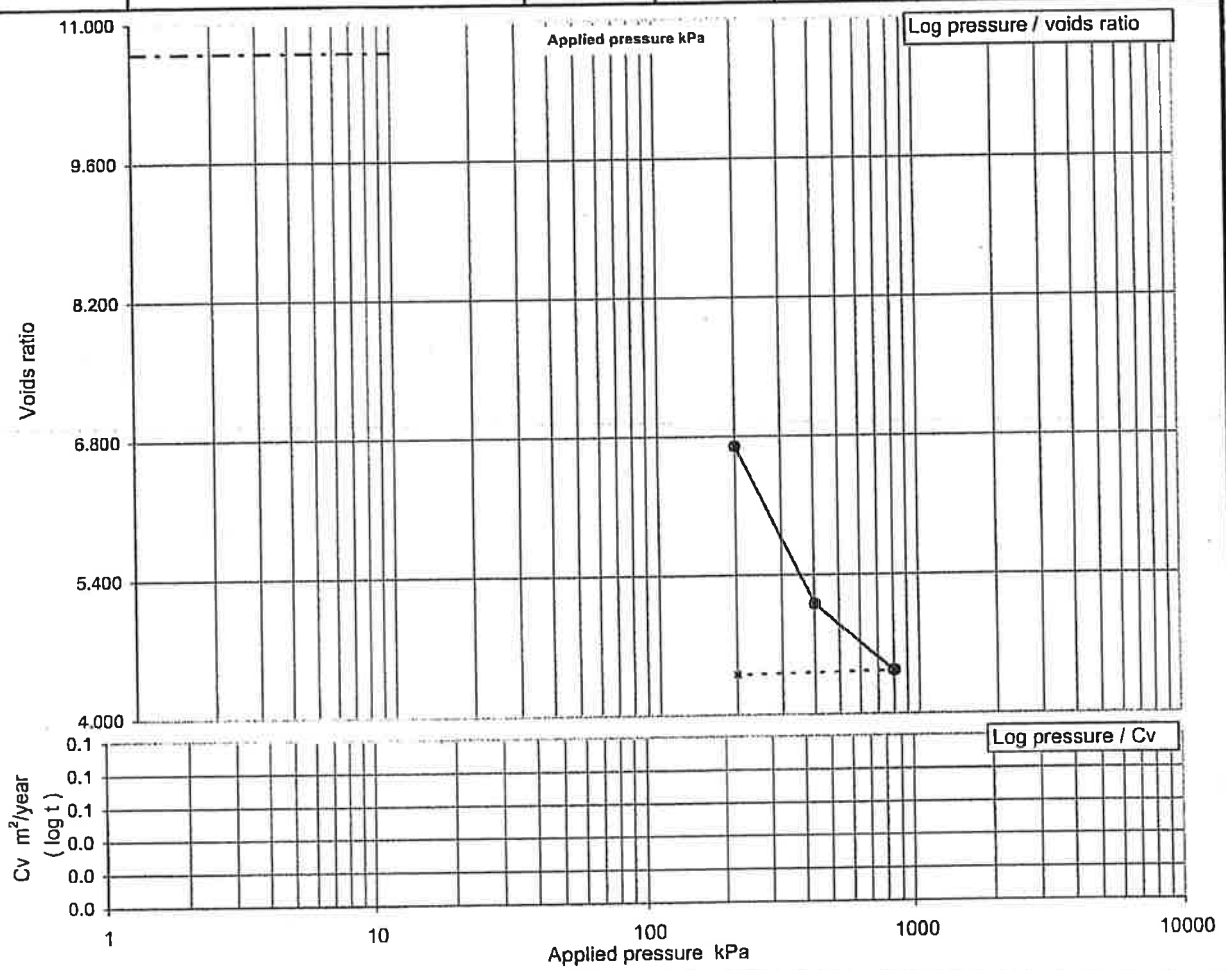
Specimen taken 425 mm from base of sample

Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50, log}$) m²/year	C_v ($t_{90, root}$) m²/year	
0	12.8772				
200	7.5861	1.906	-	4.6	
400	5.6788	1.111	-	0.58	
800	5.5499	0.048	-	4.8	
200	5.6290	0.020	-	-	

QA Ref				Figure
SLR 5.3 Rev 104 Jul 07	Soil Mechanics	UKAS 4089	Printed:20/11/2007 16:52	OED 2

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH3	
Project Name	BP Llandarcy		Depth (m BGL)	9.00	
			Samp No	11	Type U
			ID	ESGH704320070709000000216	
			Spec Ref		



Soil description: Brown black PEAT — Liquid limit %

Preparation — Plastic limit %

Specimen details	Initial	Final	
Particle density	2.65	assumed	Mg/m³
Diameter	74.90		mm
Height	18.99	8.77	mm
Voids ratio	10.695	4.401	
Moisture content	365	169	%
Bulk density	1.05	1.32	Mg/m³
Dry density	0.23	0.49	Mg/m³
Saturation	91	102	%
Average temperature for test	20		°C

Swelling pressure: not measured kPa

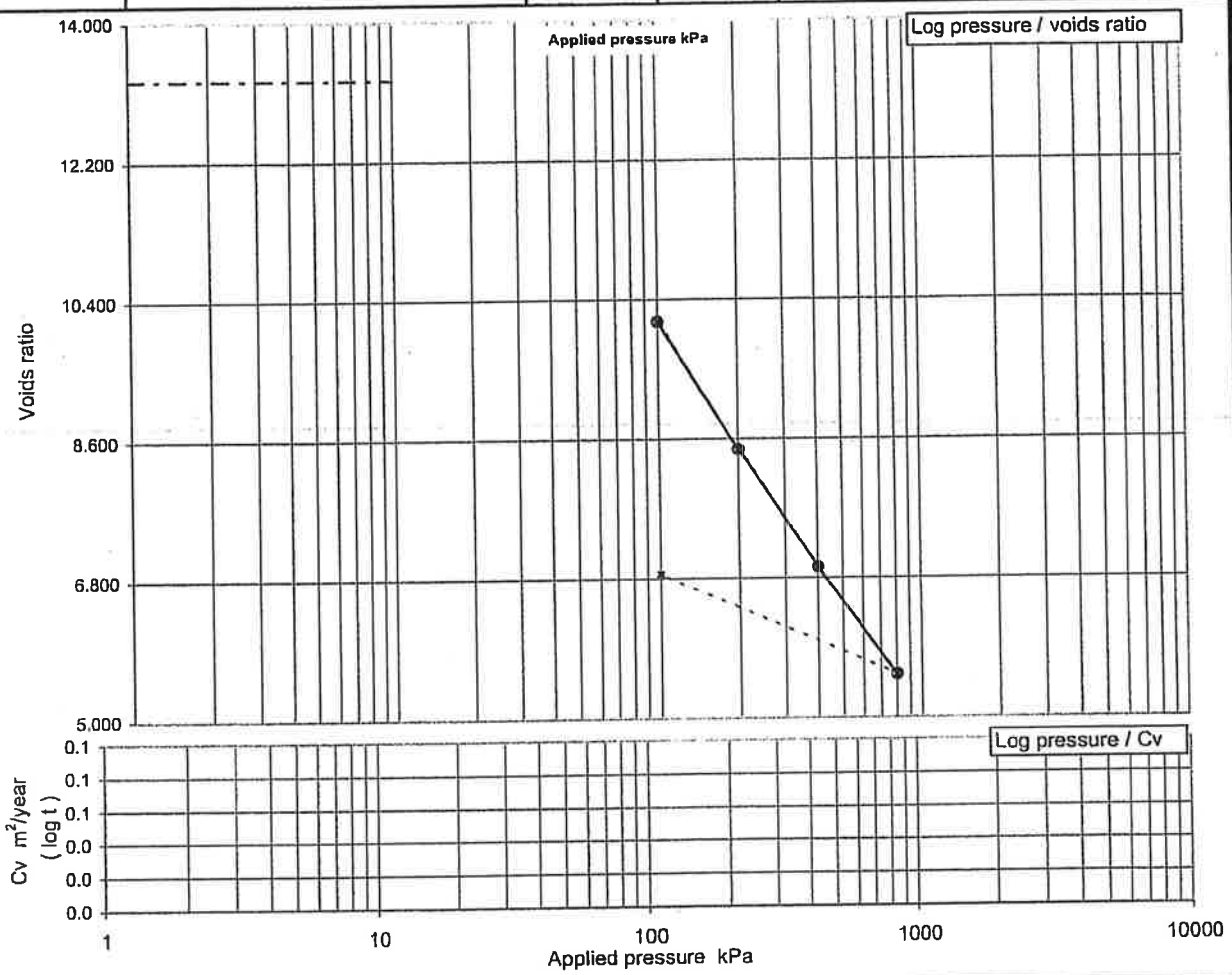
Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50, log}$) m²/year	C_v ($t_{90, root}$) m²/year	
0	10.6946				
200	6.6979	1.709	-	6	
400	5.1078	1.033	-	0.48	
800	4.4335	0.276	-	0.31	
200	4.4014	-0.010	-	-	

Notes : Consol frame reached extent of travel during third loading stage. Proceeded to unloading stage.

Specimen taken 425 mm from base of sample

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH5		
Project Name	BP Llandarcy		Depth (m BGL)	4.50		
			Samp No	4	Type	U
			ID	ESGH704320070627000000167		
			Spec Ref			



Soil description	Brown PEAT with wood pieces	Liquid limit %	
Preparation		Plastic limit %	

Specimen details	Initial	Final	
Particle density	2.65	assumed	Mg/m³
Diameter	74.93		mm
Height	18.94	10.44	mm
Voids ratio	13.251	6.858	
Moisture content	485	272	%
Bulk density	1.09	1.25	Mg/m³
Dry density	0.19	0.34	Mg/m³
Saturation	97	105	%
Average temperature for test	20		°C

Swelling pressure: not measured kPa

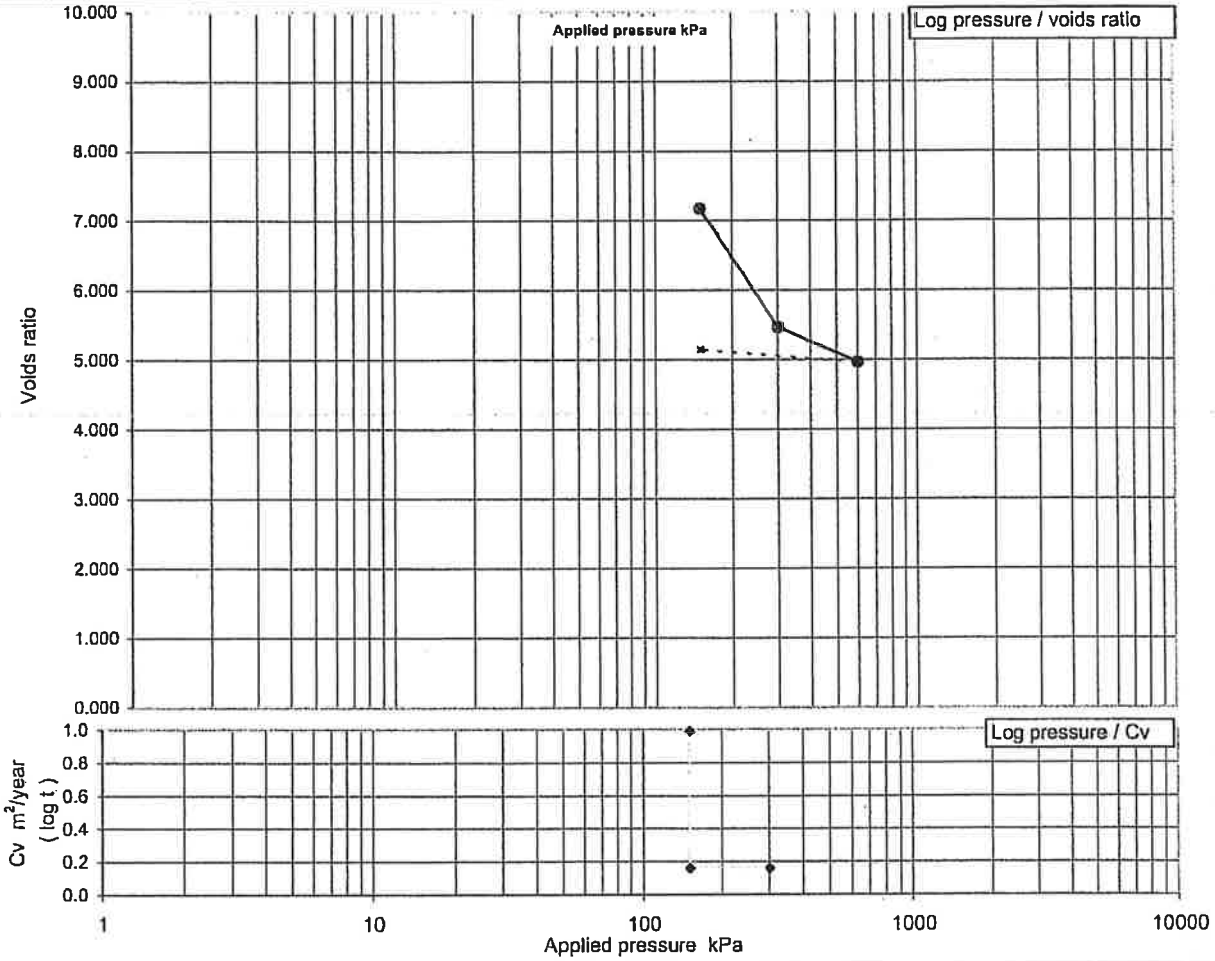
Notes :

Specimen taken 425 mm from base of sample

Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50,\ log}$) m²/year	C_v ($t_{90,\ root}$) m²/year	
0	13.2513				
100	10.1129	2.202	-	11	
200	8.4613	1.486	-	1.8	
400	6.9376	0.805	-	1.1	
800	5.5516	0.437	-	0.48	
100	6.8578	0.285	-	-	

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH5		
Project Name	BP Llandarcy		Depth (m BGL)	6.50		
			Samp No	8	Type	U
			ID	ESGH704320070627000000171		
			Spec Ref			



Soil description	Soft dark brown organic CLAY	Liquid limit %	
Preparation	UNDISTURBED	Plastic limit %	

Specimen details	Initial	Final	
Particle density	2.30	assumed	Mg/m³
Diameter	74.62		mm
Height	18.74	8.48	mm
Voids ratio	12.580	5.144	
Moisture content	507	214	%
Bulk density	1.03	1.18	Mg/m³
Dry density	0.17	0.37	Mg/m³
Saturation	93	96	%
Average temperature for test	19		°C

Swelling pressure: not measured kPa

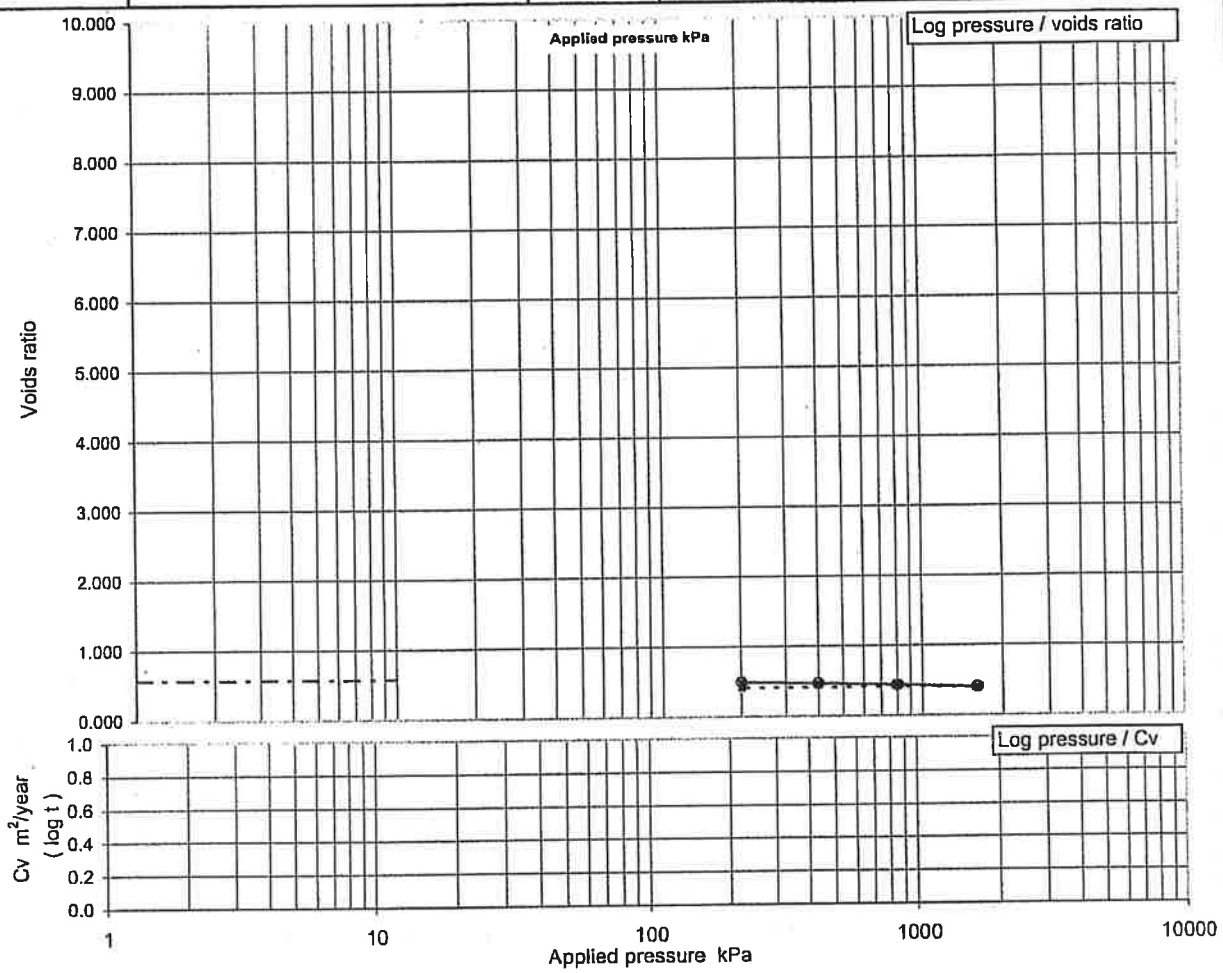
Notes : Machine out of travel on 600 kN/m2 load

Specimen taken 0 mm from base of sample

Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50, log}$) m²/year	C_v ($t_{90, root}$) m²/year	
0	12.5803				
150	7.1721	2.655	0.99	1.7	
300	5.4655	1.392	0.16	0.3	
600	4.9626	0.259	-	-	
150	5.1445	0.068	0.53	0.83	

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH5		
Project Name	BP Llandarcy		Depth (m BGL)	8.50		
			Samp No	11	Type	U
			ID	ESGH7043200706270000000175		
			Spec Ref			



Soil description	Soft brown CLAY	Liquid limit %	
Preparation	UNDISTURBED	Plastic limit %	

Specimen details	Initial	Final	
Particle density	2.65	assumed	Mg/m³
Diameter	74.62		mm
Height	18.74	16.72	mm
Voids ratio	0.574	0.404	
Moisture content	20	15	%
Bulk density	2.03	2.17	Mg/m³
Dry density	1.68	1.89	Mg/m³
Saturation	94	97	%
Average temperature for test	19		°C

Swelling pressure: not measured kPa

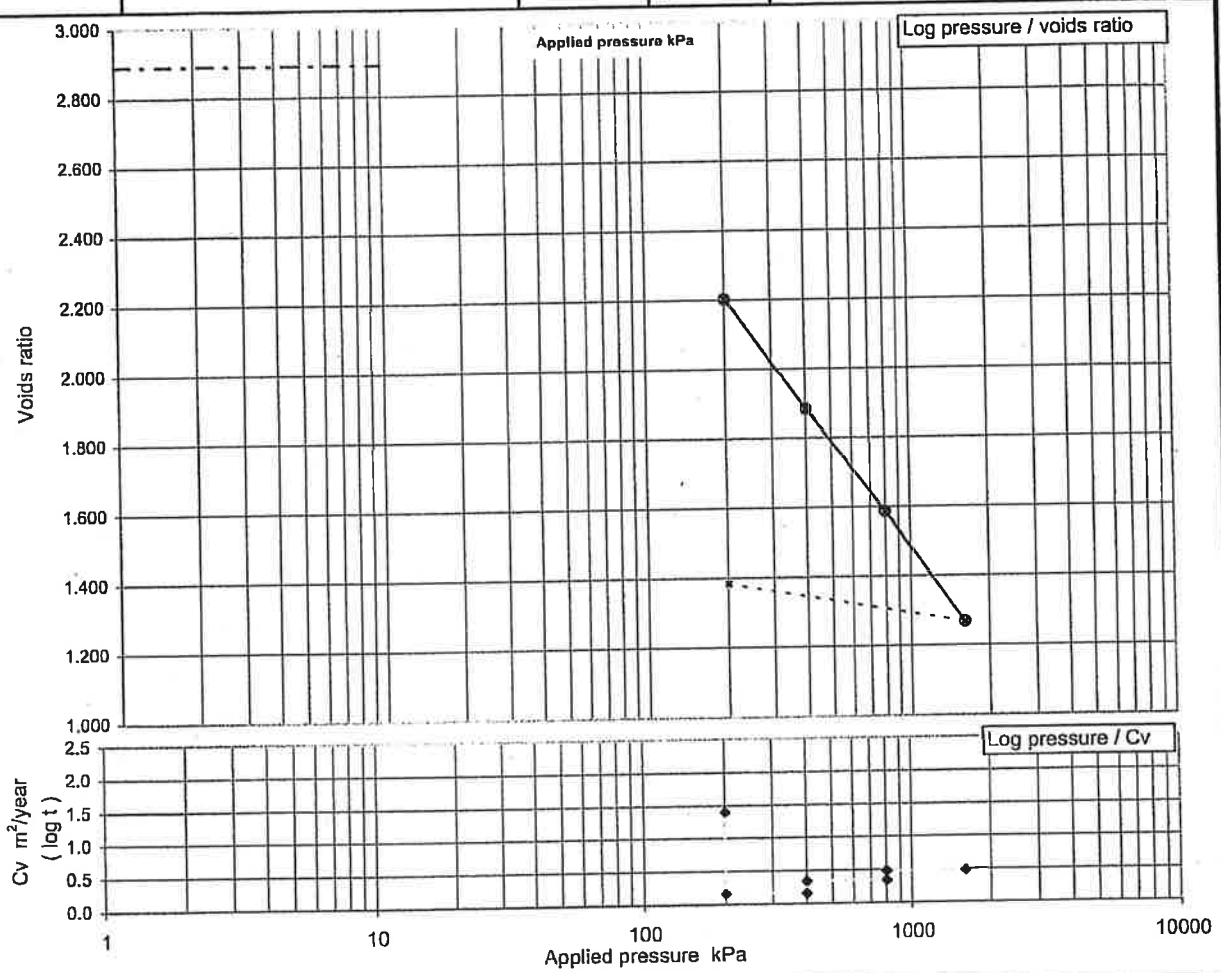
Notes :

Specimen taken 0 mm from base of sample

Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50,\ log}$) m²/year	C_v ($t_{90,\ root}$) m²/year	
0	0.5736				
200	0.4862	0.278	8.9	15	
400	0.4621	0.081	2.8	9.9	
800	0.4339	0.048	6.9	12	
1600	0.3996	0.030	6.5	24	
200	0.4038	0.002	26	63	

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH6	
Project Name	BP Llandarcy		Depth (m BGL)	9.00	
			Samp No	12	Type U
			ID	ESGH7043200706180000000113	
			Spec Ref		



Soil description	Soft dark brown organic CLAY	Liquid limit %	
Preparation	Undisturbed	Plastic limit %	

Specimen details	Initial	Final	
Particle density	2.55 measured		Mg/m³
Diameter	74.63		mm
Height	18.69	11.46	mm
Voids ratio	2.890	1.384	
Moisture content	105	54	%
Bulk density	1.34	1.65	Mg/m³
Dry density	0.66	1.07	Mg/m³
Saturation	92	100	%
Average temperature for test	19		°C

Swelling pressure: not measured kPa

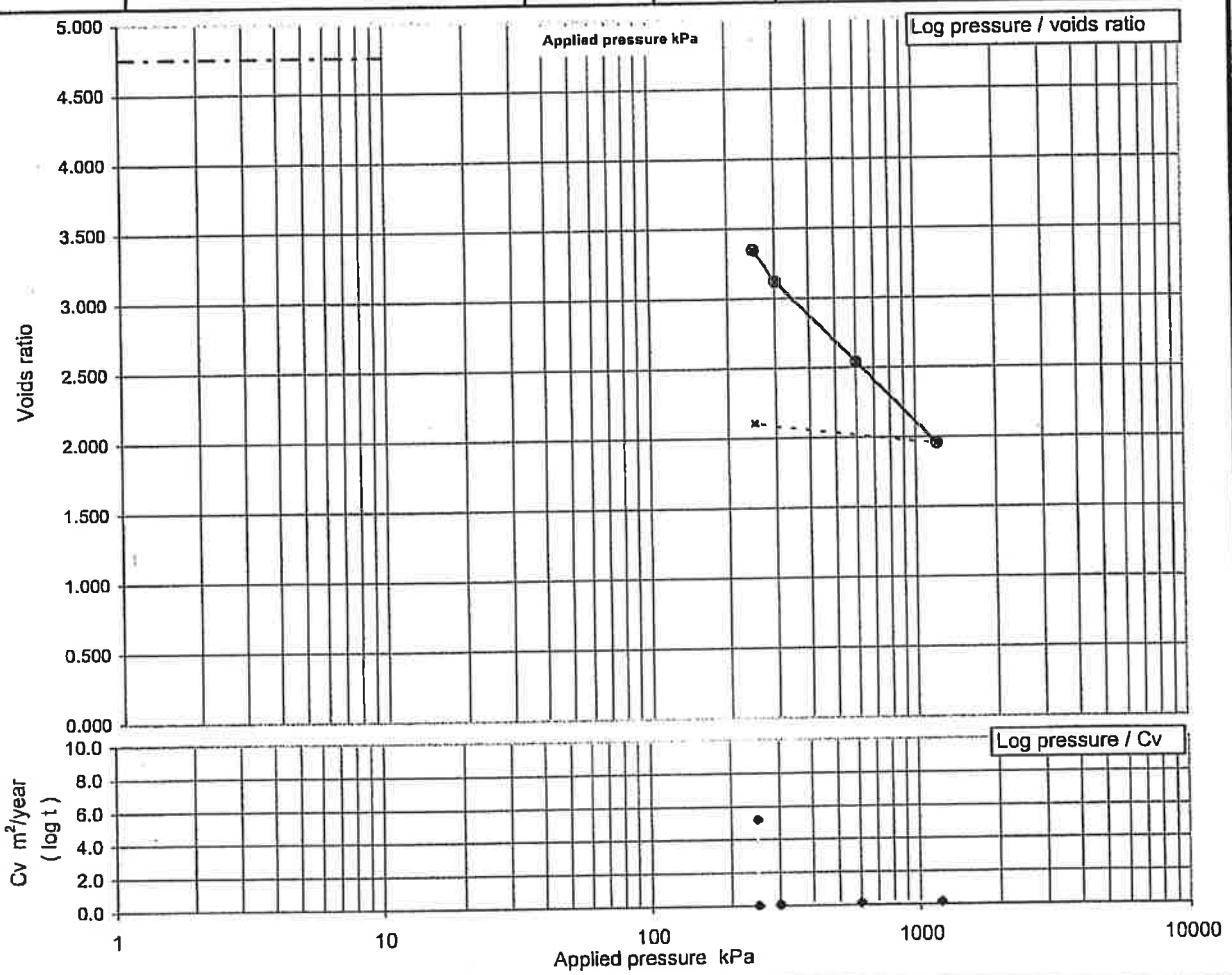
Notes :

Specimen taken 0 mm from base of sample

Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50, log}$) m²/year	C_v ($t_{90, root}$) m²/year	
0	2.8896				
200	2.2026	0.883	1.4	4.9	
400	1.8846	0.496	0.16	0.63	
800	1.5866	0.258	0.34	1.3	
1600	1.2676	0.154	0.48	1.3	
200	1.3839	0.037	0.76	2.4	

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH7		
Project Name	BP Llandarcy		Depth (m BGL)	10.50		
			Samp No	9	Type	U
			ID	ESGH704320070619000000128		
			Spec Ref			



Soil description	Soft dark brown organic CLAY with wood	Liquid limit %	
Preparation	Undisturbed	Plastic limit %	

Specimen details	Initial	Final	
Particle density	2.35	measured	Mg/m³
Diameter	74.58		mm
Height	18.60	10.03	mm
Voids ratio	4.755	2.102	
Moisture content	181	90	%
Bulk density	1.15	1.44	Mg/m³
Dry density	0.41	0.76	Mg/m³
Saturation	89	100	%
Average temperature for test	20		°C

Swelling pressure: not measured kPa

Notes :

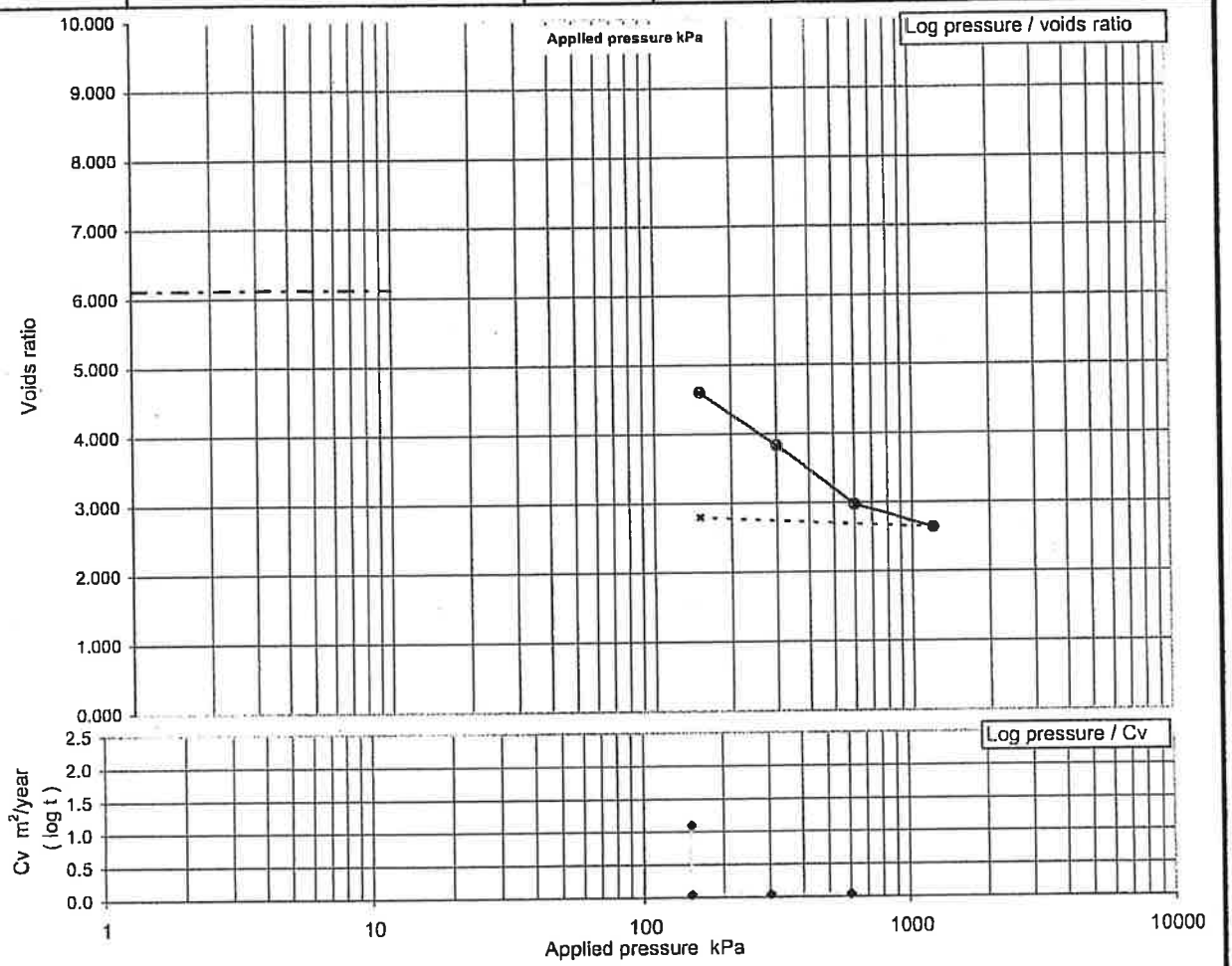
Specimen taken 0 mm from base of sample

Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50,\ log}$) m²/year	C_v ($t_{90,\ root}$) m²/year	
0	4.7549				
250	3.3412	0.983	5.2	15	
300	3.1185	1.026	0	0	
600	2.5387	0.469	0.1	0.41	
1200	1.9523	0.276	0.14	0.4	
250	2.1024	0.054	0.12	0.46	

QA Ref			Figure
SLR 5.3 Rev 104 Jul 07	Soil Mechanics	Printed:20/11/2007 16:52	OED 10

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH8		
Project Name	BP Llandarcy		Depth (m BGL)	7.50		
			Samp No	7	Type	U
			ID	ESGH7043200707020000000200		
			Spec Ref			



Soil description	Soft dark brown organic CLAY	Liquid limit %	
Preparation	Undisturbed	Plastic limit %	

Specimen details	Initial	Final	
Particle density	2.65	assumed	Mg/m³
Diameter	74.59		mm
Height	18.89	10.08	mm
Voids ratio	6.118	2.799	
Moisture content	183	97	%
Bulk density	1.05	1.37	Mg/m³
Dry density	0.37	0.70	Mg/m³
Saturation	79	92	%
Average temperature for test	19		°C

Swelling pressure: not measured kPa

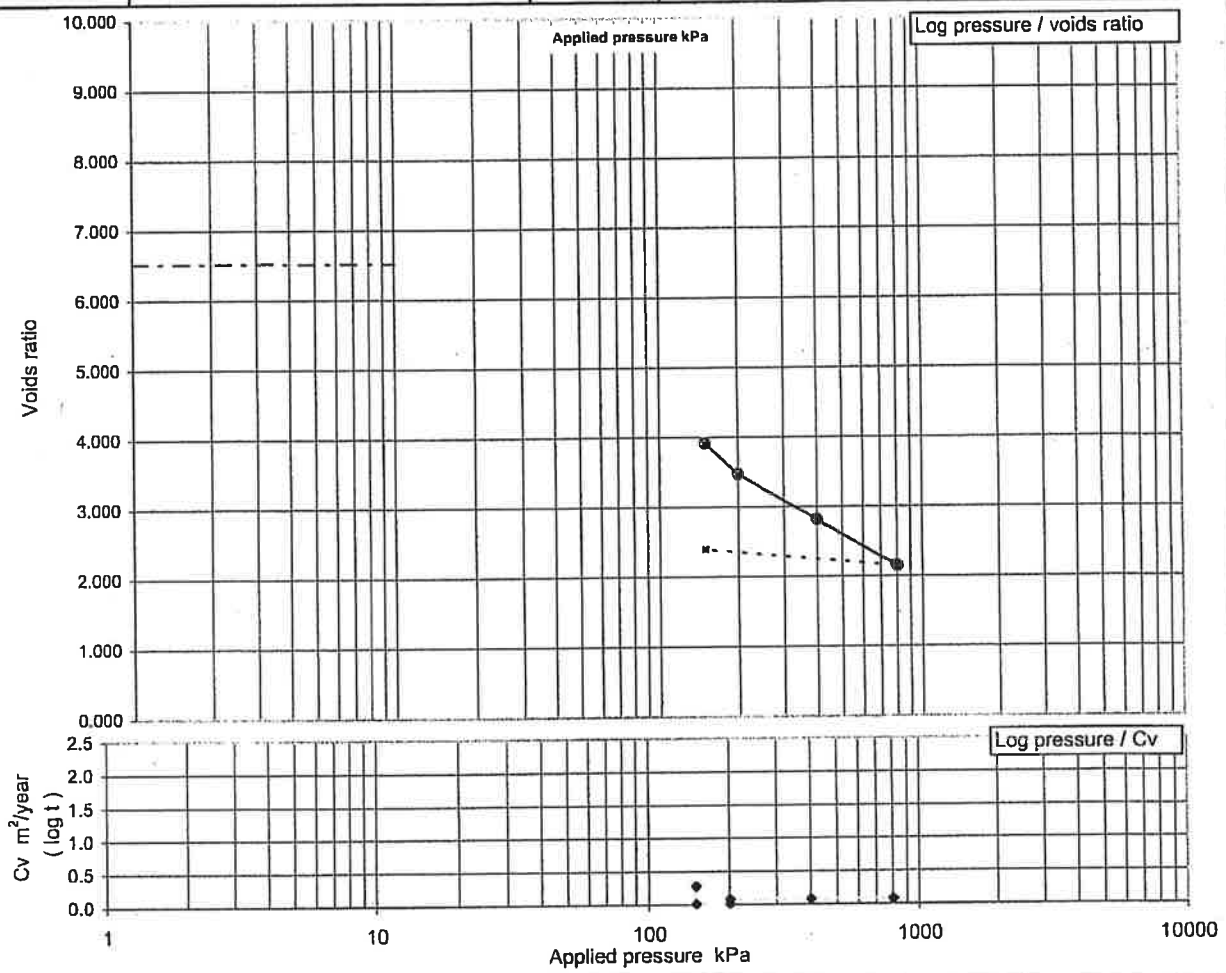
Notes : Sample out of travel at 1200kPa

Specimen taken 0 mm from base of sample

Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50, log}$) m²/year	C_v ($t_{90, root}$) m²/year	
0	6.1181				
150	4.5996	1.422	1.1	4.7	
300	3.8308	0.915	0.04	0.17	
600	2.9713	0.593	0.04	0.18	
1200	2.6341	0.142	-	-	
150	2.7991	0.043	0.08	0.3	

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH9		
Project Name	BP Llandarcy		Depth (m BGL)	5.50		
			Samp No	4	Type	U
			ID	ESGH704320070627000000179		
			Spec Ref			



Soil description	Soft dark brown organic CLAY	Liquid limit %	
Preparation	Undisturbed	Plastic limit %	

Specimen details	Initial	Final	
Particle density	2.50	assumed	Mg/m³
Diameter	74.66		mm
Height	18.72	8.45	mm
Voids ratio	6.519	2.392	
Moisture content	244	95	%
Bulk density	1.14	1.44	Mg/m³
Dry density	0.33	0.74	Mg/m³
Saturation	94	100	%
Average temperature for test	19		°C

Swelling pressure: not measured kPa

Notes :

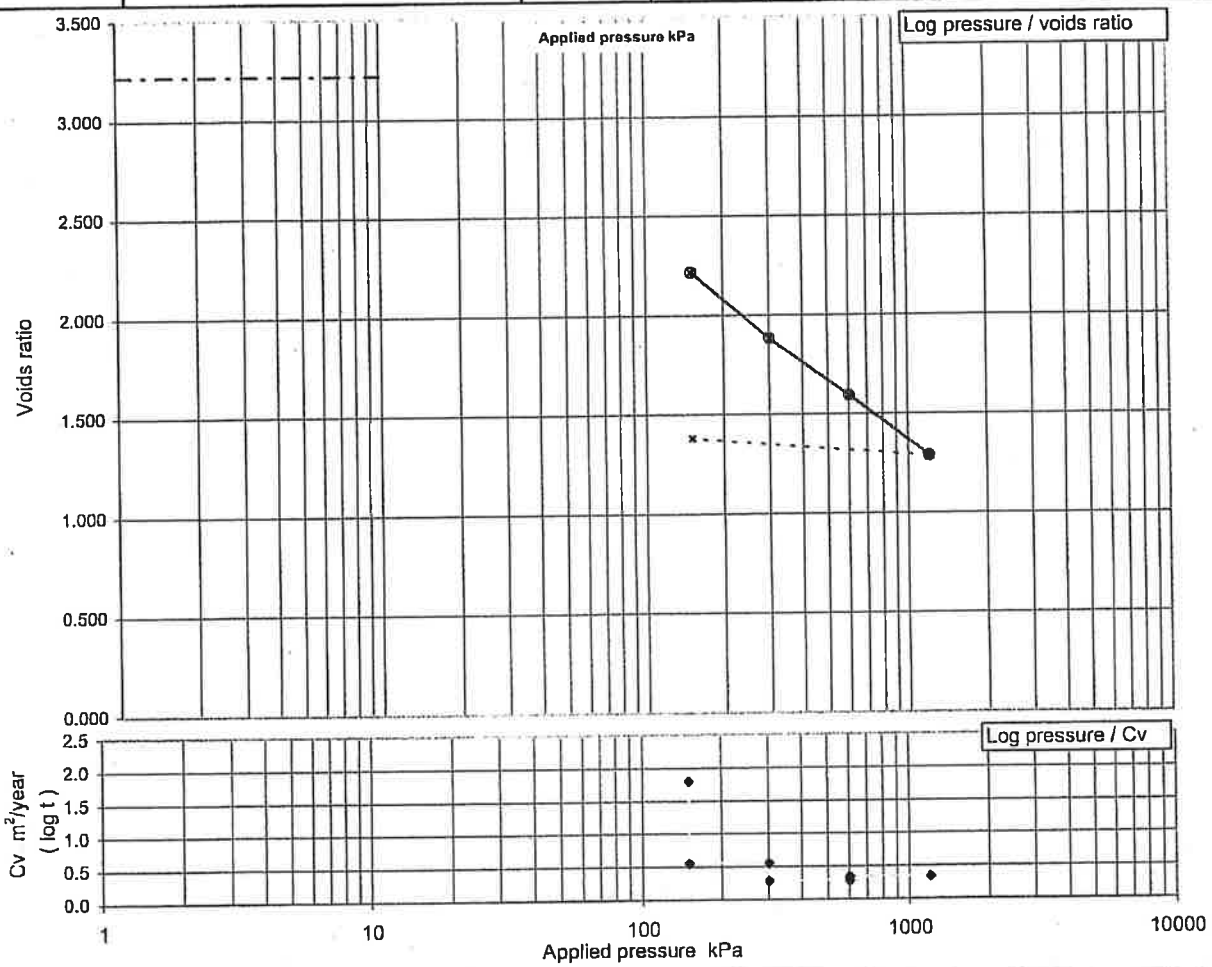
Specimen taken 0 mm from base of sample

Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50, log}$) m²/year	C_v ($t_{90, root}$) m²/year	
0	6.5187				
150	3.9125	2.311	0.28	0.65	
200	3.4707	1.799	0.01	0.03	
400	2.8120	0.737	0.08	0.15	
800	2.1505	0.434	0.08	0.12	
150	2.3919	0.118	0.09	0.26	

QA Ref			Figure
SLR 5.3 Rev 104 Jul 07	Soil Mechanics	Printed:20/11/2007 16:52	OED 12

ONE DIMENSIONAL CONSOLIDATION TEST
BS 1377 : Part 5 : 1990 : clause 3

Project No	H7043	Sample Details:	Hole No	BH9		
Project Name	BP Llandarcy		Depth (m BGL)	7.50		
			Samp No	6	Type	U
			ID	ESGH704320070627000000181		
			Spec Ref			



Soil description	Soft dark brown organic CLAY	Liquid limit %	
Preparation	Undisturbed	Plastic limit %	

Specimen details	Initial	Final	
Particle density	2.45	assumed	Mg/m³
Diameter	74.70		mm
Height	18.72	10.57	mm
Voids ratio	3.218	1.381	
Moisture content	121	56	%
Bulk density	1.28	1.61	Mg/m³
Dry density	0.58	1.03	Mg/m³
Saturation	92	100	%
Average temperature for test	19		°C

Swelling pressure: not measured kPa

Notes :

Specimen taken 0 mm from base of sample

Applied Pressure kPa	Voids ratio	M_v m²/MN	C_v ($t_{50, log}$) m²/year	C_v ($t_{90, root}$) m²/year	
0	3.2183				
150	2.2181	1.581	1.8	4.2	
300	1.8834	0.693	0.55	1.1	
600	1.5941	0.334	0.28	1	
1200	1.2872	0.197	0.34	0.92	
150	1.3809	0.039	0.25	1.1	

QA Ref			Figure
SLR 5.3 Rev 104 Jul 07	Soil Mechanics	Printed:20/11/2007 16:52	OED 13