Sidlesham Landfill Site, Pagham Harbour Nature Reserve

Phase 2 Ground Investigation Interpretative Report

Dec 2009

Prepared by

mouchel

Severn House
Lime Kiln Close
Stoke Gifford
Bristol
BS34 8SQ

T 0117 906 2300
F 0117 906 2301

For West Sussex County Council

.

DISCLAIMER

This report is presented to West Sussex County Council in respect of Sidlesham Landfill Site, Pagham Harbour Nature Reserve and may not be used or relied on by any other person or by the client in relation to any other matters not covered specifically by the scope of this Report.

Notwithstanding anything to the contrary contained in the report, Mouchel Limited is obliged to exercise reasonable skill, care and diligence in the performance of the services required by West Sussex County Council and Mouchel Limited shall not be liable except to the extent that it has failed to exercise reasonable skill, care and diligence, and this report shall be read and construed accordingly.

This report has been prepared by Mouchel Limited. No individual is personally liable in connection with the preparation of this report. By receiving this report and acting on it, the client or any other person accepts that no individual is personally liable whether in contract, tort, for breach of statutory duty or otherwise.

Mouchel has used reasonable skill, care and diligence in the design and interpretation of the ground investigation, however, the inherent variability of ground conditions allows only definition of the actual conditions at the location and depths of exploratory holes and samples/tests therefrom, while at intermediate locations conditions can only be inferred.

New information, changed practices or new legislation may necessitate revised interpretation of the report after the date of its submission.

Contents

Tables

Figures

Appendices

EXECUTIVE SUMMARY

West Sussex County Council commissioned Mouchel in January 2009 to undertake a Phase 2 ground investigation at Sidlesham Landfill Site on the Pagham Harbour Nature Reserve.

The objective of this study was to complete a geotechnical assessment and ground gas risk assessment now that the preferred location of the proposed new visitors centre has been confirmed. The phase 2 investigation included an assessment of foundations for the new visitors centre in the northern area of the site and the proposed bridge crossing at Red Barn Ditch, along with options for pavement foundations, leachate diversion drain and assessment of the landfill capping requirements including edge detail, in the light of the detailed topographical survey.

The scope of the works included an intrusive ground investigation which involved the drilling of a series of cable percussive and window sample boreholes, around the southern and western boundary of the site, at the location of the proposed visitors centre and bridge structure. Excavation of trial pits around the perimeter of landfill was also completed. Given the site is located on a closed landfill, potential generation and migration of ground gas from the made ground to off site receptors is a concern and long term ground gas monitoring of wells installed within selected boreholes was incorporated within the investigation scope. In-situ testing and geotechnical laboratory testing was scheduled on selected samples to confirm geotechnical design values.

The Phase 2 ground investigation verified the ground model developed as part of the Phase 1 works. The made ground which is present across the northern area, is highly variable both laterally and vertically and below this the soft clays of the tidal river deposits are present. Both deposits generally exhibit low shear strength.

The underlying Bracklesham Beds, Bagshot Beds and London Clay, which are a series of sandy clays and clay sands, provide the competent strata in which to construct pre-cast, driven displacement piles to support both the visitors centre and the bridge crossing. As final design loads of the structures are unconfirmed, a range of pile lengths and diameters are presented based on an assumed loading for a single storey structure along with a single carriageway steel constructed bridge, to allow discussions with a specialist piling contractor to judge the most economically advantage final design.

Both a flexible pavement and rigid pavement construction design are feasible to overcome the differential settlement and poor resistance to subgrade deformation under load from vehicle wheels, as determined from the low California Bearing Ratios determined for the made ground. To minimise the re-profiling of made ground below the pavement structure and to tie finished ground levels following construction of the landfill capping layer, the installation of a geo-grid is preferable to reduce the thickness of a capping layer within a flexible pavement.

The construction of a French drain adjacent to the ditch along the north-western boundary is designed to draw down levels of leachate to below the level of the base of the ditch, prevent leachate emerging at the surface after prolonged periods of rainfall. The level of the drain is a compromise between being low enough to prevent leachate emerging and being too low, such that the leachate flows are high. An average depth below ground surface of approximately 0.5m is envisaged, although a detailed topographical survey along the ditch is required to confirm final levels.

The construction of a landfill capping layer of minimum capping thickness is required to mitigate the risks to human health, the risk driver being elevated concentrations of benzo (a) pyrene. Re-profiling of made ground should be kept to a minimum during construction and consequently it is recommended that the capping is placed on the existing ground level across the majority of the site tying to existing topographical levels. At the perimeter of the landfill and along the banks of Red Barn Ditch, the installation of a clay plug constructed of the landfill capping material will provide continuity between the capping and the adjacent natural soils, in essence encapsulating the made ground.

It was not possible during the site investigation to prove the geology below the Red Barn ditch because access to the banks was difficult and because where the margins of the Red Barn Ditch were investigated, waste was found. It is not clear whether there is waste below the channel or not. If the waste does pass below the ditch, this will have to be removed to prevent waste emerging in the banks in a prominent visible location. The capping layer, appropriately designed to prevent erosion will have to be extended below the channel.

Along the north-western boundary, the clay plug is incorporated within the leachate diversion drain design. By extending the landfill capping over the French drain, surface run off from the landfill is prevented from entering the leachate diversion drain. The clay plug acts as a cut off impeding drainage of the surface water within the ditch entering into the leachate diversion drain.

A ground gas risk assessment indicates that gas protection measures are considered necessary for the proposed visitors centre in accordance with a characteristic situation 2 based on the Modified Wilson Card classification. Furthermore, to minimise the potential for ingress of gas into the building, consideration is given to the installation of driven piles with the visitors centre sited above ground level on piers; the air space between ground level and the underside of the building allowing free venting beneath the building. There is a likely potential for off site migration both with the site in its current form and with the addition of a landfill capping. It is recommended that venting measures are incorporated into the landfill cap design, and along the north-western perimeter of the landfill the venting can be tied into the proposed leachate diversion drain. Given that the monitoring suggests there is the potential for off site migration of landfill gas under the current gas regime, further ground gas monitoring, both during and post construction is recommended, with boreholes installed on the other side of the site boundary to understand the potential risks to off site receptors.

1 Introduction

1.1 Terms of Reference

South East of England Development Agency (SEEDA) and West Sussex County Council (WSCC) wish to upgrade facilities at the former Sidlesham Landfill Site which is now used as the Pagham Harbour Nature Reserve in West Sussex. Mouchel Limited was commissioned to carry out a ground investigation of the site to assess the ground conditions and geotechnical parameters of the soils for the design of structures and associated ancillary works, and considers potential risks of migrating ground gas, particularly to off site receptors.

Mouchel was appointed by SEEDA and WSCC on 7th March 2007 to undertake a Phase 1 preliminary assessment of the site. Subsequently, a Phase 1 ground investigation was undertaken during October and November 2007 to assess the feasibility of six locations across the site for the construction of a visitors centre. Following the investigation the most favourable location was selected which is located within the northern area of the site. The further Phase 2 ground investigation was commissioned in January 2009.

This document reports the findings and interpretation of the Phase 2 ground investigation.

1.2 Development Proposals

The Environment Agency who own the site at Pagham Harbour and WSCC who lease the land are working in partnership with the Pagham Harbour Project Team which includes WSCC, SEEDA, the Environment Agency (EA) and the Royal Society for the Protection of Birds (RSPB)), to investigate the former Sidlesham landfill site with a view to upgrading facilities at the site. This would comprise the construction of a new visitor centre at a different location on site with associated access, including the construction of a bridge across Red Barn Ditch. To address the risks to human health as identified following the Phase 1 ground investigation, the construction of a landfill capping layer will also be required. Furthermore, to remove the leachate which at times is ponding at surface along the north-western boundary some form of a leachate diversion drain will be required.

Depending on the outcome of the long term gas monitoring programme currently underway, there may be a requirement for ground gas mitigation measures not only as part of the construction of the new visitors centre but also to prevent migration of ground gas to off site receptors. This assessment will be reported under a separate cover.

1.3 Previous Studies

A preliminary assessment was carried out on the landfill site in March 2007. The report was titled Phase 1 Visual Inspection and Limited Surface Water Sampling. This was issued to SEEDA in April 2007 under the Mouchel reference number 721334/R/01. The objectives of the report were to design an intrusive ground investigation targeting six potential locations for the new visitors centre and evaluate remediation options. This involved undertaking a visual inspection of the site, a Phase 1 ecological assessment and a Phase 1 desk study. Several surface water bodies on and off the site were sampled to assess their quality. Using this information a preliminary conceptual model was developed and an assessment of the remediation options was carried out.

Following the recommendations outlined in the Phase 1 preliminary assessment a Phase 1 intrusive investigation was undertaken culminating in a report titled 'Interpretative Ground Investigation Report, Sidlesham Landfill Site, Pagham Harbour Nature Reserve, West Sussex', referenced 721334/R/2B. The report was issued to SEEDA and WSCC in February 2008.

The scope of the investigation involved the excavation of trial pits and the drilling of both window sample and cable percussive boreholes together with the installation of gas and groundwater monitoring standpipes. The objective of this investigation was to determine the thickness and nature (including geotechnical properties) of the landfill and natural strata on and adjacent to the landfill site, and provide preliminary recommendations. The installation of monitoring boreholes enabled the presence, flow rate and concentration ranges of landfill gas and groundwater quality beneath the site to be determined.

Following the site works an assessment of the risks to controlled waters and human health was undertaken together with a geotechnical assessment and recommendations for further investigations and the remediation of the site.

1.4 Objectives and Scope

The objectives of this Phase 2 investigation are to assess requirements for:

- foundations for the new visitors centre and the proposed bridge crossing of Red Barn Ditch (proposed loads are currently unknown hence provision of a range of pile designs i.e. different pile length and diameters to allow budget estimates for construction to be considered) at the preferred location.

- assess the risks to the wider environment associated within the installation of piles;

- pavement foundations and construction for vehicular access onto the site (including the disabled access/service road and upgrade of the current car parking facilities), including suggestions relating to temporary works;

- landfill capping;

- a leachate diversion drain along the north-western boundary; and

- potential mitigation measures to prevent ground gas migrating off site, through a ground gas assessment.

The scope of the works was to undertake a Phase 2 ground investigation which includes the drilling of seventeen boreholes using a combination of window sampling and cable percussive drilling techniques. Ten boreholes were installed with gas monitoring standpipes from which gas monitoring has been be carried out. Five trial pits were also excavated at the boundary of the landfill the site. Following the intrusive investigation, geotechnical and chemical laboratory testing were scheduled on recovered soil and groundwater samples.

2 Background Information

2.1 Site Location

Sidlesham Landfill Site is located adjacent to the B2145 (Sidlesham Road) between Chichester and Selsey Bill, West Sussex at National Grid Reference SZ856966. The landfill site, which is roughly triangular in shape, covers approximately 0.1 square kilometres. Pagham Harbour is located immediately to the east of the site. A Site Location Plan is provided on drawing 721374/M/01.

2.2 Site Description

Sidlesham Landfill Site forms part of Pagham Harbour Nature Reserve which is predominantly laid to grassland and scrub vegetation, with some recent planting and more established hedgerows and also includes a visitor centre, toilet block and car parking area.

Public access on the site is available via footpaths, however much of the southern part of the site and northern area is bounded within a 1m high wooden post and rail fence. The land surrounding the landfill is predominantly flat and low lying with Pagham Harbour located immediately to the east of the site. As a result of historical landfilling on the site, the landfill is up to 3 metres higher than the surrounding land.

The landfill site is understood to be made up of predominantly domestic and household waste deposited during the 1960's and 1970's when the area was used as a civic amenity tip. Anecdotal evidence and historical plans and photographs indicate that the area was previously a lagoon and salt pan, separated from Pagham Harbour by a tramway; this now forms the eastern boundary footpath.

For the purpose of this report the landfill site has been divided into three areas named Area A, Area B and Area C as shown on drawing 721374/M/02 – Pagham Harbour Areas. The splitting of the site for the purpose of this report is consistent with the approach previously taken in both reports and proposals.

Area A includes the northern third of the site and covers 0.03 square kilometres of the landfill site and forms the northern triangular point. The southern boundary is represented by a gravel path access route running along a tidally influenced, yet sluice controlled drainage ditch named Red Barn Ditch. The eastern boundary is formed by a footpath and the northwest boundary represents the northern limit, which runs down to the car park in the west. Waste is visible at the surface in areas where there is sparse vegetation. Area A lies approximately 3.20 metres (m) above Ordnance Datum (AOD). A shallow ditch runs along the northwest boundary adjacent a former historic harbour wall and fields given to pasture at a lower level further to the north.

Area B covers the central third of the landfill site and covers the largest area; approximately 0.06 square kilometres. The gravel path to the east forms the eastern boundary of the site with the B2145 road forming the western site boundary. The path forms the northern boundary and the southern boundary is marked by a wooded area containing semi-mature and mature trees. Waste can be found at the surface across much of this area forming a topographical high of 5.80m AOD. The vegetation of this area is predominantly made up of nettle cover and small shrubs. The present visitor centre and public car parking, including areas of tarmac hardstanding are found in the west.

Area C is found in the south and makes up 0.01 square kilometres of the landfill site. The eastern footpath and B2145 make up the east and western boundaries. The southern boundary is represented by a fence and marks the southern extent of the nature reserve. Semi-mature and mature trees cover this area in contrast to the nettle/shrub cover of Area B. This transition in vegetation marks the northern boundary of this area.

The harbour comprises a mixture of salt marsh and mudflats which lie approximately 1m lower than the footpath along the eastern boundary of the site. During spring tides the marshes become completely inundated with sea water.

2.3 Summary of Preliminary Ground Model

The previous ground investigation found made ground comprising general household waste with varying proportions of glass, metal, plastic, and rubble together with and organic material such as paper, wood and fabric with the potential for ground gas production.

Quaternary tidal river deposits were found beneath the made ground in all but three exploratory hole locations. These Quaternary deposits typically comprised very soft clay containing variable amounts of sand, shell fragments, organic matter and more rarely gravel. Occasional thin bands of silty sand were also encountered.

Underlying the tidal river deposits the strata comprised layers of firm, orange and grey sandy clays with pockets and partings of sand which was considered to represent the Bracklesham Group. This was confirmed in the boreholes, BH03 and BH05, and also in BH01 which also included bands of very clayey sand interbedded with sandy clay layers. .

Of the natural strata encountered on site, the Environment Agency classifies the tidal deposits as a minor aquifer. The minor aquifer status probably reflects the presence of sands and gravels in some areas. At this site these deposits are clays and are a non-aquifer. The Bagshot Beds are classified as a minor aquifer and whilst the Bracklesham Group are also classed as a minor aquifer, the lithologies encountered during the ground investigations show that the stratum in this area is a non aquifer. The London Clay is classified as a non-aquifer.

From a geotechnical perspective, the made ground and tidal river deposits were considered unsuitable founding strata for conventional shallow foundations; these are unconsolidated materials susceptible to excessive differential settlement upon loading. The Phase 1 Interpretative Ground Investigation Report recommended that the proposed visitors centre should be constructed on piled foundations driven to competent strata i.e. at least in the Bracklesham Beds and possibly deeper (depending on the final loads of the structure.

2.4 Summary of Preliminary Pollutant Linkages

Pollutant linkages were identified between the landfill as a source and humans as receptors. The previous ground investigation identified that risks to human health were driven predominantly by elevated concentration of Benzo (a) pyrene (BaP) and recommendations for a landfill cap were made.

With reference to controlled waters as a receptor, downward migration of contaminants leaching from the landfill was found to be impeded by the underlying low permeable strata.

Whilst Red Barn Ditch is tidally influenced and given the proximity of the landfill to the tidal waters of Pagham Harbour, it was considered possible within a preliminary conceptual model that any leachate within the landfill would be in hydraulic continuity with the harbour and other surface waters in the vicinity of the landfill. However, results of chemical testing of the leachate and surface water suggested that the leachate is generally hydraulically isolated from the harbour and surrounding surface waters. The surface waters sampled from the north eastern edge of the landfill are affected by landfill leachate but are diluted with surface water run-off. Although a salt and freshwater mixing zone is present across part of the landfill site (as indicated by the results of the surface water sampling in March 2007), a comparison of the ratio of magnesium to calcium in the seawater and leachate samples indicates that the influence of seawater on the landfill leachate is minor.

During the Phase 1 Ground Investigation, four rounds of gas monitoring were undertaken on seven gas monitoring wells from November 2007 to February 2008 which identified a very low risk for methane, and a very low to low risk for carbon dioxide using the Modified Wilson and Card classification within the ground gas risk assessment. However, as this was completed over a short monitoring period a further regime of long term gas monitoring was recommended.

2.5 Summary of Geotechnical Considerations

The Phase 1 Ground Investigation revealed that made ground and tidal river deposits encountered across the site reached a combined maximum depth of around 8m, and are of similar geotechnical properties. These strata are shown to have shear strengths of 25kPa and 30kPa respectively. The underlying Bracklesham Group which comprises slightly sandy clay has a shear strength in the order of 55kPa. A number of foundation options were considered with piles into the competent soils at depth being the preferred option. A design sulphate class for buried concrete was determined to be DS-4 and ACEC AC-4 in accordance with BRE SD1:2005.

Given the nature of the shallow soils at the site, a capping layer within the pavement construction was recommended

In the adjacent land to the north of the site, London Clay was encountered at shallow depth and determined to be suitable for re-use as capping material in the re-development of the nature reserve. A design CBR value of 3% was provided for the London Clay although pre-treatment i.e. drying, was considered necessary.

3 Ground Investigation

3.1 Design Rationale and Scope

The final design and layout for the upgrade of facilities at the site remain unconfirmed and as such the Phase 2 ground investigation was designed to provide supporting information to allow these decisions to be finalised.

The investigation was designed to expand on the outline information provided by the Phase 1 ground investigation and refine the ground model already established.

The investigation was designed to focus on the area around the proposed new visitors centre in Area A, to confirm ground conditions and obtain geotechnical parameters, particularly at depth to support a detailed foundation design once final loadings are confirmed.

Similarly, the ground investigation was designed to establish the ground conditions and geotechnical parameters for bridge foundations, with boreholes/window samples being drilled as close as practicable to the proposed abutments on the northern and southern banks of Red Barn Ditch. Boreholes were drilled along the southern edge of Red Barn Ditch for the purpose of confirming ground condition chiefly in relation to pavement design and also for the installation of gas monitoring standpipes to understand the potential for gas migration from Area B into Area A.

The remaining boreholes were drilled predominately to install gas monitoring standpipes to establish the ground gas regime across the northern area of the site and the potential for gas migration off site towards existing properties, hence their positioning along the north-western perimeter of the site. These boreholes were also used to determine ground conditions for the construction of a leachate diversion drain, together with landscaping and capping requirements along the boundary.

Trial pits were also excavated at the boundary of the landfill to obtain a visual perspective of the thickness and nature of the waste at the boundary of the landfill such that finishing details of the landfill capping can be assessed to contain waste and understand the need for any potential re-profiling of waste during these construction works.

The scope of the ground investigation included the drilling of seven window sample boreholes, ten cable percussive boreholes and five trial pits. The scope included for in-situ geotechnical testing to be undertaken during drilling and recovery of soil samples for laboratory geotechnical testing. Chemical testing was restricted to groundwater/leachate samples to assess the need for specific pipe material i.e. such as Protecta Pipe, within the leachate diversion drain design along the north-western boundary.

With respect to ground gas generation, whilst a low to very low risk was calculated for methane and carbon dioxide during the phase 1, this was based on a limited monitoring period including a total of four monitoring rounds. In accordance with Table 5.5a and 5.5b C665, Assessing Risks Posed by Hazardous Ground Gases to Buildings, 2007, based on Wilson et al 2005 the site is considered to be a high sensitive site (given the presence of adjacent residential properties) with moderate generation potential of source and hence a six month monitoring period with up to twelve visits is recommended. The investigation included for long term gas monitoring to be carried out over a six month period coinciding with a variety of barometric pressures. Whilst it is preferable to obtain readings on a falling barometric pressure, given the unpredictable nature of weather conditions, this is not always possible.

3.2 Fieldwork

The ground investigation was undertaken between 23 February and 10 March 2009 by Norwest Holst, an approved Contractor under the Mouchel Quality Management System. During the intrusive investigation a Norwest Holst engineer supervised the works while a Mouchel engineer monitored site activities.

The factual report provided by Norwest Holst, details the works undertaken and the laboratory results obtained is included in Appendix A.

The investigation was carried out in general accordance with the following standards:

- BS5930:1999 Code of practice for site investigations;
- BS10175:2001 Code of Practice for the Investigation of Potentially Contaminated Sites;
- BS EN 1997-2: (2007): Eurocode 7 – Geotechnical Design – Part 2: Ground Investigation and Testing;

- BS EN ISO 14688-1: (2002): – Geotechnical Investigation and Testing – Identification and Classification of Soil – Part 1: Identification and Description;
- BS EN ISO 14688-2: (2004): – Geotechnical Investigation and Testing – Identification and Classification of Soil – Part 2: Principles for a Classification;
- BS EN ISO 22476-3: (2005): – Geotechnical Investigation and Testing – Field Testing – Part 3: Standard Penetration Test; and
- Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies for Land Contamination, 2001 (EA).

Table 1 provides a summary of site activities which should be cross referenced to drawing 721374/M/03 - Exploratory Hole Location Plan.

Table 1: Summary of Site Activities

Activity	Exploratory Hole Reference	Maximum Depth	Comment
Four cable percussive borehole	BH01 to BH04	25.0m	To establish the ground conditions at depth beneath the proposed visitors centre.
Five cable percussive borehole	BH06, BH08, BH09, BH10 and BH12	7.0m	Along the southern bank of Red Barn Ditch at the southern extent of Area A.
Six window samples (using Terrier Rig)	BH05, BH07, BH11, BH11A, and BH13, BH14 and BH15,	6.0m	Method of drilling was adopted due to access restrictions within remaining areas of the site.
Two window samples (using hand held equipment)	WS01 and WS02	4.7m	Adjacent the proposed bridge crossing method – method employed due to the health and safety risks associated with uneven ground and using tracked plant in close proximity to the ditch.
Trial Pitting	TP01 to TP05	4.5m	At the landfill perimeters

All exploratory hole locations were scanned with a cable avoidance tool (CAT) and generator prior to the excavation of a hand dug inspection pit to 1.2m below ground level (bgl) to confirm the absence of buried services.

During cable percussive drilling, clean drilling techniques were used. Drilling commenced with 250mm casing and at the base of the made ground a bentonite seal was installed. Casing was then reduced to 200mm diameter and drilling was continued through the seal. This prevents the creation of a pathway for contamination migration from the made ground to the underlying natural strata.

At the location of BH11 and BH11A the Terrier Rig was unable to achieve the required depth and an addition cable percussive borehole (BH11B) was drilled.

Borehole BH03 hit an obstruction within the made ground and as such was terminated and moved to adjacent location. The redrilled BH03A reached its scheduled termination depth.

Eleven gas monitoring standpipes were installed; within BH1 to BH4 at the location of the proposed visitors centre, within BH11B, BH12 and BH13 along the north-western boundary, and within BH6, BH8, BH9 and BH10 along the southern boundary of Area 1.

Within BH13 and BH11B standpipes of a nominal diameter of 50mm were used. The remainder of the installations utilised standpipes of nominal diameter of 90mm, which provides an increase in surface area to the response zone. Slotted pipe with granular surround was installed from a minimal depth of 0.7 metres over the depth of the made ground with plain pipe above to ground level. Within BH4 the response zone of the standpipe was created below the base of the made ground, at 4.3m bgl to 11.7m bgl, to monitor potential ground gas within the natural strata.

All ground gas monitoring wells were completed with valve, end caps and stand up covers above the ground surface to aid their identification.

Heavy rain together with the bridging of bentonite granules during installing caused the standpipes of BH1, BH2 and BH5 to drop below the original installation depth. These were re-drilled at a location adjacent to the original and re-installed.

Following the fieldwork, the long term gas monitoring programme commenced. Monitoring has been completed on the following dates:

- 25 March 2009
- 06 April 2009
- 22 April 2009
- 15 May 2009
- 29 May 2009
- 11 June 2009
- 30 June 2009
- 16 July 2009
- 31 July 2009
- 12 August 2009
- 28 August 2009
- 11 September 2009

Concentrations of methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide were measured using a calibrated Geotechnical Instruments Gas Monitor GA2000. A flow pod was used to measure flow rates during all monitoring rounds.

The gas monitoring data of the twelve visits are presented in Appendix 4. During the gas monitoring visits groundwater/leachate levels were also recorded. These records are presented in Appendix C.

Leachate samples were recovered from boreholes BH11 at 1.53m bgl and BH13 at 0.74m bgl on the site visit of 25th March 2009. These samples were stored in appropriate sample containers, labelled and transported on the same day as recovery under a completed chain of custody to the testing laboratory.

3.3 Chemical Laboratory Testing

3.3.1 Soils

Soil samples were not recovered for laboratory chemical testing as past of the Phase 2 investigation. No further human health risk assessment is to be undertaken in relation to soils.

3.3.2 Leachate/Groundwater

Two leachate/groundwater samples were recovered for analysis by Scientific Analysis Laboratories (SAL). SAL is an approved Contractor under the Mouchel Quality Management System. Table 2 below details the determinands tested on each sample. The results of leachate testing and screening are presented in Appendix D.

Table 2 Summary of Groundwater Analysis

Analysis Suite	No. samples scheduled
Ammonia, Arsenic, Biochemical Oxygen Demand (BOD), Cadmium, Chemical Oxygen Demand (COD), Chloride, Chromium, Lead, Nickel, Nitrate, Nitrite, pH, Phosphate and Zinc), banded Total Petroleum Hydrocarbons (TPH), Volatile Organic Carbons (VOC's) and speciated Phenols.	2

3.4 Geotechnical Laboratory Testing

Samples were recovered for geotechnical testing from the various strata during the ground investigation. After recovery these were appropriately labelled and stored before being transported to the UKAS accredited internal laboratory of Norwest Holst. A total of eighty five samples were scheduled for the following laboratory analysis. These have been summarised in the Table 3 below.

Table 3: Summary of Geotechnical Laboratory Testing

Geotechnical Test	Test method	No. samples scheduled
Classification/Compaction		
Moisture Content	BS1377: Part 2: 1990; Clause 3	34
Atterberg limits	BS1377: Part 2: 1990	34

Geotechnical Test	Test method	No. samples scheduled
Particle size distribution	BS1377: Part 2: 1990; Clause 9	14
Recompacted California Bearing Ratio	BS1377, (1990) part 4, clause 7.4	5
Strength / Consolidation		
Undrained triaxial (total) strength	BS1377, (1990) part 7	12
1-D oedometer		20
Chemical (tests on soil and groundwater)		
BRE SD1 Suite - Total / water soluble sulphate, pH, Total sulphur, Magnesium, Chloride	TRL Report 447	42

The results of geotechnical laboratory testing are included with the factual report in Appendix 1.

4 Ground Model

4.1 Geology

The geological sequence identified during the ground investigation confirms the published geological information and the Phase 1 investigation. Made ground comprising of general household waste was encountered at the majority of the exploratory hole locations. The waste material typically lies upon Quaternary tidal river deposits comprising soft sandy clays with sands and gravels identified at the base of the deposit at the southern boundary of Area A. In line with the findings of the phase 1 ground investigation, tidal river deposits are absent within a part of the location of the proposed visitors centre. The solid geology comprising Eocene sandy clays of the Bracklesham Group, which in turn overlie the sands of the Bagshot Beds, below which the London Clay is present. In places the solid geology beneath the site; the Bracklesham Beds, Bagshot Beds and the London Clay are difficult to distinguish due to their similar characteristics. These deposits were laid under similar environmental conditions within the London Basin, resulting in the deposition of sandy clays and clayey sands. The solid strata underlying the site are horizontal.

The geological sequence described below is detailed and presented in the cross-sections presented in Appendix B.

4.1.1 Made Ground

Made ground was encountered at every location with the exception of BH12, which is located beyond the former landfill boundary, in the current car park.

The made ground is highly variable and unconsolidated reflecting the nature of material being land filled at the time. In general the material contains a high proportion of man made inclusions, including plastic, metal, wood, glass and organic material within a silt, sand and clay matrix.

The ground surface of the landfill is undulating, whilst there are some areas which are relatively flat, other areas are raised significantly above the surrounding landfill, this is particularly the case in the centre of Area A where the top of the landfill stands at approximately 4.2m AOD. Around the perimeter of Area A, ground level stands at between approximately 3.0m to 3.5m AOD.

The thickness of the deposit is highly variable, reflecting the tipping activities which were being undertaken on site. At the location of the proposed visitors centre the made ground up to 4.8m thick (-1.22m OD BH1), in line with that identified during the Phase 1 ground investigation.

The depth to base of the deposit is highly variable which may be a reflection of the undulating nature of the then ground surface of the Tidal River deposit, on which the fill was placed. Tidal flats, converse to their name, have channels running through them with topographic highs in between. Alternatively, during filling made ground may have been pushed down into the soft tidal river deposits. The Phase 2 investigation found the base of the made ground to be at its deepest south of the ditch in BH6, to -1.88m OD.

The thinning out of the made ground around the perimeter of the landfill was evident in the trial pits, particularly along the north-eastern boundary, where the base of the made ground was noted at a minimum of 0.80m bgl

It is evident on the banks of Red Barn Ditch that waste is in direct contact with the tidal waters. There remains uncertainty whether the made ground extends below the base of the ditch with the ditch constructed after filling or whether the ditch remained in place during the filling works and waste was filled in around the water body. Due to the difficulties involved in investigating the strata immediately adjacent to the ditch; the banks are steeply slope, this cannot be confirmed without an over water investigation. However, it is considered likely that, given the location of the drainage ditch in the adjacent field, which feeds into Red Barn Ditch, the ditch is a long standing feature at the site and filling occurred around it. This is reflected in the cross section DD' (721374/M/07) presented in Appendix B.

4.1.2 Tidal River Deposits

The tidal river deposits are soft dark brown and occasionally bluish grey very clayey sand to a slightly sandy clay or silt.

These were encountered in all but three of the exploratory holes; absent as a band running in a rough east to west direction marked by BH02, BH04 and BH14. Here the made ground rests directly on the Bracklesham Beds. The deposit was found as a thin layer (0.4m thick) within BH01 in this area, as presented in cross section AA' (721374/M/04).

This band divides the tidal river deposits into two distinct zones within Area A which is presented in cross sections CC' (721374/M/06) and DD'. Those to the north reach a maximum thickness of 2.60m with the base of deposits at -1.07m OD in TP01 (although the full thickness of the tidal river deposits was not proven in the adjacent TP04) thinning northwards towards BH15 where the thickness of the deposit reduces to 1.95m.

The tidal river deposits to the south thicken towards Red Barn Ditch as presented in cross section BB' (721374/M/05) and DD' , beyond which the deposits thin to a minimum thickness south of the ditch of 0.4m in BH09, as presented by cross section EE' (721374/M/08). Here gravel was found at the base of this stratum in BH08, and in the adjacent BH09 only gravel was found, with sand, clay and silt all absent immediately below the made ground.

4.1.3 Bracklesham Group

The solid formation of the Bracklesham Group is described as firm grey to bluish grey clay with occasional partings and pockets of orange fine sand and/or glauconitic sand. This is present underlying the whole of the site.

The boundary with the overlying superficial deposits represents an unconformity; the upper surface of the deposit undulates reflecting the erosion of the top of the Bracklesham Group prior to deposition of the tidal river deposits.

The base of the Bracklesham Group was only proven in the deeper exploratory holes; BH01, BH02, BH03A and BH04. The deposit was proven to be between 3.8m and 7.30m thick with the base of the deposit to a maximum depth of 11.00m bgl within Borehole BH4.

4.1.4 Bagshot Beds

The underlying Bagshot Beds are described as dark grey to brown fine sands with varying proportions of clay. Although this stratum is not marked as an interpretation on the exploratory hole logs provided by the ground investigation contractor these deposits are known to be present between the Bracklesham Group and the underlying London Clay, and were identified within BH01 to BH04. On this basis it can be assumed that the Bagshot Beds are present underlying the whole of the site at depth.

The thickness of the stratum ranges between 0.50 metres in BH4 to 3.00 metres in BH1.

4.1.5 London Clay

London Clay was proven within the deeper boreholes of BH01 to BH04, and represents the solid geology underlying the region, extending to up to 165m deep locally. It is a firm to stiff fissured dark grey to bluish grey clay. Sand is found in varying proportions within the stratum either occurring as partings or as a constituent of the clay.

The clay contains mica and glauconite minerals and pyrite nodules are common throughout the deposit. One nodule of pyrite (10mm x 6mm) was found in BH01 at 16.7m bgl.

4.2 Groundwater

Given that the landfill is not capped, rainwater can readily infiltrate through the made ground and sit as perched water where downward migration is impeded by impermeable layers within the waste. This process allows leachate to be generated.

During drilling, water strikes were recorded in the made ground in many of the exploratory holes, at levels between 1.07m AOD (BH08) and 2.54m AOD (BH02), mid way through the deposit. In BH01 and BH03A water rose 0.30m in 20 minutes after the strike while water rose 0.70m in BH04. No rise was recorded in BH02, BH06, BH08, BH09 and BH10.

Standing water levels monitored in standpipes installed in the made ground generally recorded levels between 1.59m AOD in BH03 (15/05/2009) and 2.66m AOD in BH01. The groundwater monitoring data is tabulated in Appendix C.

Review of these results in Area 1 suggests groundwater levels within the made ground are highest in the centre of the site with flow outwards towards the boundary of the landfill and Red Barn Ditch. This reflects the pattern of flow observed from the Phase 1 monitoring in Areas B and C indicate that the groundwater is highest in the centre of these combined areas, flowing in part in a north-westerly and southerly direction towards the topographically lower corners of the site in the north-west and south.

On the southern bank of Red Barn Ditch the groundwater gradient is relatively shallow trending generally in a west to east direction, which reflects the gradient identified in the Phase 1 ground investigation within Area B.

Vertical migration of leachate accumulating within the landfill is limited by the tidal river deposits and where absent, the Bracklesham Group, both of which are of low hydraulic conductivity. Whilst there is leachate flow within the made ground towards the Red Barn Ditch and landfill perimeter which may ultimately reach the harbour, dilution by several orders of magnitude is anticipated.

Monitoring of the groundwater using data loggers during the Phase 1 investigation indicated minimal interaction between the tidal waters and groundwater on site; water levels varied between 0.004m and 0.320m in a tidal cycle.

Once the landfill is capped, limited infiltration of surface water will be permitted to penetrate the made ground, hence restricting the amount of leachate generated beneath the site.

Although groundwater may be encountered in the sand layers and pockets of the Bracklesham Group, as was experienced during drilling (in BH02, BH03 and BH04 between 5.60m and 7.50m), these sandy clays are of low permeability and as such impede the downward migration of percolating water from the made ground into the underlying natural strata where the tidal river deposits are absent.

The sands of the Bagshot Beds are water bearing, strikes were recorded at the top of the Bagshot Beds in BH01 and BH02 and roses in excess of 3.00m in 20 minutes. The strike rises indicate that the fine sands of the Bagshot Beds are a confined aquifer.

No groundwater strikes were recorded in the London Clay during the ground investigation, although, like the Bracklesham Beds, the London Clay contains partings and lavers of sand which are often very locally water bearing.

4.3 Ground Gas

Ground gas emission and migration can be influenced by barometric pressure. As barometric pressure falls, so ground gas is, in essence, sucked from the ground leading to high recorded levels. Whilst it is good practice to monitor ground gas over a range of barometric pressures, it is preferable to capture worst case ground gas readings which will be achieved by monitoring during falling pressure.

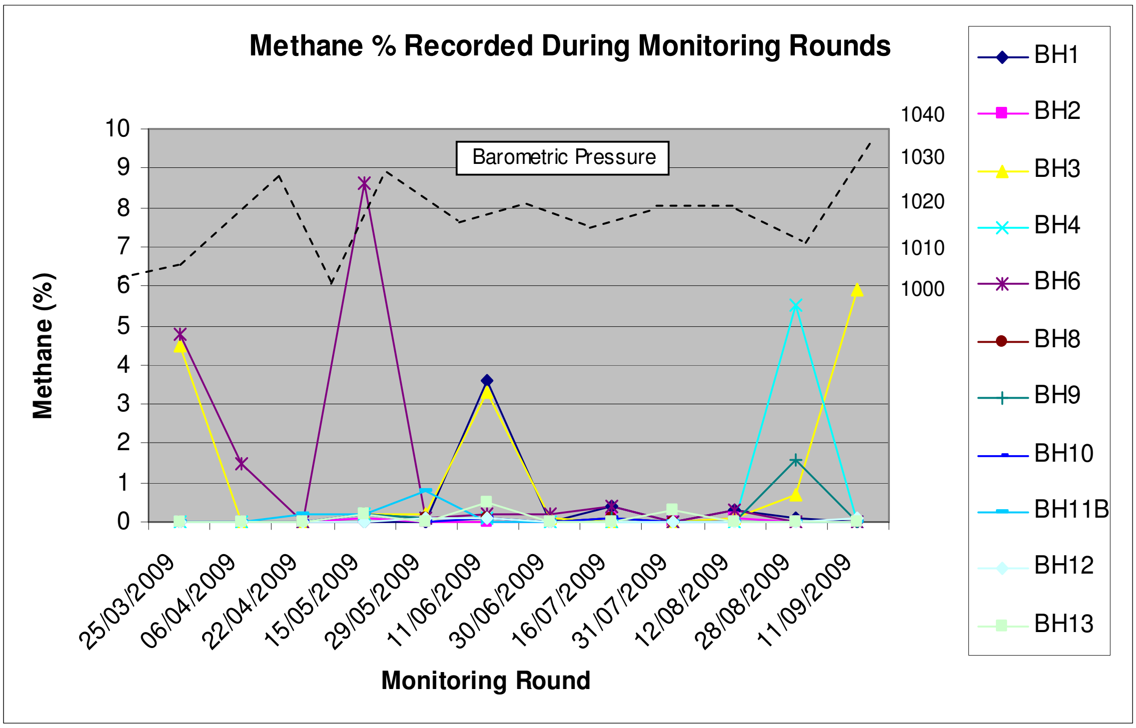
Atmospheric pressure trends were considered from the Weather on Line website (http://www.weatheronline.co.uk/). The trends prior to the few days preceding each monitoring visit were noted and recorded in the monitoring results in Appendix C. No visits were undertaken when barometric pressure was below 1000mb, whilst the first, fourth, tenth and twelfth visits were during falling pressure trends.

The barometric pressures recorded during each monitoring round have been plotted on Figure 1 to Figure 3 .

Measured flow rates were found to be consistent across the boreholes during the monitoring visits, with a range of -1.3 to +0.9l/hr.

The methane results recorded in the eleven boreholes during the twelve rounds of monitoring has been plotted with barometric pressure in Figure 1.

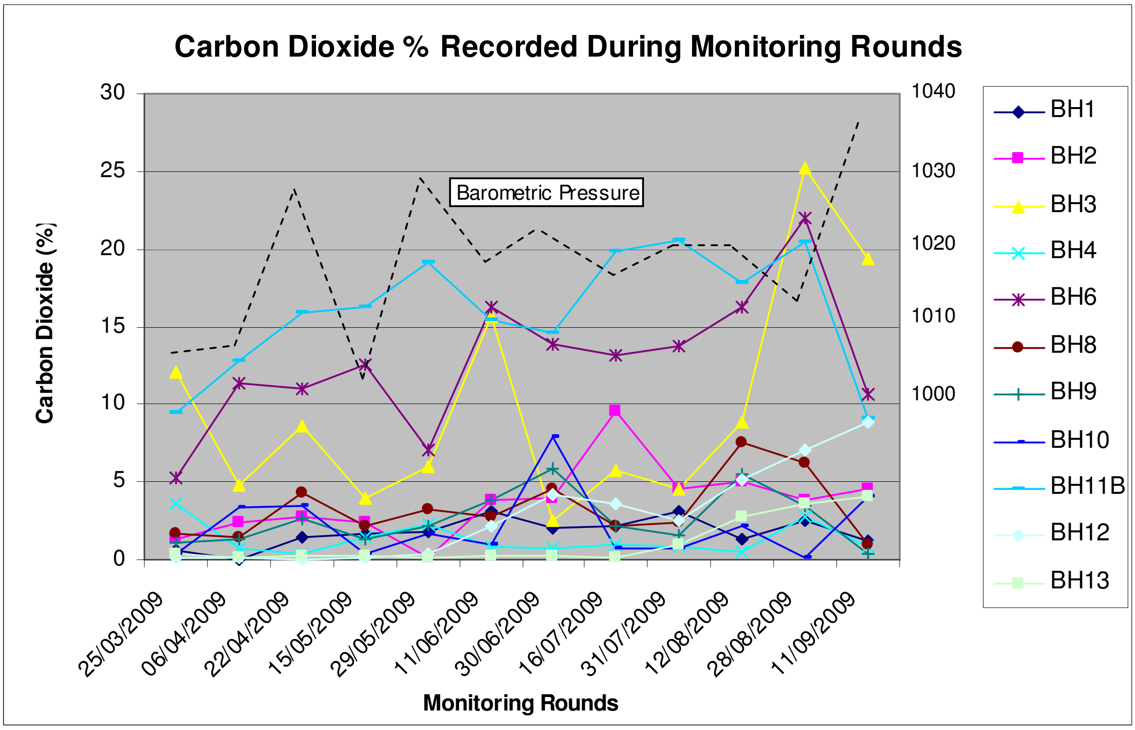
Figure 1 Methane levels by percentage during post site works monitoring



The results from the gas monitoring shows a correlation between barometric pressure and the methane concentration recorded at the site in two of the eleven boreholes. During the first and fourth monitoring round where barometric pressure is at its lowest, the methane concentrations in BH3 and BH6 are found to increase; in BH6 to a high of 8.6%. The remaining exploratory holes with the exception of BH1, BH4 and BH9 all have consistently low methane concentrations ranging from 0% to 0.8%. These three boreholes were found to have elevated concentrations on only one occasion: BH1 recorded an elevated concentration of 3.6%, BH4 a concentration of 5.5% and BH9 recorded a maximum concentration of 1.6%. All the elevated concentrations were recorded at barometric pressures ranging between 1013mb and 1019mb.

The carbon dioxide levels have been plotted with barometric pressure, as presented in Figure 2.

Figure 2 Carbon Dioxide levels by percentage during post site works monitoring



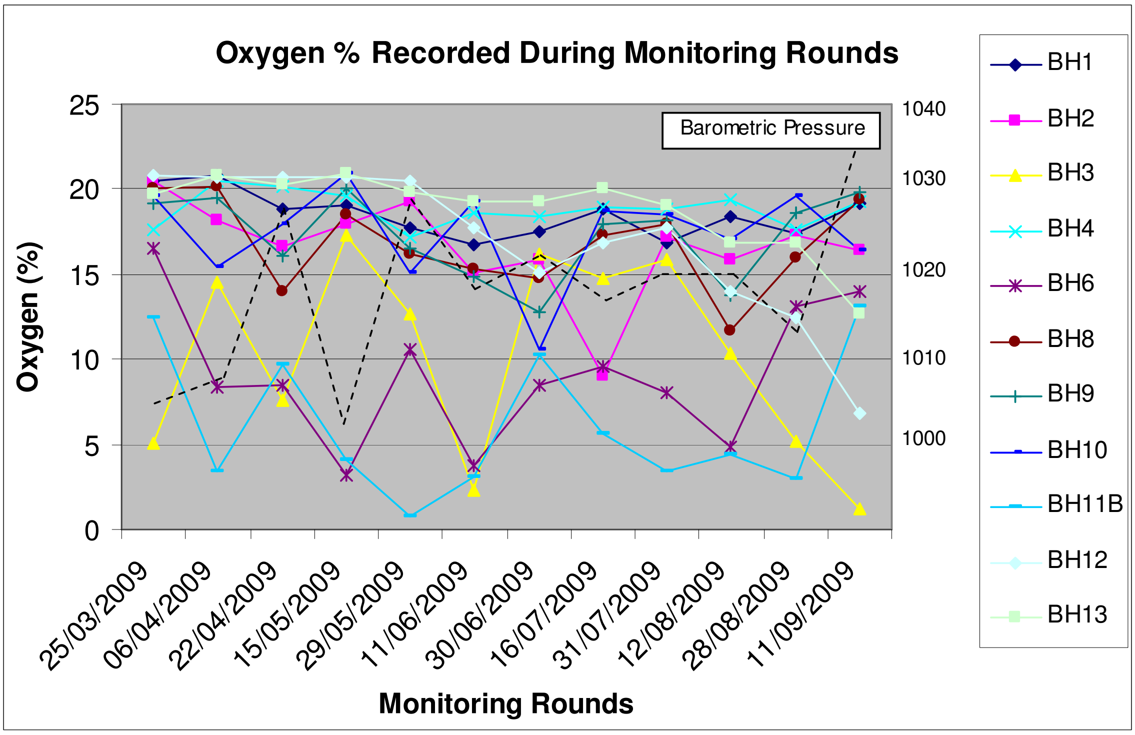
Exploratory holes BH3, BH6 and BH11B recorded relatively high carbon dioxide concentrations ranging from 2.5% to 25.2%. BH1, BH4 and BH13 all have consistently low carbon dioxide concentrations ranging from 0% to 4.1%.

The remaining exploratory holes have slightly elevated levels on one or two occasions, however relatively low concentrations were recorded on all the other visits. The elevated carbon dioxide concentrations recorded in BH3 and BH6 also fit in with the elevated levels of methane found in these exploratory holes.

The results show a correlation between carbon dioxide concentrations and barometric pressure for BH2 and BH6. The pattern for BH2 is more difficult to see on the graph as the results are plotted amongst many the other BH records but both boreholes recorded higher carbon dioxide concentrations during periods of low barometric pressure.

The oxygen levels recorded were plotted with barometric as shown in Figure 3 below.

Figure 3 Oxygen levels by percentage during post site works monitoring



As expected the recorded oxygen levels show a corresponding drop with an increase in methane and carbon dioxide. Exploratory holes BH3, BH6 and BH11B were identified as having the lowest oxygen concentrations which were previously identified as having the highest methane and/or carbon dioxide concentrations.

Concentrations of hydrogen sulphide or carbon monoxide were recorded in all locations during the monitoring rounds with the exception of BH1 and BH8 for hydrogen sulphide. The highest concentration of carbon monoxide was found at BH11B on the tenth visit at 6ppm and the highest concentration of hydrogen sulphide was found at BH10 on the sixth visit at 2ppm. The majority of the highest concentrations were found on the ninth and tenth visit when the barometric pressure was recorded at 1020.

In respect of groundwater levels, BH12 had a response zone of 1.0m bgl – 5.0m bgl, however during the first 5 visits the groundwater was observed at 0.47m bgl to 0.89m bgl and therefore saturated this zone. The groundwater lowered from the seventh visit to expose the response zone, which allowed the gas to ingress and as a consequence the carbon dioxide levels increased in concentration. No further trends were noted in relation to groundwater levels.

The full gas monitoring results and summary sheets are presented in Appendix C.

5 Geotechnical Assessment

5.1 Introduction

The purpose of this geotechnical assessment is to determine the most appropriate ground engineering design solutions, for various elements of the upgrade of facilities at the site, as follows: foundations for the new visitors centre and for the bridge crossing over Red Barn Ditch, pavement foundations for the service road and car park, leachate diversion drain requirements along the north-western boundary and capping of the landfill. The assessment also highlights where temporary construction works can be incorporated within the final construction design.

5.2 Soil Properties and Characteristics

The tables below combine information from both the Phase 1 investigation and Phase 2 investigation, where appropriate.

5.2.1 Made Ground

The range of geotechnical parameters (both measured and derived) for the Made Ground, determined from both the Phase 1and Phase 2 ground investigations, and the selected design values are shown in Table 4 below.

Table 4 Summary of Geotechnical Parameters for the Made Ground

Properties	Min	Max	Mean	No. of Tests	Design Value derived from Phase 1	Design Value derived from Phase 2	Design Value
Layer Thickness (m)	1.5*	6.5*	N/A	N/A	N/A	-	**N/A**
	0.80	5.20	N/A	N/A	-	N/A	
Natural Moisture Content (%)	9.9*	88.0*	36.4*	17*	40*	-	**40**

Properties	Min	Max	Mean	No. of Tests	Design Value derived from Phase 1	Design Value derived from Phase 2	Design Value
Liquid Limit	51.0*	78.0*	64.5*	2*	70*	-	**70**
Plasticity Index	29.0*	52.0*	40.5*	2*	45*	-	**45**
SPT N Value	0.5*	14*	6.5*	26*	6*	-	**6**
	0.5	22**	6.3**	29**	-	6	
Derived Undrained Shear Strength C_u (kPa)	2.3*	63.0*	26.0*	26*	25*	-	**25**
	2.25	99	28.3#	-	-	25	
pH	7	8.8	7.7	9	-	7	**7**
Water Soluble Sulphates (g/l)	0.161*	3.910*	1.504*	6*	3.910*	-	**3.910**
	0.238	1.521	0.674	9	-	1.521	

*data from Phase 1 ground investigation (also greyed out)

#based on SPT N values below N=30

The relative density of this material as measured by the Standard Penetration Test (SPT) N values was found to be very loose/very soft to medium dense/stiff., Locally along the northern boundary of the site, the Standard Penetration Test sampler fell under its own weight. The results of SPT N values above 30 have been removed from the averaging data due to the likelihood that obstructions within the made ground were causing the SPT to refuse and as such exaggerating the average N value.

Using the empirical relationship Cu = 4.5*N (after Stroud and Butler 1975), the calculated undrained shear strength is low. When the sampler fell under its own weight, this suggests that the landfill waste has no shear strength.

The samples of the made ground recovered during the Phase 2 ground investigation and subject to sulphate testing under BRE Special Digest SD1:2005 'Concrete in Aggressive Ground', give a design sulphate class of DS-2. The pH analysis indicates that an ACEC class of AC-2 would apply to the made ground. However, with reference to the results of the Phase 1 ground investigation, given the variability of the material a conservative approach should be taken and a design sulphate class of DS-4 and ACEC class of AC-4 should be adopted across the site in this material.

5.3 Tidal River Deposits

The range of geotechnical parameters (both measured and derived) for the tidal river deposits, determined from both the Phase 1and Phase 2 ground investigations, and the selected design values are shown in Table 5 below.

Table 5 Summary of Geotechnical Parameters for the Tidal River Deposits

Properties	Min	Max	Mean	No. of Tests	Design Value derived from Phase 1	Design Value derived from Phase 2	Design Values
Layer Thickness (m)	3.3	5	N/A	N/A	N/A	-	**N/A**
	0.80	5.30	N/A	N/A	-	N/A	
Natural Moisture Content (%)	22.0*	65.0*	37.3*	7*	40*	-	**40**
Optimum Moisture Content (%)	9.0**	12.0**	10.0**	4**	12**	-	**12**
California Bearing Ratio (%)	0.6**	3.5**	1.7**	4**	1.5**	-	**1.0**
	<1.0	2.1	-	3		1.0	
Liquid Limit (%)	31.0*	68.0*	44.0*	5*	45*	-	**45**
Plasticity Index (%)	14.0*	41.0*	23.0*	5*	23*	-	**23**
SPT N Value	0.5*	18*	5.6*	9*	6*	-	**8**

Properties	Min	Max	Mean	No. of Tests	Design Value derived from Phase 1	Design Value derived from Phase 2	Design Values
	0	24	8.8	14	-	9	
Derived Undrained Shear Strength C_u (kPa)	2.3*	81.0*	25.0*	9*	25*	-	25
	0	108	39.6	-	-	40	
Measured Undrained Shear Strength C_u (kPa)	12.0*	60.0*	35.0*	3*	30*	-	
Water Soluble Sulphates (g/l)	0.009*	0.585*	0.347*	5*	0.585*	-	**0.585**

*data from Phase 1 ground investigation (also greyed out)

**data from Phase 1 ground investigation from the adjacent land (also greyed out)

In places the description of the tidal river deposits is similar to the underlying strata i.e. the Bracklesham Group, and N values of what is actually the Bracklesham Beds may have been included within SPT range for the tidal river deposits. Therefore when assessing the derived undrained shear strength via the SPT N values a conservative approach in the selection of the adopted design value has been made.

5.3.1 Bracklesham Group

The range of geotechnical parameters (both measured and derived) for the Bracklesham Group, determined from both the Phase 1and Phase 2 ground investigations, and the selected design values are shown in Table 6.

Table 6 Summary of Geotechnical Parameters - Bracklesham Group

Properties	Min	Max	Mean	No. of Tests	Design Value derived from Phase 1	Design Value derived from Phase 2	Design Values (Depth Relationship)
Layer Thickness	3.80	7.30	4.90	4	N/A	**N/A**	**N/A**

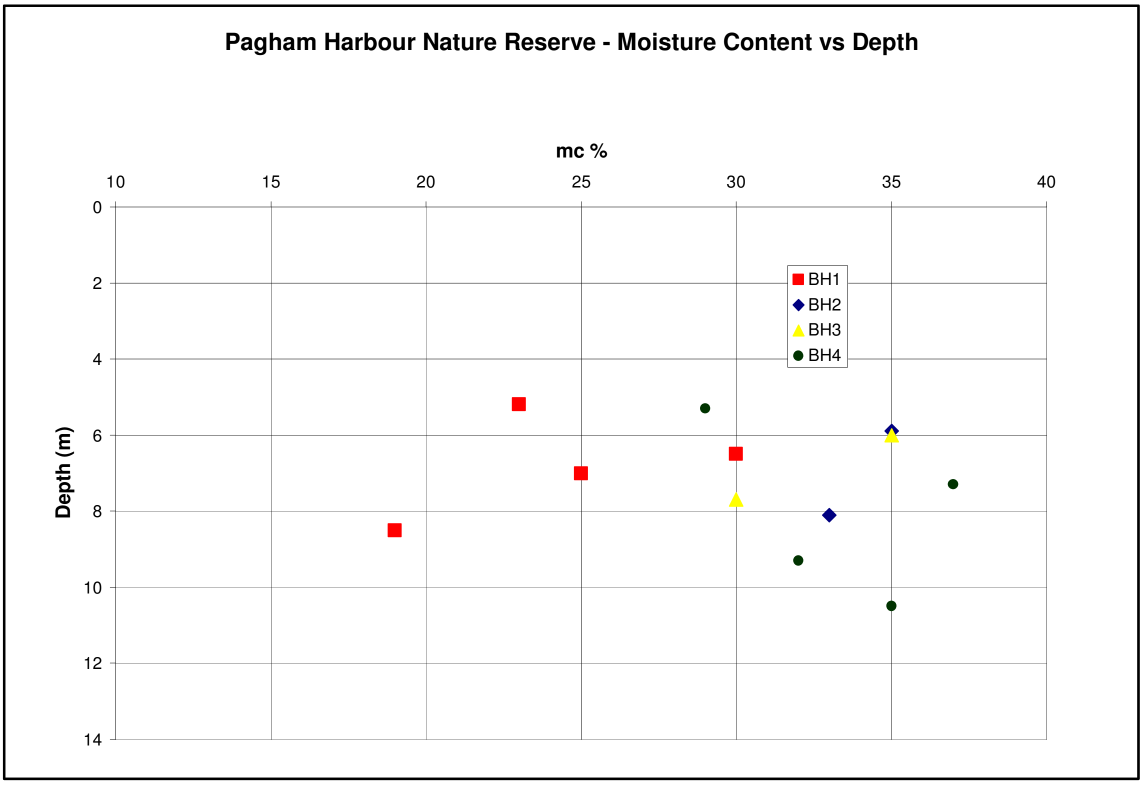
Properties	Min	Max	Mean	No. of Tests	Design Value derived from Phase 1	Design Value derived from Phase 2	Design Values (Depth Relationship)
Natural Moisture Content (%)	24.0*	48.0*	33.5*	12*	35*	-	**32**
	19.0	37.0	30.3	12	-	30	
Liquid Limit (%)	52.0*	90.0*	70.0*	6*	70*	-	**70**
	30.0	77.0	62.0	12	-	62	
Plasticity Index (%)	33.0*	60.0*	45.0*	6*	45*	-	**42**
	12.0	53.0	41.8	12	-	42	
SPT N Value	2*	22*	15*	11*	10*	-	**(1.7 x D)**
	7	29	13	19	-	13	
Derived Undrained Shear Strength Cu (kPa)	9.0*	99.0*	65.0*	11*	60*	-	**(7.2 x D)**
	31.5	130.5	58.5	-	-	60	
Measured Undrained Shear Strength Cu (kPa)	32.0*	92*	54.0*	7*	50*	-	
	23.0	48.0	39.0	5	-	40	
Coefficient of Compressibility M_v (m^2/MN)	0.18	0.51	0.29	5	-	0.29	**0.29**
pH	7.6	9.2	8.1	10	-	7.6	**7.6**
Water Soluble	0.168*	0.551*	0.421*	4*	0.551*	-	**0.585**

Properties	Min	Max	Mean	No. of Tests	Design Value derived from Phase 1	Design Value derived from Phase 2	Design Values (Depth Relationship)
Sulphates (g/l)	0.172	0.585	0.335	10	-	0.585	

*data from Phase 1 ground investigation (also greyed out)

The natural moisture content within the Bracklesham Group is shown to be relatively broad with a slight increase in moisture content with depth as illustrated in Figure 4 below.

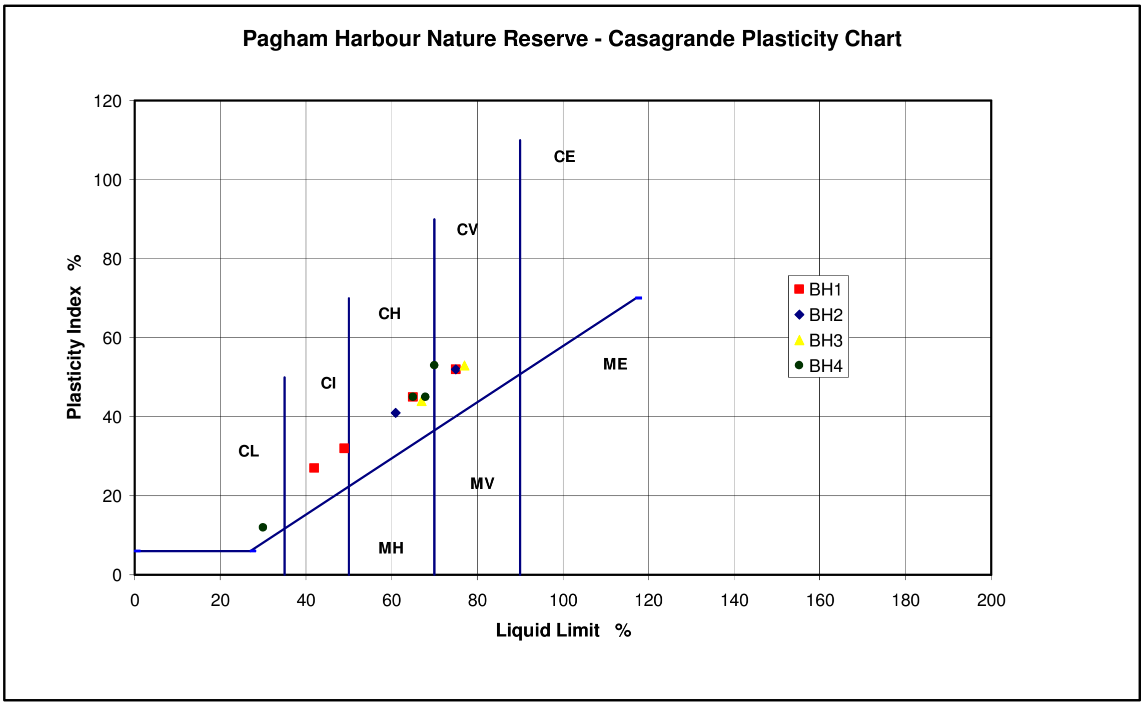
Figure 4 Moisture Content - Bracklesham Group



The range of grading of this sandy to very sandy micaceous clay is reflected in the results of the Atterberg Limits. The plasticity indices range from 12% to 53% averaging 41.8%. The Casagrande Chart in Figure 5 below shows the Bracklesham Beds are generally high to very high plasticity clays, which reflects the findings of the Phase 1 ground investigation.

The result of the particle size distribution analysis confirms that the Bracklesham Group are predominantly sandy clays.

Figure 5 Casagrande Chart - Bracklesham Group



A depth relationship has been provided for both the standard penetration test and derived undrained shear strength. With reference to Figure 8, N values increase with depth. To illustrate this design value, where D=7m within the Bracklesham Group, the undrained shear strength would be 7.2 x 7 = 50.4kPa.

When compared to BRE Special Digest SD1:2005 ‘Concrete in Aggressive Ground’, the results of the Phase 1 and Phase ground investigation are consistent and a design sulphate class of DS-2 and ACEC class of AC-2 is appropriate for the Bracklesham Group.

5.4 Bagshot Beds

The range of geotechnical parameters (both measured and derived) for the Bagshot Beds, determined from the Phase 2 ground investigation, and the selected design values are shown in Table 7 below. The Bagshot Beds were not encountered during the Phase 1 investigation as exploratory holes were terminated in the overlying Bracklesham Beds.

Table 7 Summary of Geotechnical Parameters for the Bagshot Beds

Properties	Min	Max	Mean	No. of Tests	Design Values
Layer Thickness	0.5	3.2	1.93	N/A	N/A
SPT N Value	10	83	28	5	**28**
pH	7.5	8.1	7.8	2	**7.5**
Water Soluble Sulphates (g/l)	0.119	0.221	0.17	2	**0.221**

The results of the standard penetration tests undertaken within these sands present between 9.0 and 12.0m bgl indicate that the soils are generally medium dense, and locally very dense.

The particle size distribution analysis indicates that the Bagshot Beds comprise clayey silty sand and silty sand.

The samples recovered of the Bagshot Beds subject to sulphate and pH testing in accordance with BRE Special Digest SD1:2005 'Concrete in Aggressive Ground', suggests a design sulphate class of DS-1 and ACEC class of AC-1 are appropriate for the Bagshot Beds.

5.5 London Clay

The range of geotechnical parameters (both measured and derived) for the London Clay, determined from both the Phase 1and Phase 2 ground investigations, and the selected design values are shown in Table 8 below.

Table 8 Summary of Geotechnical Parameters for the London Clay

Properties	Min	Max	Mean	No. of Tests	Design Value derived from Phase 1	Design Value derived from Phase 2	Design Values (Depth Relationship)
Natural Moisture Content (%)	22.0*	31.0*	26.0*	6*	25*	-	**28**
	22.0	47.0	29.6	22	-	30	
Optimum Moisture Content (%)	12.0*	15.0*	13.0*	3*	14*	-	**14**
Liquid Limit (%)	42.0*	63.0*	50.0*	4*	50*	-	**55**
	43.0	75.0	60.0	22	-	60	
Plasticity Index (%)	19*	41*	31*	4*	30*	-	**35**
	26.0	56.0	38.0	22	-	38	
SPT N Value	10	36	23	27	-	23	**(1.3 x D)**
Derived Undrained Shear Strength Cu (kPa)	45	162	104	-	-	104	**(5 x D)**
Measured Undrained Shear Strength Cu (kPa)	19	159	70	14	-	70	
Coefficient of Compressibility M_v (m^2/MN)	0.10	0.27	0.17	6	-	0.17	**0.17**
pH	6.5	8.4	7.8	18	-	6.5	**6.5**

Properties	Min	Max	Mean	No. of Tests	Design Value derived from Phase 1	Design Value derived from Phase 2	Design Values (Depth Relationship)
Water Soluble Sulphates (g/l)	0.151	1.431	0.599	18	-	1.431	**1.431**

*data from Phase 1 ground investigation from the adjacent land (also greyed out)

With the exception of four samples tested from BH1 and BH3 (where the samples were recovered within clay containing frequent partings and pockets of sand, which are water bearing), the range of moisture contents within the London Clay is shown to be relatively consistent, between approximately 22% and 34%. A slight increase in moisture content with depth is noted, as illustrated in Figure 6 below.

Plotting of the plasticity and liquid limit on the Casagrande Chart in Figure 7 below confirms that the deposits predominantly high plasticity clays. The results of the particle size distribution analysis shows that the London clay consists of predominantly sandy clay and sandy silt.

Figure 6 Moisture Content - London Clay

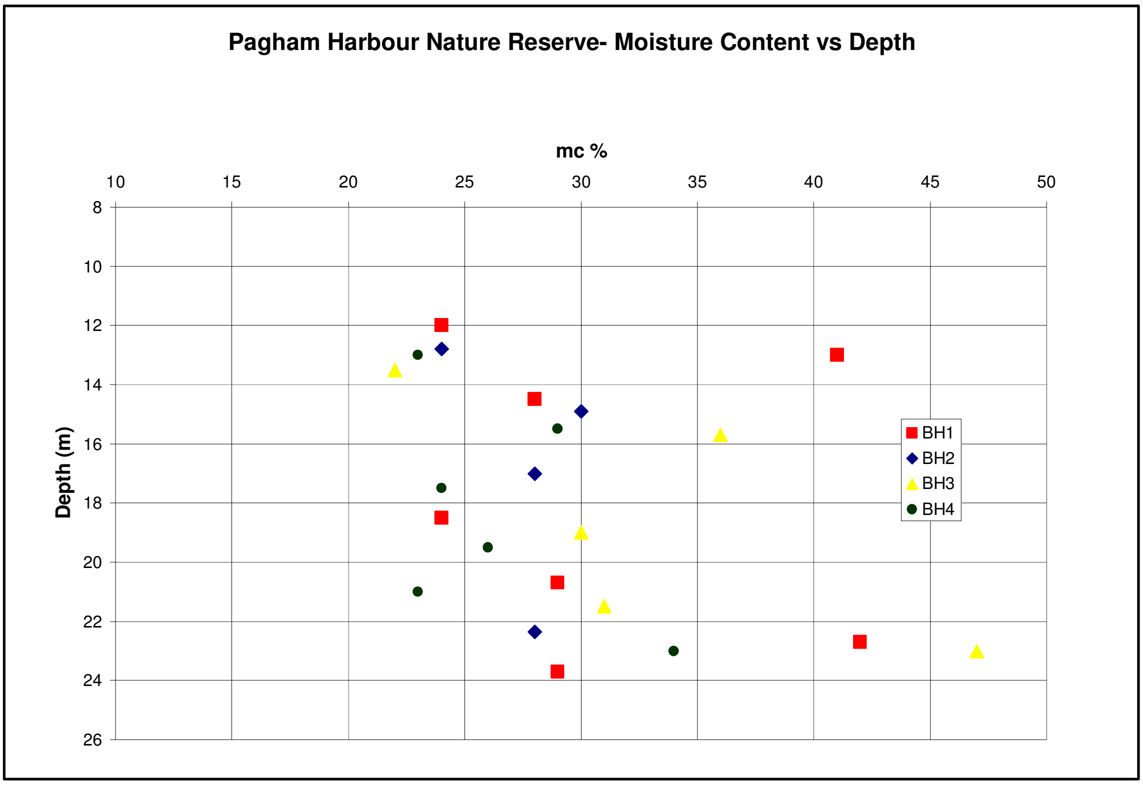


Figure 7 Casagrande Chart - London Clay

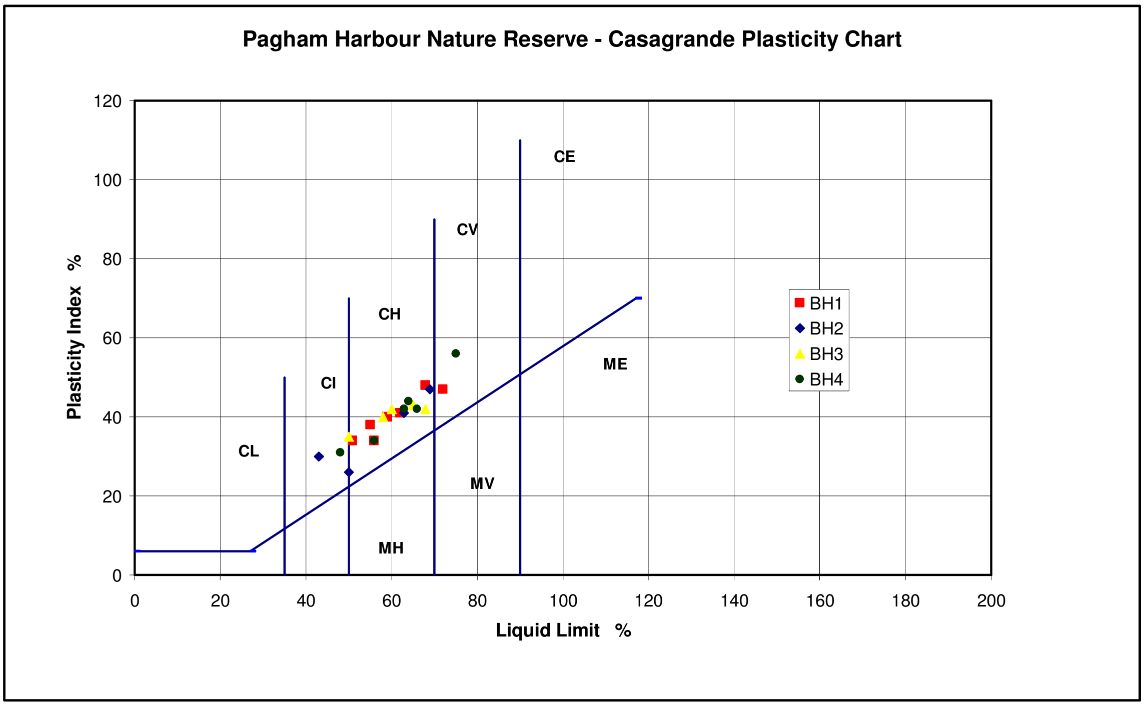
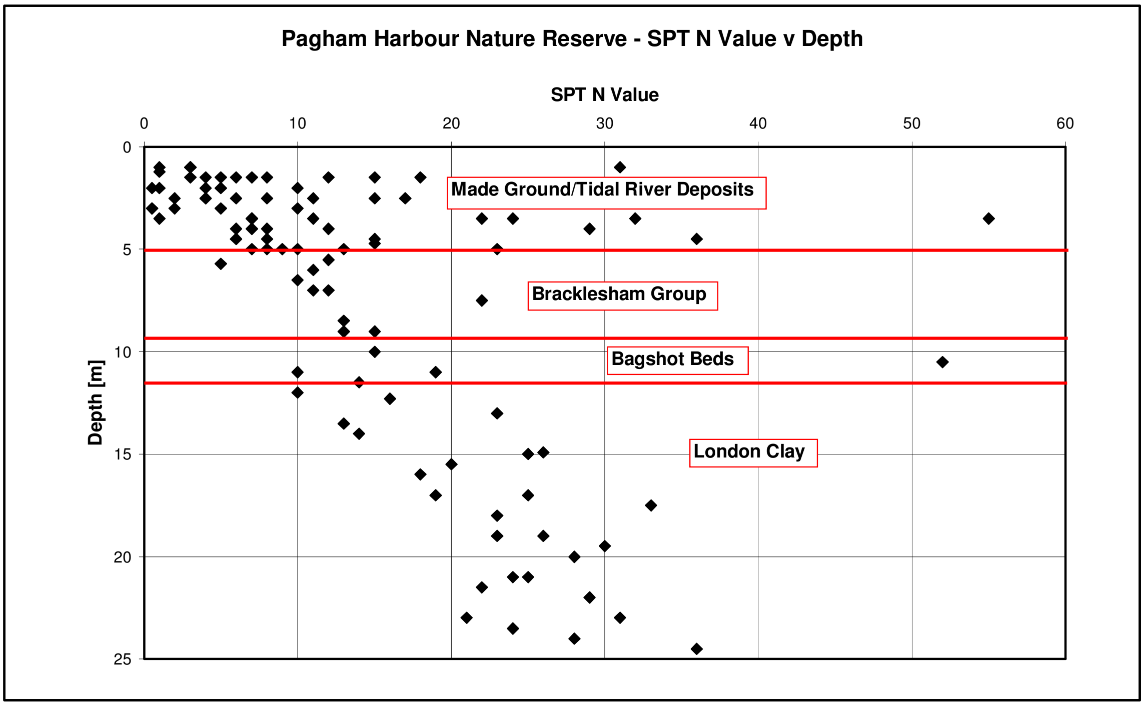


Figure 8 Standard Penetration Tests - All Strata

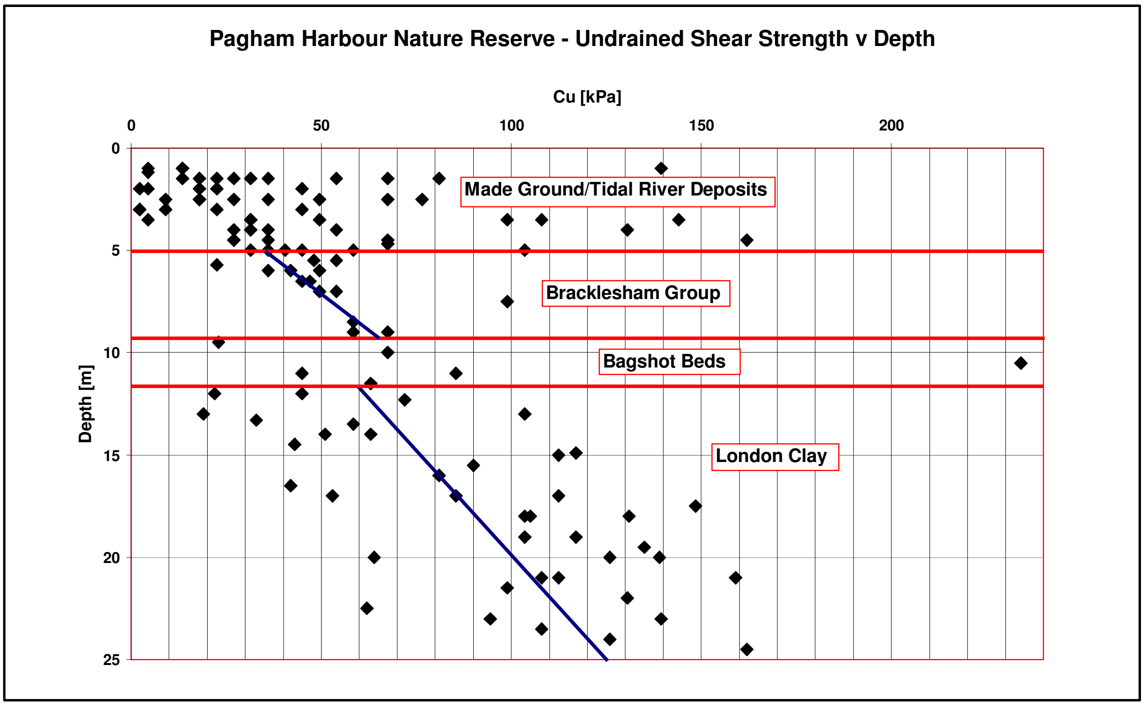


With reference to Figure 8 which includes N values for all the strata from ground level to 25m bgl, the N values increase with depth. The results of standard penetration tests indicate that the upper horizons of the London Clay are firm, with the formation becoming stiff with increased depth, and stiff to very stiff at a depth of around 25m bgl.

The measured undrained shear strength and the derived undrained shear strength are plotted on the graph against depth (including all stratum) shown in Figure 9 below.

A depth relationship has therefore been provided for both the standard penetration test N value and the derived undrained shear strength within Table 8. To illustrate this, where D=15m within the London Clay strata, the undrained shear strength would be 5 x 15 = 75kPa. Similarly at 12m and 25m bgl, the shear strength is 60kPa and 125kPa respectively.

Figure 9 Undrained Shear Strength - All Strata



The samples of the London Clay subject to sulphate testing under BRE Special Digest SD1:2005 ‘Concrete in Aggressive Ground’, indicate that a design sulphate class of DS-2 and an ACEC class of AC-2. However, the London Clay contains pyrite, which was confirmed by visual observation during borehole sample logging and from the oxidisable sulphide (OS) concentrations, which are typically above the threshold of 0.3% in the samples tested.

On this basis, the characteristic value of total potential sulphate (TPS) was determined as 2.65%, indicating that Design Class DS-5 should apply to this site. However, a limitation can be applied if the sulphate class for the TPS is initially found to be Sulphate Class 5, but sulphate classes for groundwater and the water extracts tests are Sulphate Class 3 or less, as shown above. In this case therefore, the Design Sulphate Class for the site can be limited to DS-4, and ACEC AC-4. Given this is the same classification as for the made ground, DS-4, and ACEC AC-4 represents the worst case situation and should be applied across the whole of the site.

5.6 Foundation Analysis and Recommendations

5.6.1 Visitors Centre

Due to the thickness (proven up to 6.5m thick in the Phase 1 investigation), variable nature both vertically and laterally, and low shear strength of the made ground, this stratum is considered unsuitable to support conventional shallow foundations for neither the visitors centre nor the bridge crossing. Significant differential settlement would be anticipated on loading. Similarly, the tidal river deposits, which are soft and exhibit similarly low shear strength have a calculated ultimate bearing capacity of 128.5kPa, (after Brinch Hansen, 1961) which yields a safe bearing capacity of less than 45kPa, and insufficient to support the proposed structures. This stratum is not recommended as a founding stratum.

A selection of ground improvement options can be considered to permit the construction of shallow foundations for structures on poor, low strength soils. Of the methods available, the use of a form of dynamic compaction/loading is considered inappropriate at the site, given its environmental sensitivity to vibration and noise. The installation of stone columns, to strengthen the soils is deemed unsuitable, as given the soft nature of the soils, on loading the stone columns would be pushed laterally into the soft soils and become ineffective with the installed stones adding more load to the underlying soils.

Pre-surcharging the ground involves the addition of bulk soil to the ground surface to load the ground and accelerate consolidation settlement in advance of construction works. A comprehensive understanding of the settlement characteristics is required to predict the time required for up to 95% of the consolidation settlement to have occurred prior to construction of the foundations. Given the variable content and nature of the made ground this cannot be calculated and is considered to a high risk option.

On the whole, given the size of the scheme, costs incurred in undertaking the ground improvement, the impact on programme and versus risk this is not considered a practicable option.

The use of a shallow raft foundation could be considered for the visitors centre. A raft allows differential settlement of the underlying soils but prevents this movement translating to the overlying structure. The raft moves/tilts as one unit which would otherwise cause failure of the superstructure. This is, however, an unsuitable option for the proposed bridge structure as potential different movement at either abutment would cause flexing and failure of the bridge structure in between.

Furthermore, raft foundations would require the excavation of a volume of made ground and any surplus during construction, without prior approval from the Environment Agency, would be classified as waste. Whilst this is a former landfill discussions with the Agency would be required to obtain a Waste Management Licence Exemption, to allow the soils to remain on site. Alternatively, the soils would need to be disposed of off site, with associated cost implications.

Based on the size of the proposed development/foundation requirements it is considered prohibitive to construct two different foundations types on this site to cater for the requirements of the bridge and the visitors centre. As such transferring the load to depth via a piled foundation solution is deemed most suitable.

A piled foundation solution provides the least risk option, i.e. the load is transferred down the piles to more competent strata, within the Bracklesham Group and London Clay, at depth. Piles offer the advantage of overcoming the settlement concerns and with careful selection of construction materials, can fit in with the overall environment suitable to a nature reserve.

A foundation works risk assessment, has been completed and is presented in Chapter 7 of this report to assess the most appropriate piling method for the site condition and any risks posed.

There are two types of piles from a design and construction perspective; driven or displacement piles, and bored or replacement piles. Within the Phase 1 report an outline design for driven piles was presented. Given the environmental sensitivity of the site, the vibration of hammering or jacking piles into the ground an alternative design has been presented below based the installation of bored Continuous Flight Augered (CFA) piles.

The analyses is presented to indicate the safe working loads of a number of circular piles of varying length (10-15m) and diameter (300mm, 400mm and 500mm).

For the purpose of the analysis, the contribution of the upper two layers (made ground and river tidal deposits) to the skin friction is constant. The variation will be in the shaft resistance in the Bracklesham Group, Bagshot Beds and London Clay which will be a function of the pile length.

The calculated safe working loads are based on the maximum thickness of made ground found in the boreholes at the visitors centre, and whilst absent in BH2 and BH4, 1.5m of tidal river deposits have been included within the calculations due to their presence in BH03.

The made ground is unconsolidated and ongoing settlement of the made ground under its own self weight around the pile, which adds load to the pile, is likely. The pile calculations have allowed for negative skin friction, or down drag within the made ground.

Allowance has also been made for the construction of a 350mm capping layer, which would settle with the underlying made ground and as such has been added as negative skin friction within the calculations. If the phasing of the work differs from this assumption, a review of the pile design presented here will be necessary to remove the capping layer and associated negative skin friction.

For the purposes of design, the undrained shear strength of the Made Ground and the Tidal River Deposits is 25kPa, and using an adhesion factor (α) of 0.5 in line with published information. The shaft resistance in the Bracklesham Group, Bagshot Beds and London Clay is a function of the increase in shear strength with depth and the embedment depth in the respective strata. An adhesion factor (α) of 0.50 is applied to the Bracklesham Group, and 0.45 for the Bagshot Beds and London Clay. A maximum 25 metre pile has been allowed with shear strength restricted to 125kPa for end bearing in the London Clay.

A factor of safety of 2.5 has been applied to these calculations.

Assuming a design load for the proposed visitors centre of 75kPa and a plan area of approximately 20m by 20m which gives a total load for the structure of 30MPa, Table 9 below illustrates the number of piles likely to be required to support the structure, based on the safe working load of single piles between lengths of 10m and 25m and diameters of 300mm, 400mm and 500mm.

Table 9 Safe Pile Loads for various pile Lengths and diameters for the proposed visitors centre

Pile Length (m) / Founding Depth (mBGL)	300mm dia.		400mm dia.		500mm dia.	
	Safe Working Load per pile (kN)	No. of Piles Req'd*	Safe Working Load per pile (kN)	No. of Piles Req'd*	Safe Working Load per pile (kN)	No. of Piles Req'd*
10	31	964	47	636	66	455

Pile Length (m) / Founding Depth (mBGL)	300mm dia.		400mm dia.		500mm dia.	
	Safe Working Load per pile (kN)	No. of Piles Req'd*	Safe Working Load per pile (kN)	No. of Piles Req'd*	Safe Working Load per pile (kN)	No. of Piles Req'd*
11	42	719	62	485	85	353
12	53	564	78	386	106	284
13	66	458	95	317	128	236
14	79	382	113	266	151	199
15	93	324	132	228	176	171
16	107	280	152	197	202	149
17	123	244	174	173	229	131
18	140	215	196	153	258	117
19	157	191	220	137	289	104
20	175	172	245	123	321	94
21	194	155	271	111	354	85
22	214	140	298	101	388	78
23	235	128	327	92	424	71
24	257	117	356	85	462	65
25	279	108	386	78	501	60

* across an assumed area of 20m x 20 m

Based on a configuration of pile spacing no greater than three times the pile diameter, the number of piles is limited within the area of the proposed loadings, and these have been greyed out in Table 9.

The pile lengths, diameter and grouping will need to be adjusted to suit the final design loads and footprint of the proposed structure. Final selection of pile length and diameter versus number of piles required will be a function of cost of installation and material. Discussion with a specialist piling Contractor will therefore be required to judge the economic advantages of the final design.

5.6.2 Bridge Crossing

Design of the bridge crossing remains unconfirmed. For the purpose of these calculations, the construction of a steel road bridge with a 4m wide carriageway has been assumed, contributing an abutment load of 1500kN which is currently assumed to be spread over a 5m x5m area, on both sides of Red Barn Ditch.

The safe working loads in the table assume the maximum thickness of made ground in the area of the bridge crossing. As with the foundations for the visitors centre it has been assumed that the made ground will provide negative shaft friction or drag down. An element of overburden has also been included to account for 350mm of capping in the area. A factor of safety of 2.5 has been used for the analysis.

Table 10 illustrates the safe working load per pile and number of piles required to support the structure, assuming single piles between lengths of 10m and 25m and diameters of 300mm, 400mm and 500mm.

Table 10 Safe Pile Loads for various pile lengths and diameters for the proposed bridge crossing

Pile Length (m) / Founding Depth (mBGL)	300mm dia.		400mm dia.		500mm dia.	
	Safe Working Load per pile (kN)	No. of Piles Req'd	Safe Working Load per pile (kN)	No. of Piles Req'd	Safe Working Load per pile (kN)	No. of Piles Req'd
10	57	30	82	21	109	16
11	68	25	96	18	128	13
12	79	21	112	15	149	12
13	91	19	129	13	171	10
14	105	16	147	12	194	9
15	119	14	167	10	219	8
16	133	13	187	9	245	7
17	149	12	208	8	273	7
18	166	11	231	8	302	6
19	183	10	255	7	332	5
20	201	9	280	6	364	5
21	220	8	306	6	397	5
22	240	7	333	5	432	4
23	261	7	361	5	468	4
24	283	6	391	5	505	4
25	305	6	421	4	544	4

*Based on the design assumption detailed in the text

Based on a configuration of pile spacing no greater than three times the pile diameter, the number of piles is limited within the area of the proposed loadings, and these have been greyed out in Table 10.

The pile lengths, diameter and grouping may be adjusted to suit the final requirements of the proposed bridge crossing and proposed loadings once the final design is confirmed.

5.7 Concrete Classification

If concrete is selected as the construction material for the piles a design sulphate class for the site will be DS-4 with an ACEC class of AC-4.

5.8 Pavement foundations

Pavements will be required for the access road to the visitors centre and upgrade of car parking facilities

The made ground and underlying tidal river deposits are highly variable, and in places soft, exhibiting no shear strength. The main geotechnical consideration is the unpredictable potential for settlement of the strata on loading. The risk of differential settlement is also deemed to be high.

Whilst the majority of the roads and hardstanding within the site are not deemed highly sensitive to total and differential settlements, particular attention must be paid pavement to the tie with the proposed bridge structure over Red Barn Ditch and drainage infrastructure which will be highly sensitive to small movements. The drainage design tolerances are likely to be the controlling factor.

Zero movement of drainage pipelines is generally required to ensure the design gradient is not altered which could otherwise cause water to back up within the system. Additionally, movement will cause the cracking of pipes, leading to leakage within the system and washing out of fines within the underlying soil stratum, which will further exacerbate the failure. The use of plastic pipes and flexible joints between pipe sections will allow the accommodation of very small scale i.e. 10mm differential movement.

With respect the pavement design, highways construction in the UK is based on materials specification rather than performance specification, determined from the design CBR value for the sub grade material across the site. Therefore professional judgement is required to establish design tolerances for the site.

A number of options are available for pavement areas to accommodate the settlement, according to the desired appearance, initial construction cost, and future maintenance and repair costs of the structure. These include a 'granular' surface, a flexible pavement with tarmac surface or rigid pavement construction.

Whilst a granular road surface would fit into the overall aesthetics of the site, the potential settlements and loss of granular material into the underlying made ground, with the associated frequent and long term maintenance costs is likely to make this option prohibitive. The installation of geotechnical grid (geo-grid) to limit settlement and also a geotechnical membrane to prevent mixing of the gravels with the underlying made ground may reduce maintenance levels, the lifetime of the pavement is considered to be limited.

Flexible pavements can move considerable from their original build levels (100mm or more) without significant loss of service provided traffic speeds are low and surface water run off can still be achieved. However when differential settlement occurs at a sudden change in ground conditions such as along a trench excavation then cracking of the surface may occur with as little as 20mm of movement.

In view of the relatively flat nature of the site it is considered that for a flexible pavement a maximum total and differential settlement of 25 mm would be acceptable. Greater differential movement will cause depressions and deformation of the flexible pavement which will eventually crack and fail, beyond which the ponding of surface water may cause operational problems.

For a rigid pavement where the concrete slabs may move and tilt independently of adjacent slabs, a maximum total and differential movement of 10 to 15mm would be considered acceptable for vehicular traffic, however it would create a potential trip hazard to pedestrians. Greater differential movement will cause the concrete to crack and fail, or in the case of a block paver option, adjacent pavers to part allowing wash out of the fine bedding sand and eventual failure of the pavement.

It is considered that the applied loadings in areas of roads and hardstanding only will be not greater than 50kPa. This is based on the dead weight of the pavement and loadings of goods delivery vehicles with the addition of a carrying load (taken as the worse case loading for the site).

The CBR measured on remoulded samples during the Phase 1 and Phase 2 ground investigation produced a CBR of 1.5% and 1.0%, respectively. The resistance of the subgrade to deformation under load from vehicle wheels across the site is considered to be extremely poor and sub-grade improvement will be required.

Bearing on the made ground, a capping layer, potentially in combination with a geo-grid, will need to be included within a flexible pavement construction. Without a geo-grid, the capping layer will need to be in the order of 1000mm thick. However, with installation of a series of polypropylene geogrids combined with a granular material within a flexible pavement construction, the capping layer can be reduced to in the order of 450mm thick.

To minimise the re-profiling of made ground below the pavement structure and to tie finished ground levels following construction of the landfill capping layer, the installation of a geo-grid is preferable.

Material used for the capping layer is typically a granular material which complies with the requirements in the Specification for Highway Works (SHW) produced by the Highways Agency (recycled crushed demolition material can be used as capping layer if a source is available).

It is recommended that this is installed on a geotechnical membrane such as 'Terram 1000' or equivalent to prevent contamination of the capping material by the made ground. This impermeable layer should be incorporated into the base of the pavement structure, to tie into the road drainage.

Rigid pavement construction would take the form of in-situ reinforced concrete paving slabs. A design appropriate for use by heavy goods vehicle traffic would generally be as follows:

- 200mm C40 Air-entrained pavement quality concrete (PQQ) complete with mesh reinforcement; over
- Polythene slip membrane
- 225mm type 1 subbase Type 1; giving a total pavement thickness of 425mm

The inclusion of the mesh reinforcement combined with mechanical expansion and contraction joints will reduce the potential for cracking of the slabs as a result of differential settlement and thermal conditions. Use of cellular grasscrete paving would provide an aesthetical advantage, blending the road construction into the site wide conditions.

A further option to consider is the use of small element concrete paving, i.e. concrete block paving. A pavement construction appropriate for heavy goods vehicles would be as follows:

- 80mm thick concrete block pavers; over
- 30mm compacted sand laying course; over

- 150mm base (roadbase); over
- 225mm type 1subbase Type 1 with underlying geo-grid; giving a total pavement thickness of 485mm.

The use of a concrete block paver solution provides the durability of a rigid concrete pavement surface but also provides the benefits of a flexible pavement design due to the movement that can be accommodated between the small paver units (200mm by 100mm).

Once the route of the road, proposed vehicle movements on site and area for car parking is confirmed, with reference to the Highways Agency Design Manual for Roads and Bridges (DMRB), County Council Design guides and current best practice, a tailored design should be produced to suit the proposed application.

5.9 Temporary Works during Construction

The requirements for piling platform and haulage roads within the site would form part of the temporary works and would therefore be the responsibility of the main Contractor. However, the requirement for a safe internal tracking route for the piling rig required to facilitate the construction of the visitors centre in Area A may also be combined with the permanent construction of the access road affecting a cost saving.

Similarly, a bridge crossing will be required to provide access for the piling rig over Red Barn Ditch into Area A. The current ditch crossing and Tramway footpath are inadequate. Rig access may be available along the existing harbour wall; however a further assessment would be required and consideration should be given to accommodating the construction of this otherwise temporary structure within the design of the permanent bridge crossing.

5.10 Excavation Stability

Excavations of near surface materials can be handled by back acting excavators, however given the nature of the made ground and the proximity of the groundwater, sidewalls may require bracing if left open for extended periods.

In areas of un-surfaced made ground, using tracked plant is preferable to prevent settlement of plant and machinery during construction.

5.11 Re-use of Arisings

Reuse of the natural soils arising from excavations and the piles may be possible on condition these are sufficiently segregated from the made ground. The clay deposits may be suitable for reuse within the landfill capping layer.

The natural moisture contents over the soils; the tidal river deposits, the Bracklesham Group and the London Clay is greater than the optimum moisture content and will require pre-treatment i.e. drying prior to compaction and re-use

5.12 Landfill Capping

The construction of a landfill capping layer is required to mitigate the risks to human health, the risk driver being elevated concentrations of benzo (a) pyrene. A minimum capping thickness of 352mm has been calculated.

Re-profiling of made ground should be kept to a minimum during construction and consequently it is recommended that the capping is placed on the existing ground level across the majority of the site tying to existing topographical levels, between approximately 2.5m and 6m AOD.

Suitable material would be available from the neighbouring site to the north if this were purchased and used for a wetland creation (Phase 1 Mouchel report 721334/R/2B). The Contractor will need to pay particular attention to the method of construction of the capping to achieving sufficient compaction, as detailed in the Phase 1 report, in the light that the shallow soils in areas of the site are confirmed to have no or very low shear strength.

The trial pits identified waste abutting the east and western boundary of Area1. Whilst the landfill capping layer could simply be extended to the perimeter of the landfill, over time the capping layer would erode and break out of waste would occur. A finishing detail is required within the landfill capping design to contain the waste. A conceptual design has been provided within the following design sketches;

- 721374/M/09 -Design Sketch Landfill Capping at Bank of Red Barn Ditch);
- 721374/M/10 - Design Sketch Landfill Capping on Eastern Perimeter); and
- 721374/M/11 - Design Sketch Landfill Capping and Leachate Diversion Drain (North West Boundary).

The installation of a clay plug constructed of the landfill capping material will provide continuity between the capping and the adjacent natural soils, in essence encapsulating the made ground.

It was not possible during the site investigation to prove the geology below the Red Barn ditch because access to the banks was difficult and because where the margins of the Red Barn Ditch were investigated, waste was found. It is not clear whether there is waste below the channel or not. If the waste does pass below the ditch, this will have to be removed to prevent waste emerging in the banks in a prominent visible location. The capping layer, appropriately designed to prevent erosion will have to be extended below the channel.

Along the north-western boundary, the clay plug is incorporated within the leachate diversion drain design. By extending the landfill capping over the French drain, surface run off from the landfill is prevented from entering the leachate diversion drain. The clay plug acts as a cut off impeding drainage of the surface water within the ditch entering into the leachate diversion drain.

Detailed design, including quality of imported material, and installation specification would need consultation with the regulator, Environmental Health Officer.

5.13 Groundwater Impact

Ingress of groundwater into shallow excavations was encountered during the investigation and was described as a fast inflow and as such groundwater control measures would be required in shallow excavations.

Groundwater ingress should be anticipated during piling operations, not only within the shallow soils, but also from within the sand lenses and pockets in the Bracklesham Beds and London Clay, and also from the sand layer of the Bagshot Beds.

Particular water control measures will be required during the construction of the landfill cap and clay pug on the banks of Red Barn Ditch. Discussion with the construction contractor will be required to determine a suitable method of construction.

6 Ground Gas Risk Assessment

A ground gas risk assessment has been undertaken in accordance with CIRIA Guidance C665, "Assessing Risks Posed by Hazardous Ground Gases to Buildings" 2007, and comprises the following:

- Assessment of results;
- Calculation of Gas Screening Values for Methane and Carbon Dioxide (Planning);
- Assessment of risks from ground gas;
- Development options

6.1 Assessment of Results

A summary of the results has been presented within the Ground Model section of the report with graphical plots of measured levels of each of the ground gases.

No volatile compounds were identified within the BTEX or fractionated TPH analysis undertaken on the soil samples from the landfill during the previous phase of the investigation, so no volatile gas monitoring for these compounds was considered necessary.

6.2 Calculation of Gas Screening Values

A Gas Screening Value is derived by multiplying the maximum gas concentration (%) by the maximum measured flow rate (l/h). These are presented in Table 11 and Table 12 below.

Table 11 Gas Screening Value for Methane

Gas monitoring well	Highest measured CH4 concentration (%)	Flow Rate (l/h)	GSV	Risk Classification	Characteristic Situation
BH1	3.6	1.2	0.0432	Very low risk	1
BH2	0.1	1.3	0.0013	Very low risk	1
BH3	5.9	0.4	0.0236	Very low risk	1
BH4	5.5	0.3	0.0165	Very low risk	1
BH6	8.6	0.6	0.0516	Very low risk	1
BH8	0.2	0.6	0.0012	Very low risk	1
BH9	1.6	0.4	0.0064	Very low risk	1
BH10	0.2	0.7	0.0010	Very low risk	1
BH11B	0.8	0.9	0.0072	Very low risk	1
BH12	0.1	0.4	0.0003	Very low risk	1
BH13	0.5	0.9	0.0045	Very low risk	1

Table 12 Gas Screening Value for Carbon Dioxide

Monitoring Location	Highest measured CO2 concentration (%)	Flow Rate (l/h)	GSV	Risk Classification	Characteristic Situation
BH1	3.1	1.2	0.0372	Very low risk	1
BH2	9.6	1.3	0.1248	Low Risk	2
BH3	25.2	0.4	0.1008	Low Risk	2
BH4	3.6	0.3	0.0108	Very low risk	1
BH6	22.0	0.6	0.132	Low Risk	2

BH8	7.5	0.6	0.045	Very low risk	1
BH9	5.8	0.4	0.0232	Very low risk	1
BH10	7.9	0.7	0.0553	Very low risk	1
BH11B	20.5	0.9	0.1845	Low Risk	2
BH12	8.8	0.4	0.0352	Very low risk	1
BH13	3.6	0.9	0.0369	Very low risk	1

6.3 Assessment of Risk from Ground Gas

From the observations made during the ground investigation and the results of the monitoring, it is evident that the source of ground gas comprises the degradable fraction of waste within the landfill across the site.

The results of monitoring suggest that the generation of ground gas is low, however some elevated concentrations of both carbon dioxide and methane exist, with a maximum positive flow rate of 0.9l/hr.

Based on the maximum concentrations of methane and carbon dioxide, and the maximum flow rates recorded in each of the borehole monitored, a Very Low Risk classification can currently be applied to seven of the boreholes using the Modified Wilson Card classification scheme.

Very low risk indicates there is a low possibility that harm could arise to a receptor and in the event of such harm being realised it is not likely to be severe. This gives a characteristic situation of 1 which indicates no levels of protection are required and no special precautions have to be taken.

Four of the boreholes (BH2, BH3, BH6 and BH11B) can be classified as a Low Risk using the Modified Wilson Card classification which indicates that it is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild. This gives a characteristic situation of 2. A worst case scenario approach is recommended and it is advisable that gas precaution measures as detailed below are incorporated into the build. The proposed visitors centre is understood to be sited within the area of two of these four boreholes; BH2 and BH3.

Furthermore, it is observed that the borehole (BH12) closest to receptors on the western boundary is drawing gas in. This is shown by the rising carbon dioxide and falling oxygen levels as the monitoring period progressed, which would suggest the potential for off site migration of landfill gas.

6.4 Development Options

The results indicate that the gas regime beneath the site is of very low to low risk under a range of atmospheric conditions. A characteristic situation 2 has been assigned, which indicates levels of protection are required including:

a) Reinforced concrete cast *in situ* floor slab (suspended, non-suspended or raft) with at least 1200 g DPM[2].

b) Beam and block or pre cast concrete slab and minimum 2000 g DPM/reinforced gas membrane.

c) Possibly underfloor venting or pressurisation in combination with a) and b) depending on use.

d) All joints and penetrations sealed.

Alternatively it may be possible to consider zoning the site with a view to relocating the visitors centre to an area of lower gas risk. However, any such decision would need to be made in conjunction with consideration of, and cost versus benefit assessment of geotechnical risk, and aesthetics.

Furthermore, even with the relatively low concentrations of gas and rates of flow recorded, it is considered that the construction of a clay capping layer which is proposed to be installed on the site to be protective of human health, will affect the gas regime. The cover system will reduce surface passive venting and force any gas generated towards the periphery of the landfill. As such it is recommended that venting measures are incorporated into the landfill cap design.

7 Foundation Works Risk Assessment

7.1 Objectives and Scope

The objectives of this foundation works risk assessment are to:

- identify potentially significant pollutant linkages associated with the piling methods;
- produce a qualitative risk assessment;
- identify the preferred piling method; and
- provide mitigation measures to minimise the affects of pollutant linkages

The Environment Agency guidance on piling: NC/99/73 E.A. National Groundwater & Contaminated Land Centre. *Piling & Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention*, May 2001 has been followed.

This foundation work risk assessment considers the:

- creation of preferential pathways, allowing contaminated groundwater to leach downwards and impact an aquifer, or allowing gas to migrate upwards posing a risk within buildings,
- breaching of impermeable capping layers, allowing contaminated groundwater to leach downwards and impact an aquifer, gas to migrate upwards posing a risk within buildings or exposure of contaminated soils at surface potentially posing a risk to human receptors,
- the risks associated with the piling method i.e. driving of made ground and potentially contaminated materials downwards into the underlying natural strata during pile installation,
- the generation of contaminated soil arisings posing a risk to human health and disposal requirements,
- effects of aggressive ground conditions on piles,
- the effect of piling installation method on the surrounding environment, and
- potential for contamination of surface and groundwater from pile construction materials.

In line with the guidance this risk assessment recommends the use of an appropriate quality assurance and quality control (QA/QC) regime to cover the emplacement of piles.

7.2 Background Information Pertinent to Piling

7.2.1 Site Setting and Description

The proposed location of the new visitors centre is within the southeast section of Area A, as defined within drawing 721374/M/02.

Area A includes the northern third of the site and covers 0.03 square kilometres of the landfill site and forms the northern triangular point. Area A lies approximately 3.20 metres (m) above Ordnance Datum (AOD) and is laid to grassland and scrubs. Waste is visible at the surface in areas where there is sparse vegetation.

The southern boundary is represented by a gravel path access route running along the southern back of a sluice controlled tidally influenced drainage ditch named Red Barn Ditch. The eastern boundary is formed by a footpath beyond which is Pagham Harbour and the northwest boundary is marked by a footpath beyond which lies a mature hedgerow and a ditch.

7.2.2 Site History

The landfill site is understood to be made up of predominantly domestic and household waste deposited during the 1960's and 1970's when the area was used as a civic amenity tip. Anecdotal evidence and historical plans and photographs indicate that the area was previously a lagoon and salt pan, separated from Pagham Harbour by a tramway; this now forms the eastern boundary footpath.

7.2.3 Geology

In summary, made ground comprising of general household waste is present across the site. The thickness and depth to base of the deposit is highly variable, reflecting the filling activities which were being undertaken on site and the undulating nature of the ground surface prior to filling. The made ground was identified as thinning out around the perimeter of the site. At the location of the proposed visitors centre the made ground is up to 4.8m thick.

The made ground is underlain by Quaternary tidal river deposits comprising soft sandy clays, with sands and gravels identified at the base of the deposit at the southern boundary of Area A. Tidal river deposits are absent within a part of the location of the proposed visitors centre.

The solid geology comprising Eocene sandy clays of the Bracklesham Group, which in turn overlie the sands of the Bagshot Beds, below which the London Clay is present. In places the solid geology beneath the site; the Bracklesham Beds, Bagshot Beds and the London Clay are difficult to distinguish due to their similar characteristics. The solid strata underlying the site are horizontal.

For detailed descriptions of the soils present at the site, reference should be made to section 4.1

7.3 Hydrology

The site is located adjacent to Pagham Harbour, which is present beyond the eastern boundary of the site. The Red Barn Ditch is present crossing east – west forming the southern boundary of Area A. This ditch is tidally influenced by the harbour but is also sluice controlled. A ditch runs in a northeast to southwest direction along the western boundary of area A. Surface water flows within this ditch at times of high rainfall, and ponding of leachate has been noted, in low points along this boundary.

Results of chemical testing of the leachate and surface water suggested that the leachate is generally hydraulically isolated from the harbour and surrounding surface waters. The surface waters sampled from the north eastern edge of the landfill are affected by landfill leachate but are diluted with surface water run-off. Although a salt and freshwater mixing zone is present across part of the landfill site (as indicated by the results of the surface water sampling in March 2007), a comparison of the ratio of magnesium to calcium in the seawater and leachate samples indicates that the influence of seawater on the landfill leachate is minor.

7.4 Hydrogeology

Given that the landfill is not capped, rainwater can readily infiltrate through the made ground allowing leachate to be generated. Once the landfill is capped, infiltration of surface water into the landfill will be prevented thus reducing the amount of leachate generated.

The underlying Quaternary tidal river and the Eocene Bracklesham Beds are classified as a minor aquifer by the Environment Agency. However the minor aquifer status probably reflects the presence of sands and gravels in some areas across the region, and given the lithologies encountered during the ground investigations (these deposits are described as clays) these stratum at the site will act as a non aquifer.

The presence of the Quaternary River Tidal Deposits and Bracklesham Beds below the made ground hydraulically isolates perched water/leachate within the landfill.

The Bagshot Beds, underlying the Bracklesham Beds, are classified as a minor aquifer and the London Clay is classified as a non-aquifer.

Dataloggers installed as a part of the Phase 1 ground investigation showed a tidal response within the groundwater within the natural strata, but no discernable response within the landfill.

Review of previous groundwater data suggests water levels within the made ground are highest in the centre of the site with flow outwards towards the boundary of the landfill and Red Barn Ditch. The hydraulic gradient within the natural strata is indicated to be southwards, but the hydraulic gradient within landfill is shown to be westwards, away from the harbour. This also indicates that the landfill leachate is likely to be hydraulically separate from the groundwater within the natural strata beneath.

Ingress of groundwater into shallow excavations was encountered during the Phase 2 ground investigation and was described as a fast inflow. Groundwater ingress should be anticipated during piling operations, not only within the shallow soils, but also from within the sand lenses and pockets in the Bracklesham Beds and London Clay, and also from the more permeable Bagshot Beds horizon which is predominantly sand.

7.5 Soil Chemistry

The Phase 1 ground investigation identified that risks to human health were driven predominantly by elevated concentrations of Benzo (a) pyrene and lead in the made ground. These were the only contaminants where the 95% upper confidence level exceeded the screening value, with the exception of arsenic that had a nominal exceedence of the screening value by 0.7 mg/kg.

7.6 Leachate/Groundwater Chemistry

In terms of risks to controlled waters, the Phase 1 ground investigation identified that the landfill leachate is characterised by high ammonium concentrations and some low concentrations of metals, specifically chromium.

7.7 Ground Gas

A very low risk for methane, and a very low to low risk for carbon dioxide was established using the Modified Wilson and Card classification within the ground gas risk assessments.

7.8 Environmental Designations and Ecology

The site is located within a RAMSAR site, Site of Special Scientific Interest, Special Protection Areas and Local Nature Reserve, and as such all invasive work should only be undertaken after consultation and with the permission of Natural England, the Environment Agency and the RSPB.

A variety of habitats were identified during the site survey undertaken in 2007. These include broadleaved woodland, hedgerows, grassland and water bodies. Although the value of the majority of the habitats is currently considered only of local value, several habitats, such as the drain (due to its connection to external water bodies) and some areas of grassland, show potential to be of supporting or even intrinsic value at a national scale. Several rare and protected species were found present on site, including black poplar, mature Aspen, small flowered buttercup, birds, invertebrates and reptiles.

Whilst the presence of habitats within the survey area do not pose a constraint to the proposed works, impacts should be minimised and avoided where possible.

7.9 Remediation Considerations

7.9.1 Made Ground

A capping layer across the surface of the landfill is proposed to construct a barrier between the contaminants in the made and human receptors. Using BRE guidance 465 (2004) a capping thickness for the landfill site was calculated using 95% upper confidence level for benzo(a)pyrene and lead. The calculation based on being protective to human health assumed a 600mm thick mixing zone.

The installation of a clay plug constructed of the landfill capping material will provide continuity between the capping and the underlying natural soils at the landfill margin and the banks of Red Bard Ditch, in essence encapsulating the landfill material.

It has been assumed, for the pile design, that the capping layer will be constructed prior to the installation of piles.

7.9.2 Leachate Management

The construction of a leachate diversion drain is recommended running along the north western boundary of the site to draw down levels of leachate to below the level of the base of the adjacent ditch and prevent leachate emerging at the surface.

7.9.3 Ground Gas Protective Measures

Given that a characteristic situation 2 has been assigned to the site, a worst case scenario approach is recommended and it is advisable that gas precaution measures are incorporated into the build of the visitors centre. Details of these are provided in section 6.4. The site is currently surface passive venting. Following construction of the clay capping the gas regime will alter and it is recommended venting measures are incorporated into the landfill cap design, particularly along the north-western perimeter of the landfill to prevent migration of ground gas to off site receptors.

7.10 Piling Method

A piled foundation solution is proposed for the new visitors centre as it provides the least risk option by transferring the load down the piles to more competent strata, within the Bracklesham Group and London Clay, at depth. Piles offer the advantage of overcoming the settlement concerns of the thick made ground and the low bearing capacity of the Tidal River Deposits.

Safe working loads have been provided for two viable piling methods; pre cast driven (displacement) and cast in situ (non displacement) piles.

Both installation methods have been reviewed with the perceived advantages and disadvantages presented in Table 13 below.

Table 13 : Piling Method Review

Factors for Consideration		Displacement	Non Displacement
Sources of contamination	Made Ground	No spoil arisings created which would require disposal.	Creating of spoil arisings. Re-profiling of the waste material will be required in places to form the clay plugs, and spoil arisings could potentially could be incorporated into this re-profiling works. However, consultation with the Environment Agency would be required. If this method of working is considered acceptable by the regulatory authorities re-phasing of construction works would be required to ensure piling and re-profiling is completed before the waste is encapsulated by the clay capping layer. A review of the safe bearing loads provided in this report would also be required.
	Leachate	Radial displacement generally leads to densification of soil surrounding the pile and a reduction in permeability of the surrounding soil. Densification, along with the high stresses induced, mean that the soil closes up around pile. The pile/soil interface pathway in displacement piles is therefore generally less than that for non displacement pile installation.	With the installation of CFA piles the bore is filled with concrete from the base of the pile as the auger is retracting spoil arising to the surface and as such minimal likelihood of leachate filling into the bore or arriving at ground surface. Potential void space in made ground adjacent to pile may not be filled with concrete so can increase the pile/soil interface pathway and allow leachate/groundwater flow to occur preferentially.
	Landfill Gas	Radial displacement generally leads to densification of soil surrounding the pile and a reduction in permeability of the surrounding soil, preventing the pile becoming a preferential pathway.	No densification of the soils during installation so soil permeability remain unchanged after pile installation. The pile could become a preferential pathway to gas.

Factors for Consideration		Displacement	Non Displacement
Receptors	Human	No production of contaminated spoil arisings. No direct contact with human receptors. No disposal requirements.	Spoil arisings brought to surface exposing Contractors in direct contact to contaminated arisings. Disposal required, either on site as part of the re-profiling works or off site. Management of spoil on site required to prevent leaching of contaminants to surface water bodies.
	Groundwater	Although the site's hydrogeology is identified as minor aquifers, due to the high clay content of the strata the soils are acting as non aquifers. Therefore there is no unacceptable risk of driving contaminants and waste to a sensitive underlying receptor. Driven pile design forms preferential pathways (as stated in the above guidance). The action of driving piles causes densification of the surrounding soils and the high stresses induced, mean that the soil closes up around pile. Therefore production of preferential pathways are unlikely. This applies both to the downward migration of leached contaminants and for gas movement upwards.	As the site is underlain by low permeability aquifers, there is no risk from driving down contaminants or creating pathways into aquifers during the boring process. As the site is underlain by low permeability aquifers there is no risk of injecting concrete into sensitive aquifers.
	Surface Water	Piling close to Red Barn Ditch for the bridge abutments could displaced waste towards this surface water body,	Voids may be present within the waste material adjacent to Red Barn Ditch, and pumping of concrete into the waste for pile formation for the bridge abutments could migrate through voids and preferential pathways towards the surface water body.
	Ecology/	Significant noise and vibrations during driving of piles	Noise and vibration minimal in CFA pile installation minimising impact on

Factors for Consideration		Displacement	Non Displacement
	wider site environ	impacting on wildlife on site. No arisings brought to surface which could place wildlife in direct contact with contaminated spoil & also lead to ingestion of spoil. Pre-cast piles transported directly to site minimising site activities which could cause disturbance.	wildlife Contaminated arisings brought to surface which could place wildlife in direct contact with contaminated spoil & also lead to ingestion of spoil. .Batching plant required on site for concrete production facilities. Alternatively excessive vehicle movements from concrete being brought to site pre-mixed. Potential for spillage during transportation or overflow during pile construction.
Geotechnical	Stability/ obstructions	Potential for obstructions within the made ground to prevent piles reaching full penetration depth. Although some minor obstructions were noted in some of the exploratory holes, based on this information, these are not considered sufficient to stop the installation of the displacement piles.	Trial pits collapsed in the short term and whilst the bored hole has the potential to collapse, the use of CFA to install the piles will mean the ground is not open to collapse. If voids are present in the made ground immediately adjacent to the installed pile, during pumping of concrete, these voids will be filled with concrete creating an uneven pile profile. From a sustainability perspective this will lead to excessive concrete being pumped into the ground and also lead to unevenly distributed load being carried by the piles, potentially leading to their failure. Concrete mix to take account of groundwater which will influence the strength of the pile.

Based on the review of advantages and disadvantages of both piling installation methods, it is considered that, given the site setting, pre-cast displacement driven piles will offer the most suitable solution for the foundations at both the visitors centre and bridge over Red Barn Ditch.

7.11 Potential Environmental Factors

The following pollution scenarios that are identified in National Groundwater & Contaminated Land Centre report (ref NC/99/73), have been assessed for their likelihood on this site, as presented in Table 14 below.

Table 14: Pollution Scenarios for the site

Ref.	Pollution Scenario	Likely on site?	Justification
1	Creation of preferential pathways through a low permeability layer, to cause contamination of groundwater in any minor aquifer horizons.	No	The Quaternary River Tidal Deposits and Eocene Bracklesham Beds that underlay the Made Ground are classified by the Environment Agency as minor aquifers. However, these are predominantly clay and therefore act as a non aquifer. Piles would terminate in this low permeability material and as such migration of contaminants to sensitive receptors is not a perceivable risk.
2	Creation of preferential pathways, through a low permeability surface layer, allowing migration of landfill gases, soil gases of contaminant vapours to the surface.	No	Displacement piles increase the densification, thus lower the permeability of the soil around the pile. Furthermore, gas protection measures are proposed within the visitors centre mitigating the risk of gas migration within the building.
3	Direct contact with contaminated soil arisings which have been brought to the surface.	No	Displacement piling methods involve the pile being formed by displacing soil from the space to be occupied by the pile without the removal of spoil to the ground surface.
4	Direct contact of piles or structures with contaminated soil or	No	Sulphate concentrations within the underlying soil, leachate and groundwater can adversely affect the integrity of the piles. Chemical

Ref.	Pollution Scenario	Likely on site?	Justification
	leachate causing degradation of the pile material.		analysis has been carried out and a suitable concrete design (DS and ACEC class) has been recommended to prevent the effects of aggressive ground conditions on buried concrete.
5	The driving of solid contamination down into an aquifer during pile-driving.	No	Displacement piles can drive down contaminants; however the Environment Agency, in their guidance, recognises that this is a small and finite amount. Furthermore no aquifer is present at sufficiently shallow depth to be affected. The Quaternary River Tidal Deposits and Eocene Bracklesham Beds whilst classified as minor aquifers, are of predominantly clay and act as non aquifers. Piles will be terminated within the clay and as such risk of driving waste to a sensitive receptor is not a perceivable risk.
6	Contamination of groundwater and surface waters by concrete spills, cement pastes or grout.	No	Displacement piles are pre-cast, and as such the method of installation does not involve introducing wet concrete, cement pastes or grout into the ground.
7	Pile Caps	Yes	Arisings will occur by any piling method for the construction of pile caps. These will have to be disposed of.

7.12 Mitigation Measures

7.12.1 Ref. 7 - Table 14

Displacement piles will not generate spoil arisings. However arisings will be generated from the pile caps. This would apply to any piling method. These will have to be disposed of offsite and will require classification to Waste Acceptance Criteria. Alternatively, with consent from the regulatory bodies the arisings could be incorporated within the re-profiling works as required for the installation of the clay plugs around the landfill margin and along the banks of Red Barn Ditch.

An alternative approach would to be to consider the installation of driven piles with the visitors centre sited above ground level on piers. This would remove the need to excavate within the made ground to construct the pile caps. Pile caps would be incorporated within the underside of the building. The air space between ground level and the underside of the building would mitigate against the risk of migrating ground gas up the side of the pile into the building, allowing free venting beneath the building.

Furthermore, with careful selection of construction materials i.e. driven timber piles these could fit in with the overall environment suitable to a nature reserve.

Consideration to the pile design would be required to ensure the embedded length of the pile and strength of the pile is sufficient to resist the lateral forces generated as a result of wind forces on the building.

7.13 QA/QC Methods and Measures

Prior to the piling works being undertaken, the capping layer is likely to be installed which will create a barrier to the underlying landfill material and the associated contaminants. During the construction of pile caps, care will be taken to prevent cross contamination of the capping layer, either by placing a geotextile between the excavated material and the capping layer, or by removing the material immediately offsite.

During the pile installation for the bridge that crosses Red Barn Ditch, there is a potential for contaminants to be displaced towards the surface water of the ditch. However, it is likely that the piles will be at a sufficient distance for this not to negatively affect the receptor. Whilst piling work is being carried out there are a number of options to prevent a potential negative affect on the ditch, including bunding the piling operations or piling within caissons. However, the preferred option would be to cut off the ditch using the sluices, i.e. open the seaward sluice on a falling tide to empty the ditch with the sluice remaining closed for the duration of the works. Residual seawater in the base of the ditch would be pumped over the seawall until the ditch is sufficiently dry to allow construction works to proceed. Therefore any contamination that enters the ditch can be removed easily, and it reduces the health and safety risks associated with working next to water. It should be noted that any contaminated waters which are pumped from the ditch during the works would need to be appropriately disposed of, which may have an additional cost dependant on the quality of these waters.

Monitoring of groundwater is not required as the minor aquifers identified in the area, have been found by the site investigation to be clay rich and of low permeability. Therefore at this location the underlying geology acts as non-aquifers.

A specialist piling contractor will undertake the detailed pile design and will need to incorporate within a Method Statement and Environmental Management Plan any proposed mitigation measures required by their method of work.

8 Leachate Management

8.1 Leachate Diversion Drain

After prolonged wet periods, typically in winter, leachate is visible as surface ponding in the ditch and topographic lows along the north western boundary of the site, which raises a negative perception for site users. Furthermore, concern was highlighted during the Phase 1 ground investigation that leachate may overtop the northern margin of the site and potential leachate losses may occur via unidentified pathways such as service runs.

The elevated concentrations of ammonia (32mg/l-34mg/l) and relatively low concentrations of chloride (290mg/l-350mg/l) in perched water samples taken from boreholes BH11 and BH13 indicate the groundwater along the northwest boundary is likely to be leachate resulting from the percolation of surface water through the made ground, with no tidal water component.

A conceptual leachate diversion drain design is presented within drawing 721374/M/11. A French drain configuration is designed to draw down levels of leachate to below the level of the base of the adjacent ditch and prevent leachate emerging at the surface. The level of the drain is a compromise between being low enough to prevent leachate emerging and being too low, such that the leachate flows are high. An average depth below ground surface of approximately 0.5m is envisaged.

The final design level of the drain cannot be confirmed until a detailed topographic survey of the boundary and ditch is completed. Once ground levels are confirmed, location and level of the drain can be confirmed to ensure that flow of leachate will be under gravity to an outlet point at a topographic low.

8.2 Drain Construction Material

Results of soil testing in the Phase 1 assessment recorded slightly elevated levels of arsenic, petroleum hydrocarbons and PAH in soils above the 'Material Selection Threshold Level', (Waste Regulations Advisory Scheme (WRAS) Information and Guidance Note (October 2002) No. 0-04-03, Table 1). However, the leachate collection drain will be constructed in a French drain surrounded with inert granular material and no direct contact to the made ground.

Groundwater samples were analysed from boreholes BH11 and BH13 at the north-western boundary of the site to determine the potential risks associated with elevated contaminants to materials used in the construction of the leachate drain at this location.

The results tend to suggest that concentration levels of determinants in the made ground and leachate are unlikely to be detrimental to construction materials within the leachate collection drain although discussions with specialist suppliers regarding proprietary pipe materials are recommended prior to construction.

8.3 Leachate Quality

The leachate quality following capping of the landfill will depend on the degree of dilution with rainwater which will inevitably occur in the collection system. Depending where the how the leachate is managed it may be preferable to have a relatively low flow concentrated leachate or a higher flow relatively diluted leachate. The ranges of concentrations presented in Table 15 below reflect the anticipated concentrations of key determinands for the high and low flow scenarios.

Table 15: Leachate Chemical Concentrations Ranges

Determinand	Concentration (High Flow)	Concentration (Low Flow)
pH	6.5	8.5
Electrical Conductivity	1000 uS/cm	2500 uS/cm
BOD	10 mg/l	-20 mg/l
COD	50 mg/l	150 mg/l
Sulphate	100 mg/l	500 mg/l
Chloride	100 mg/l	500 mg/l
Ammonium	10 mg/l	50 mg/l
Chromium	<0.1 mg/l	<0.1 mg/l
Arsenic	<0.05 mg/l	<0.05 mg/l

Determinand	Concentration (High Flow)	Concentration (Low Flow)
Nickel	0.05 mg/l	0.05 mg/l
Copper	<0.3 mg/l	<0.3 mg/l
Zinc	<0.05 mg/l	<0.05 mg/l
Iron	0.5-5 mg/l	0.5-5 mg/l

These concentrations are preliminary and should not form the basis of any discharge consent.

8.4 Flow Rate

The flow rate is difficult to quantify since there are no measurements of any leachate flows at present and therefore limited basis for future prediction. It is clear from site observations that even with no cap flows are intermittent (if any flow occurs at all) and low.

Following construction of the drain and landfill capping layer, initial levels of leachate collection within the drain are anticipated to be relatively high. These are like to reduce to minimal levels over time, as the residual levels of leachate within the made ground fall and installed landfill capping layer limits further percolation and generation of leachate.

The following serves as a preliminary estimate for discussion purposes. The northern part of the site is approximately 2.6 ha in area. Assuming 10% of rainfall will infiltrate once a cover is placed, this would be approximately 70mm per year infiltration. Assuming that 20% of this infiltration is captured by the drain over the area of the northern part of the landfill this equates to approximately 2m3/day for 6 months of the year. This preliminary estimate serves to demonstrate the approximate order of magnitude of the discharge flow rate.

8.5 Leachate Management Options

The following options for the management/treatment of the leachate are as follows:

- wetland/reed bed on the land to the north of the site should this be purchased for further ecological enhancement works;
- wetland/reed bed on the land to the north which is already owned by the local authority;
- -wetland/reed bed between the site and the road in the area of the existing car park;
- any of the above combined with treatment of the site sewage;
- -discharge to foul sewer; and
- collection and tankering away.

Mouchel recommends progression of the wetland option with combined treatment of site sewage, if possible. This is consistent with the project objective of environmentally sustainable design.

Given the anticipated low flow rate and the chemistry of the leachate it is likely that wetland/reed bed treatment could be effective in mitigating the COD/BOD, ammonium and metals concentrations.

The susceptibility of the metals in the leachate to this treatment approach is dependent on the iron concentrations. Iron is easily removed in wetlands through oxidation and precipitation /settlement. Typically if the iron concentration is high compared to other metals, removal of the iron would reduce concentrations of the other metals by sorption of these metals onto the surfaces of the precipitated iron oxy-hydroxide minerals. Observations show effective iron removal from the leachate in surface water accumulations (orange sludges). It is expected therefore that wetland treatment would improve the metals concentrations. Further testing and/or geochemical modelling would be required to confirm this.

In view of the anticipated flow rates, the size of the reedbed would be relatively small i.e. <0.1 Ha.

Consultation with the Environment Agency would also need to determine whether such discharge would require discharge consent. There is currently no known discharge of leachate or surface seepage of leachate in any other part of the site. However, it is recognised that a detailed design for this option would need to be submitted to the Environment Agency for approval. Dependant on the outcome of discussions with the regulator, the Pagham Harbour Project Team may need to explore alternative options for leachate drainage.

It is understood that the Environment Agency usually only considers wetland treatment as a polishing stage following more conventional treatment. There are certainly exceptions to this however as there are many mine water treatment schemes in the UK using wetlands as the primary treatment step. In this case the mitigating factors are the very low flow and the relatively low concentrations of contaminants in the leachate.

9 Conclusions

9.1 Ground Model

The geological sequence beneath the site comprises made ground, consisting typically of general household waste, resting upon tidal river deposits above the solid geology of the Bracklesham Group, Bagshot Beds, and the London Clay.

The made ground is inherently variable in nature, thickness and depth across the site and the ground surface of the landfill is undulating. Thinning out of the made ground was observed around the perimeter of the landfill particularly along the north-eastern boundary.

The tidal river deposits were encountered in all but three of the exploratory holes; absent as a band running in a rough east to west direction marked by BH02, BH04 and BH14. Here the made ground rests directly on the Bracklesham Beds. To the north of this band the deposits reach a maximum thickness of 2.60m thinning northwards, and to the south of the band the deposits thicken towards Red Barn Ditch.

The underlying solid formation of the Bracklesham Group, comprising firm clay is present underlying the whole of the site to a maximum depth of 11.00m bgl. These strata rest on the Bagshot Beds, which are fine sands with varying proportions of clay of a maximum thickness of 3.0m, which in turn lie upon London Clay.

Leachate is shown to be generated beneath the site as a result of rain infiltration across the soft landscaped surface. Vertical migration of leachate accumulating within the landfill is limited by the tidal river deposits and where absent, the Bracklesham Group, both of which are of low hydraulic conductivity.

9.2 Geotechnical Assessment

Due to a number of issues concerning the nature of the proposed development, as well as the consistency of the made ground and the tidal river deposits, time constraints and the potential for excess arisings during construction, a piled foundation solution provides the least risk option.

Using this technique, building loads would be transferred down the piles to more competent strata within the Bracklesham Group and London Clay.

Safe working loads have been provided for both driven/displacement (Phase 1 report) and cast in situ (non displacement) piles (this report). The safe working loads presented within this report are based on varying length (10-25m) and diameter (300mm, 400mm and 500mm) assuming a plan area of the visitors centre of 20m by 20m. Safe working loads have also been included for the construction of the proposed bridge crossing. The pile lengths, diameter and grouping will need to be adjusted to suit the final design loads and footprint of the proposed structure. Final selection of pile length and diameter versus number of piles required will be a function of cost of installation and material. Discussion with a specialist piling Contractor will therefore be required to judge the economic advantages of the final design.

The foundation works risk assessment concludes that in terms of pollution prevention pre-cast displacement driven piles will offer the most suitable solution for the foundations at both the visitors centre and bridge over Red Barn Ditch.

Allowance has also been made for the construction of the 350mm capping layer proposed for the enhancement of the nature reserve, which would settle with the underlying made ground.

Reuse of the natural soils arising from excavations and piling may be possible on condition these are sufficiently segregated from the made ground. The clay deposits may be suitable for reuse within the landfill capping layer.

Should concrete be selected as the construction material for the piles and other below ground infrastructure, the design sulphate class for the site will be DS-4 with an ACEC class of AC-4.

With respect to the pavement design the resistance of the made ground sub-grade to deformation under load is considered to be extremely poor. Pavement design is settlement dependant, and to accommodate these settlements and to minimise the requirements for re-profiling when bearing on the made ground, a capping layer, potentially in combination with a geo-grid, will need to be included within a flexible pavement construction. A geogrid combined with a granular material within a flexible pavement construction, would restrict the requirements of the capping layer to 450mm.

Once the route of the road, proposed vehicle movements on site and area for car parking is confirmed, with reference to the Highways Agency Design Manual for Roads and Bridges (DMRB), County Council Design guides and current best practice, a tailored design should be produced to suit the proposed application.

To overcome the negative visual perception for site users of the accumulation of leachate, and the potential that leachate may overtop the northern margin of the site a leachate diversion drain is recommended at the boundary of the site. A French drain configuration is proposed to draw down levels of leachate to below the level of the base of boundary ditch currently located along the boundary. The final design level of the drain is dependant on a detailed topographic survey of the boundary and ditch.

Following construction of the drain and landfill capping layer, initial levels of leachate collection within the drain are anticipated to be high. These are likely to reduce to minimal levels over time, as the residual levels of leachate within the made ground fall and installed landfill capping layer prevents further percolation and generation of leachate.

9.3 Ground Gas Risk Assessment

Based on the maximum concentrations of methane and carbon dioxide, and the maximum flow rates recorded in each of the boreholes monitored, a Very Low Risk and a Low Risk classification applies to the current ground gas regime. Gas protection measures are recommended for the proposed visitors centre.

During the six month monitoring period, it is noted that landfill gas is drawing into BH12. Carbon dioxide levels have progressively risen whilst falling oxygen levels have fallen over time. This borehole is closest to off site receptors on the western boundary and suggest a potential for off site migration of landfill gas under the current gas regime.

Despite the low levels of gas being recorded during the monitoring period, with the construction of a landfill capping, the gas regime will alter. The landfill is currently passively venting at ground surface, resulting in the low flow levels being recorded within boreholes.

Following the construction of a landfill capping and without a form of venting build up of gas within the landfill will occur. Gas will then migrate laterally, from high pressure to low pressure, towards the periphery of the landfill, increasing the potential for off site migration towards off site receptors.

As such it is recommended that venting measures are incorporated into the landfill cap design and it is recommended that, particularly along the north-western perimeter of the landfill, the venting is tied into the proposed leachate diversion drain.

10 Recommendations

10.1 Further Intrusive Investigations

It remains unclear as to whether there is waste below the Red Barn Ditch channel or not. Access during the Phase 2 investigation was difficult due to the steep gradient of the banks. Where the margins of the Red Barn Ditch were investigated, waste was found.

It is recommended that an over water investigation is completed to confirm the absence or otherwise of the waste. Otherwise, this will remain as a large risk item with the main Contractor in the design and construction of the capping layer.

Given that the landfill gas levels recorded in BH12 suggest gas is being drawn into the borehole and there is a potential for off site migration of landfill gas under the current gas regime, it is recommended further ground gas monitoring is completed to understand the potential risks to off site receptors. Monitoring boreholes on the other side of the site boundary would be preferable if agreement with the landowners can be reached.

Ongoing landfill gas monitoring both during and post construction will be required, particularly along the north-western boundary, to assess the potential for lateral migration to off site receptors to the northwest of the site.

Furthermore, a detailed topographical survey along the north-western boundary which includes the ditch is recommended. This will tie in with the existing topographical survey which covers the rest of the site to allow the final design level of the drain to be confirmed. Once ground levels are confirmed, location and level of the drain can be confirmed to ensure that flow of leachate will be under gravity to an outlet point at a topographic low.

11 References

BRE Special Digest 1, 2005. Concrete in Aggressive Ground

BS5930, 1999. Code of Practice for Site Investigations, BSI.

BS10175, 2001. Code of Practice for the Investigation of Potentially Contaminated Sites, BSI.

C552, 2001. Contaminated Land Risk Assessment, A Guide to Good Practice, CIRIA/DETR.

C665, 2007. Assessing Risks Posed By Hazardous Ground Gases to Buildings, CIRIA.

Department for Environment, Food and Rural Affairs and the Environment Agency, 2006. Model Procedures for the Management of Land Contamination (CLR11).

Regulations Advisory Scheme (WRAS) Information and Guidance Note (October 2002) No. 0-04-03, Table 1

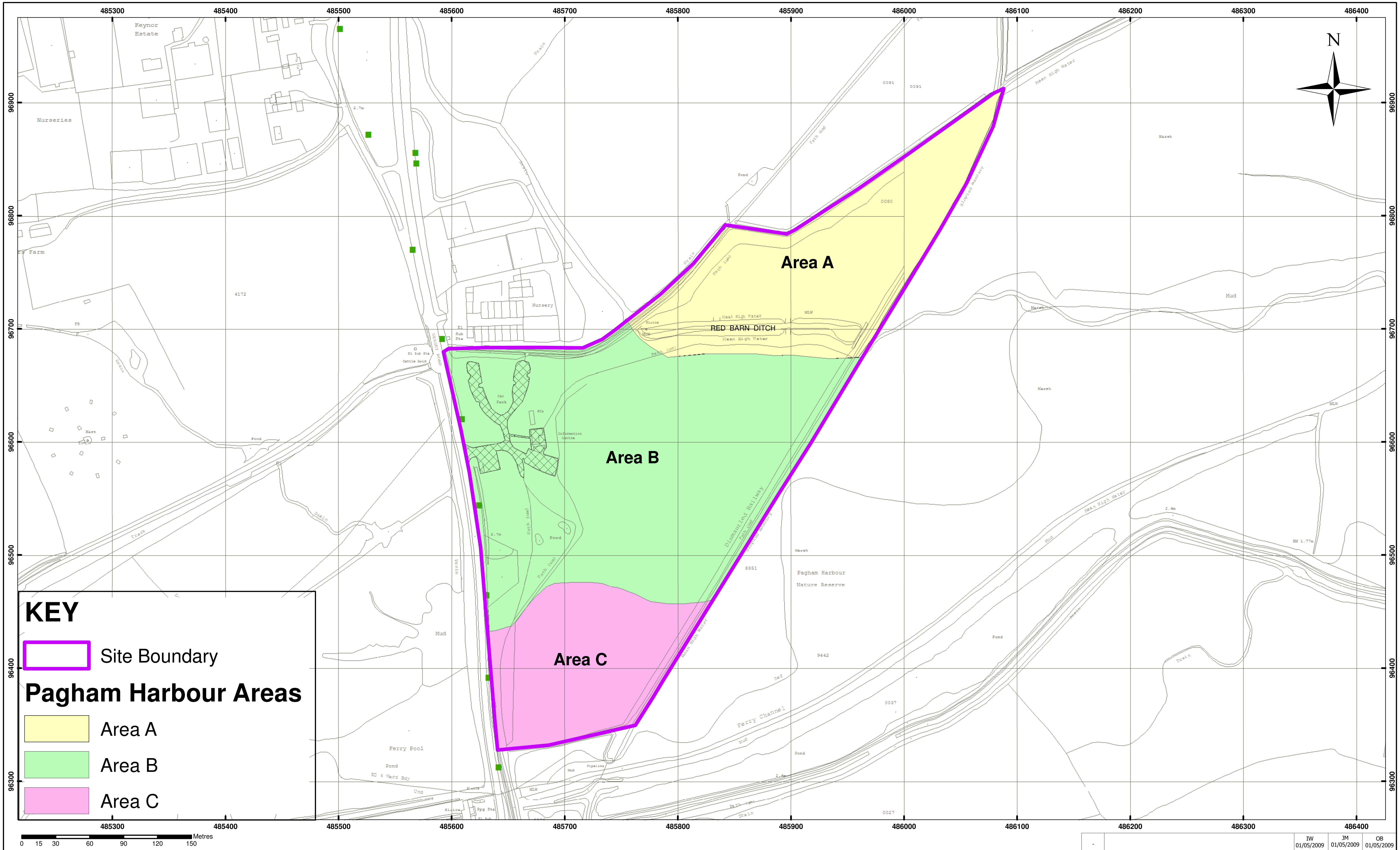
Mouchel Parkman, 2007. Phase 1 Visual Inspection and Limited Surface Water Sampling, ref 721334/R/01.

Mouchel, 2008. Phase 1 Interpretative Ground Investigation Report, ref 721334/R/2B.

Drawings

-		IW 11/02/2009	JM 11/02/2009	RE 11/02/2009
Version	-	Originated by and date	Checked by and date	Approved by and date

mouchel	
Client	SEEDA
Project	Pagham Harbour - Phase 2
Purpose: Information	Drawing Title: Site Location Plan
Scale (at A3 size): 1:50,000	Issuing Office: Bristol; Telephone: 0117 906 2300
Drawing number: 721374/M/01	Version: A



		IW 01/05/2009	JM 01/05/2009	OB 01/05/2009
Version	-	Originated by and date	Checked by and date	Approved by and date

mouchel

Client: SEEDA

Project: Pagham Harbour - Phase 2

Purpose: Information

Drawing Title: Pagham Harbour Areas

Scale (at A3 size): 1:3,000

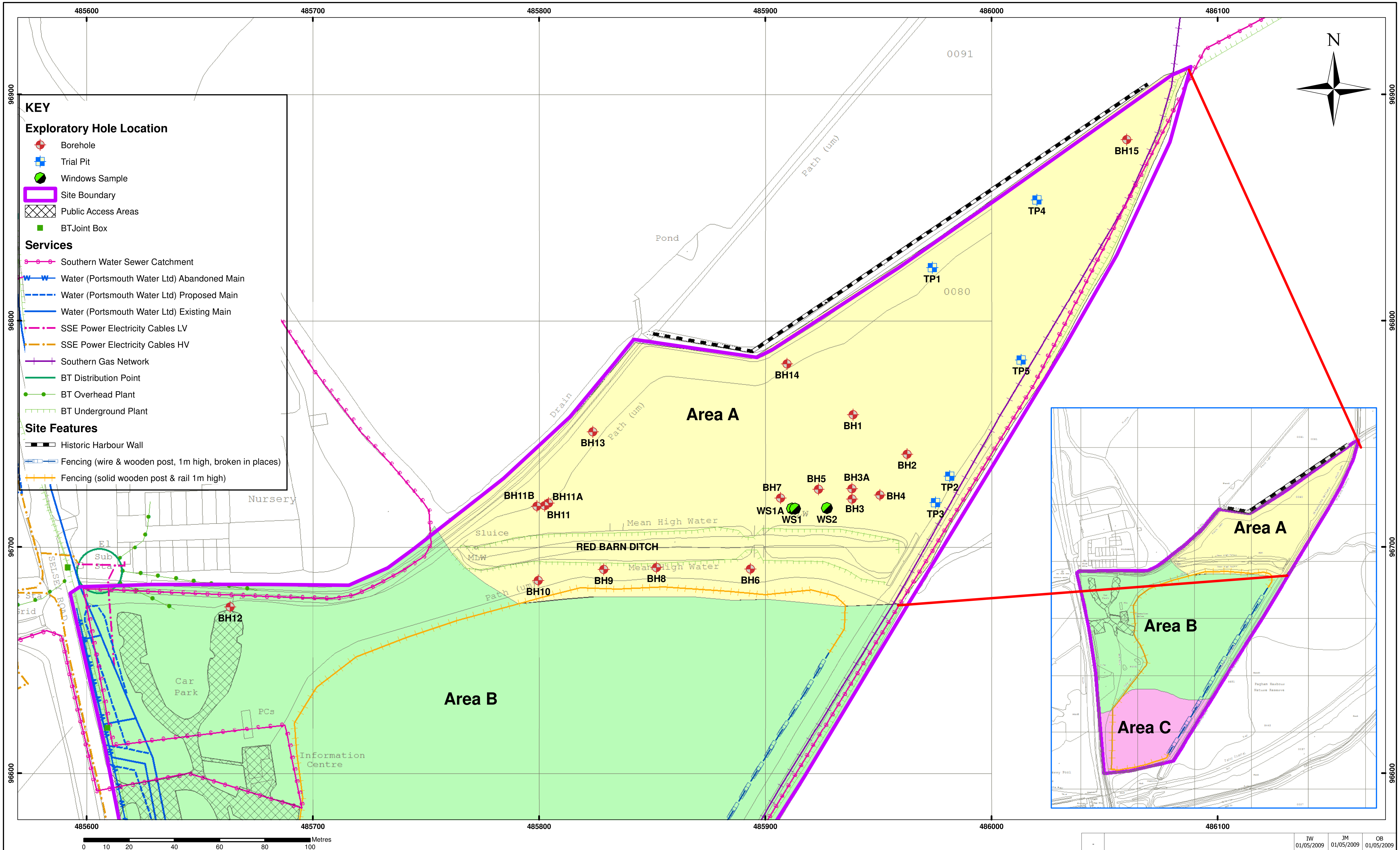
Issuing Office: Bristol

Telephone: 0117 906 2300

Drawing number: 721374/M/02

Version: A

W:\721374 Pagham Harbour Phase 2\09 - Documents\Drawings\MP\GIS_Data\721374_M_02 exploratory hole loction plan.mxd

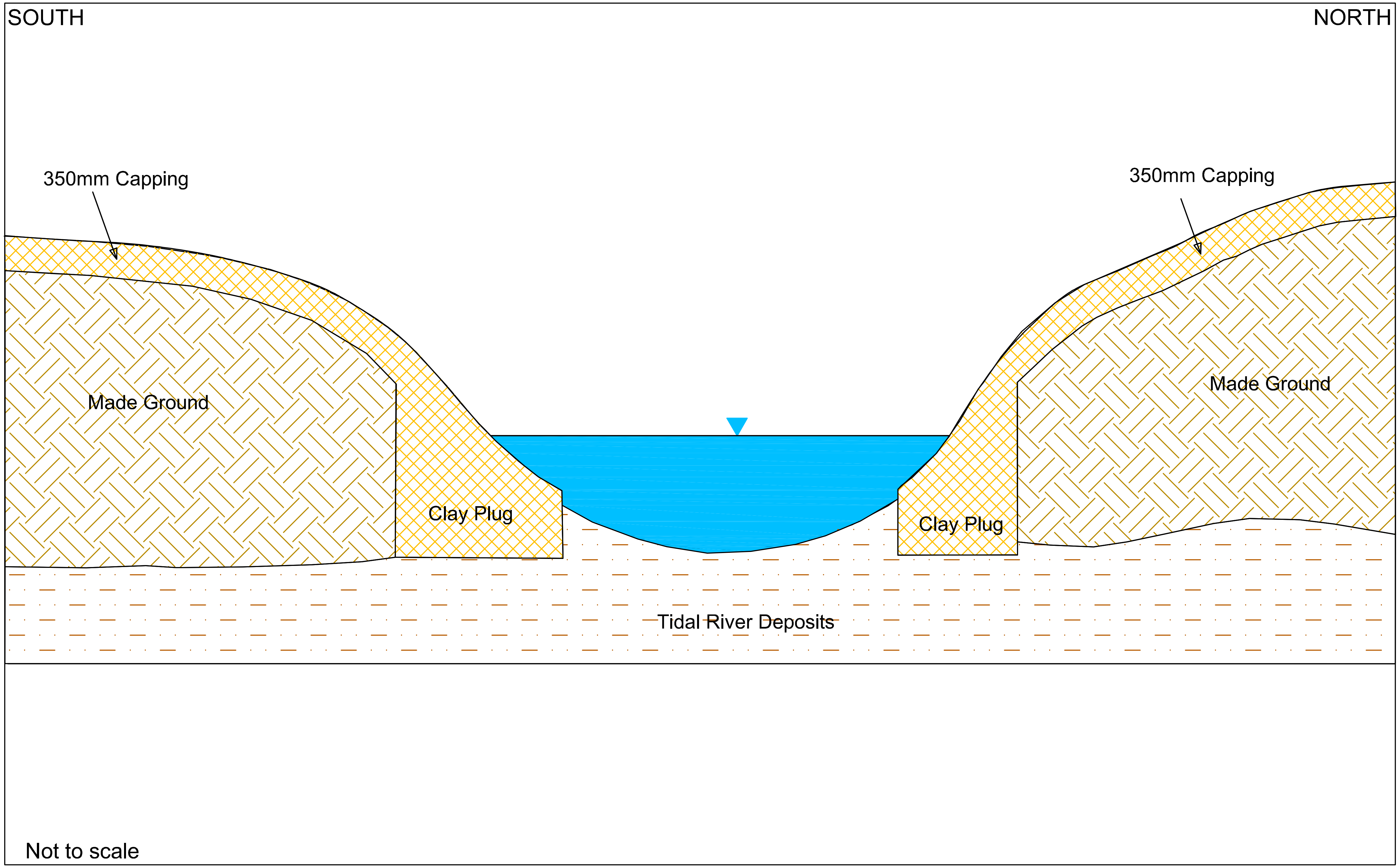


		IW 01/05/2009	JM 01/05/2009	OB 01/05/2009
Version	-	Originated by and date	Checked by and date	Approved by and date

mouchel

Client	SEEDA
Project	Pagham Harbour - Phase 2
Purpose	Information
Drawing Title	Exploratory Hole Location Plan
Scale (at A3 size)	1:1,500
Issuing Office	Bristol
Telephone	0117 906 2300
Drawing number	721374/M/03
Version	A

W:\721374 Pagham Harbour Phase 2\09 - Documents\Drawings\MP\GIS_Data\721374_M_02 exploratory hole loction plan.mxd

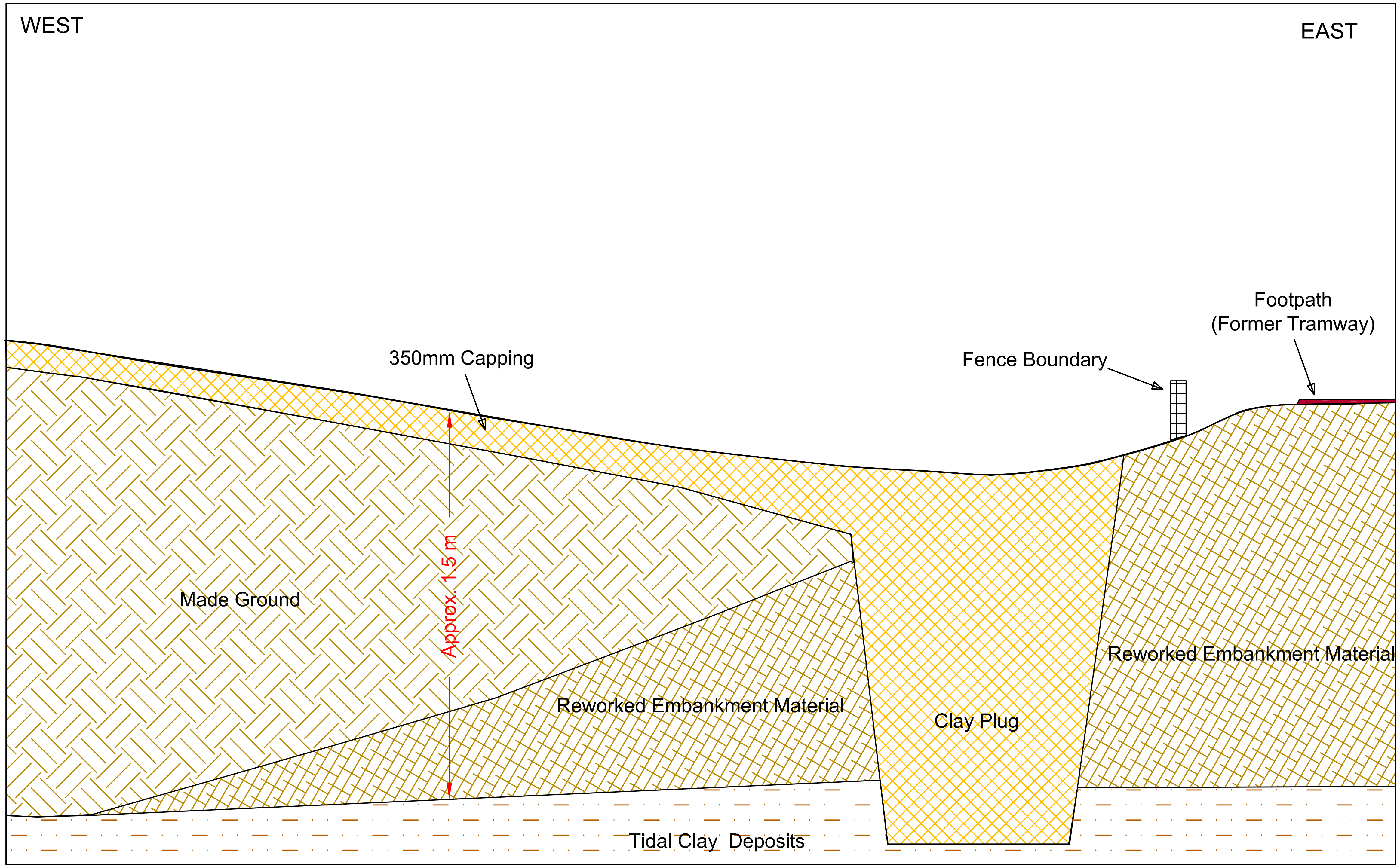


mouchel

Purpose	Information
Client	SEEDA
Project	Pagham Harbour – Phase 2
Drawing Title	Design Sketch – Landfill Capping at Bank of Red Barn Ditch
Scale (at A3 size)	N.T.S.
Issuing Office	Bristol
Telephone	0117 906 2300
Drawing number	721374/M/09
Version	A

Version	Originated by & date	Checked by & date	Approved by & date
A	IW 15/05/09	RE 15/05/09	PS 15/05/09

Draft
Issue ●



Not to Scale

mouchel

Client: SEEDA

Project: Pagham Harbour – Phase 2

Purpose: Information

Drawing Title: Design Sketch – Landfill Capping on Eastern Perimeter

Version	Originated by & date	Checked by & date	Approved by & date
A	IW 15/05/09	RE 15/05/09	PS 15/05/09

Draft / Issue ●

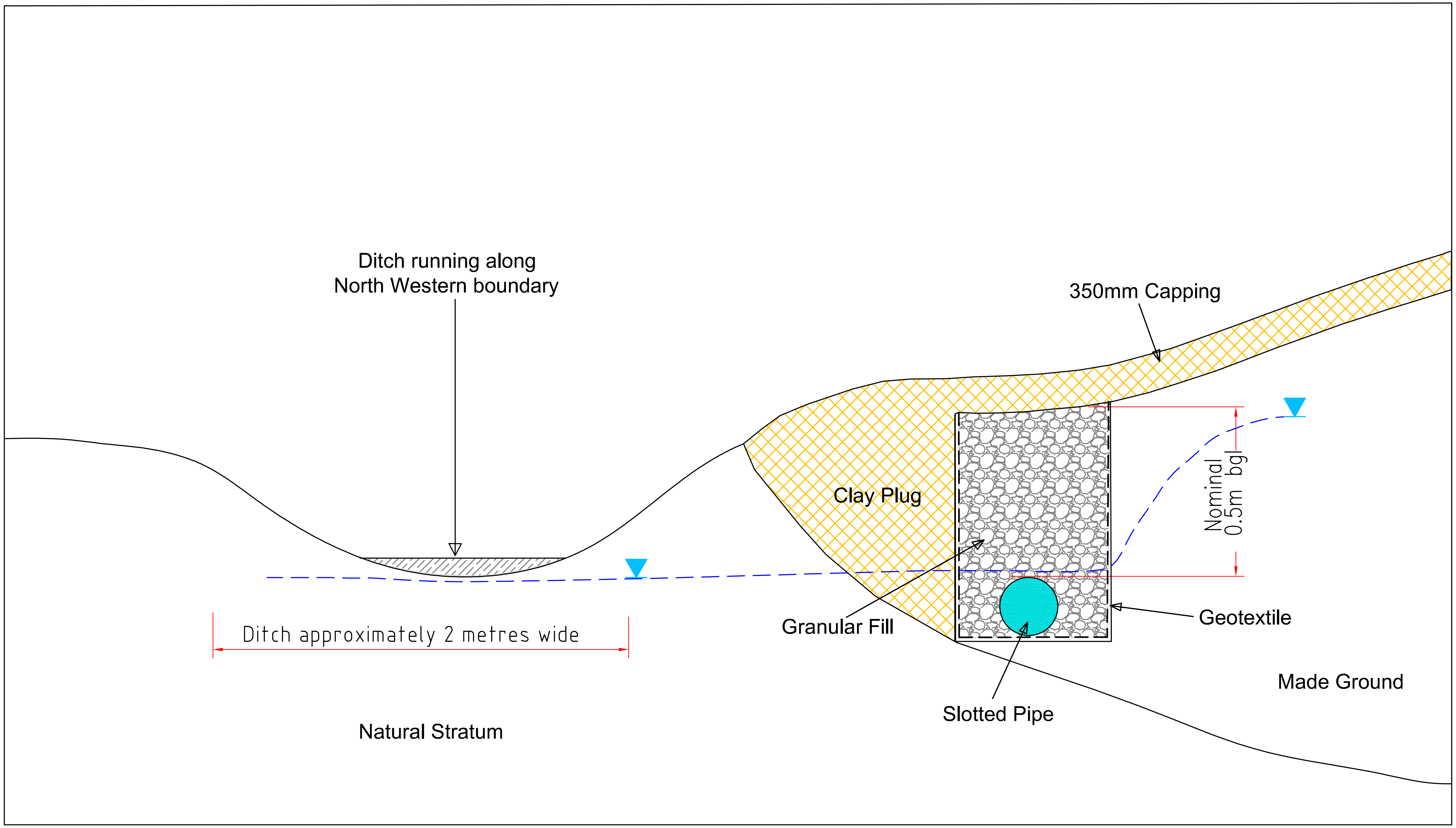
Scale (at A3 size): N.T.S

Issuing Office: Bristol

Telephone: 0117 906 2300

Drawing number: 721374/M/10

Version: A



Not to scale

A	IW 26/06/09	RE 26/06/09	PS 26/06/09
Version	Originated by & date	Checked by & date	Approved by & date

mouchel

Purpose	Information
Draft	
Issue	●
Scale (at A3 size)	N.T.S.
Client	SEEDA
Project	Pagham Harbour – Phase 2
Drawing Title	Design Sketch – Landfill Capping & Leachate Diversion Drain (North West Boundary)
Issuing Office	Bristol
Telephone	0117 906 2300
Drawing number	721374/M/11
Version	A

Appendix A - Norwest Holst Ground Investigation Factual Report

Appendix B Geological Cross Sections

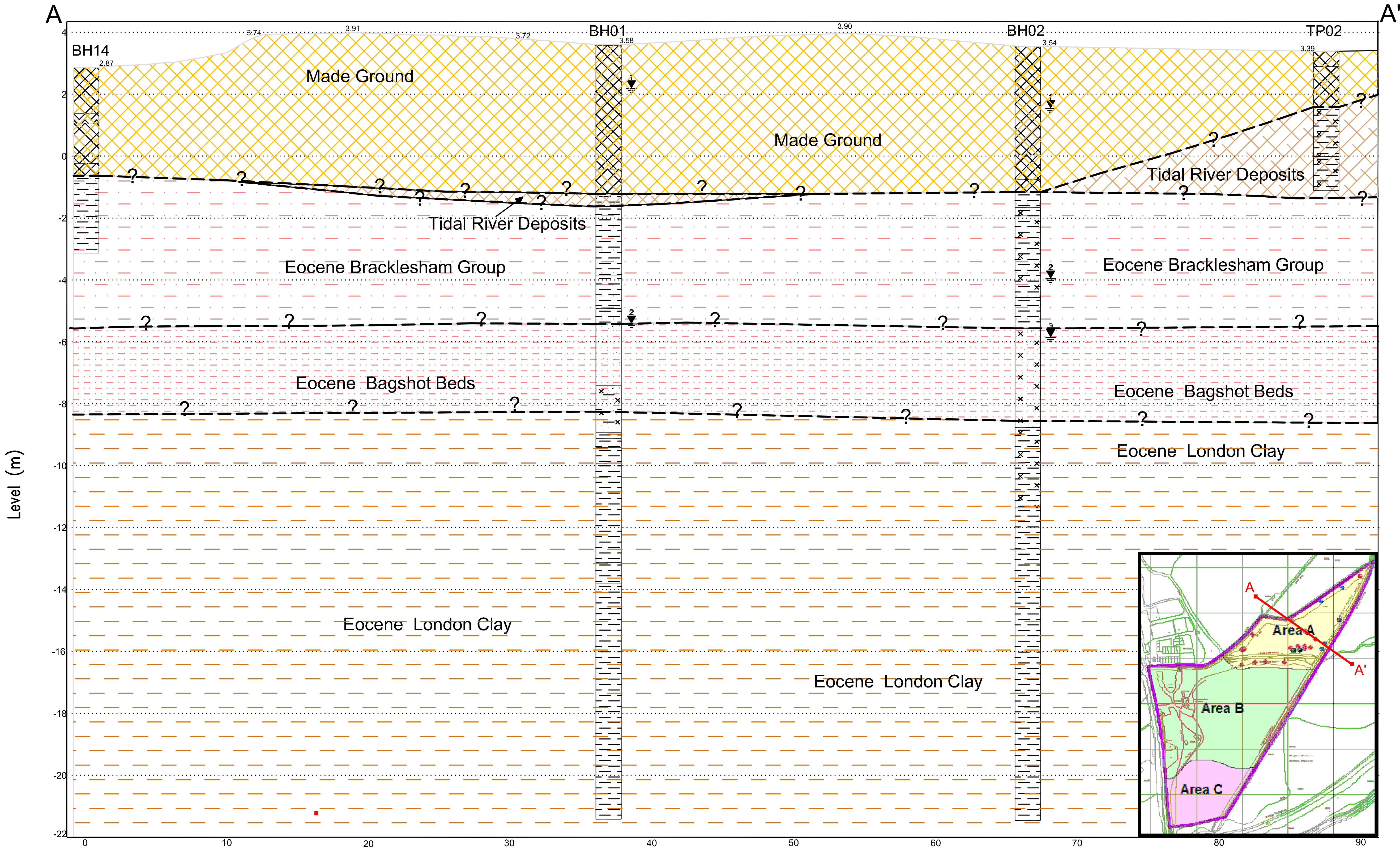
Cross Section AA' (721374/M/04)

Cross Section BB' (721374/M/05)

Cross Section CC' (721374/M/06)

Cross Section DD' (721374/M/07)

Cross Section EE' (721374/M/08)



mouchel

Purpose: Information

Client: SEEDA

Project: Pagham Harbour – Phase 2

Drawing Title: Cross–section AA'

Version	Originated by & date	Checked by & date	Approved by & date
A	IW 25/06/09	OB 25/06/09	RE 25/06/09

Draft

Issue ●

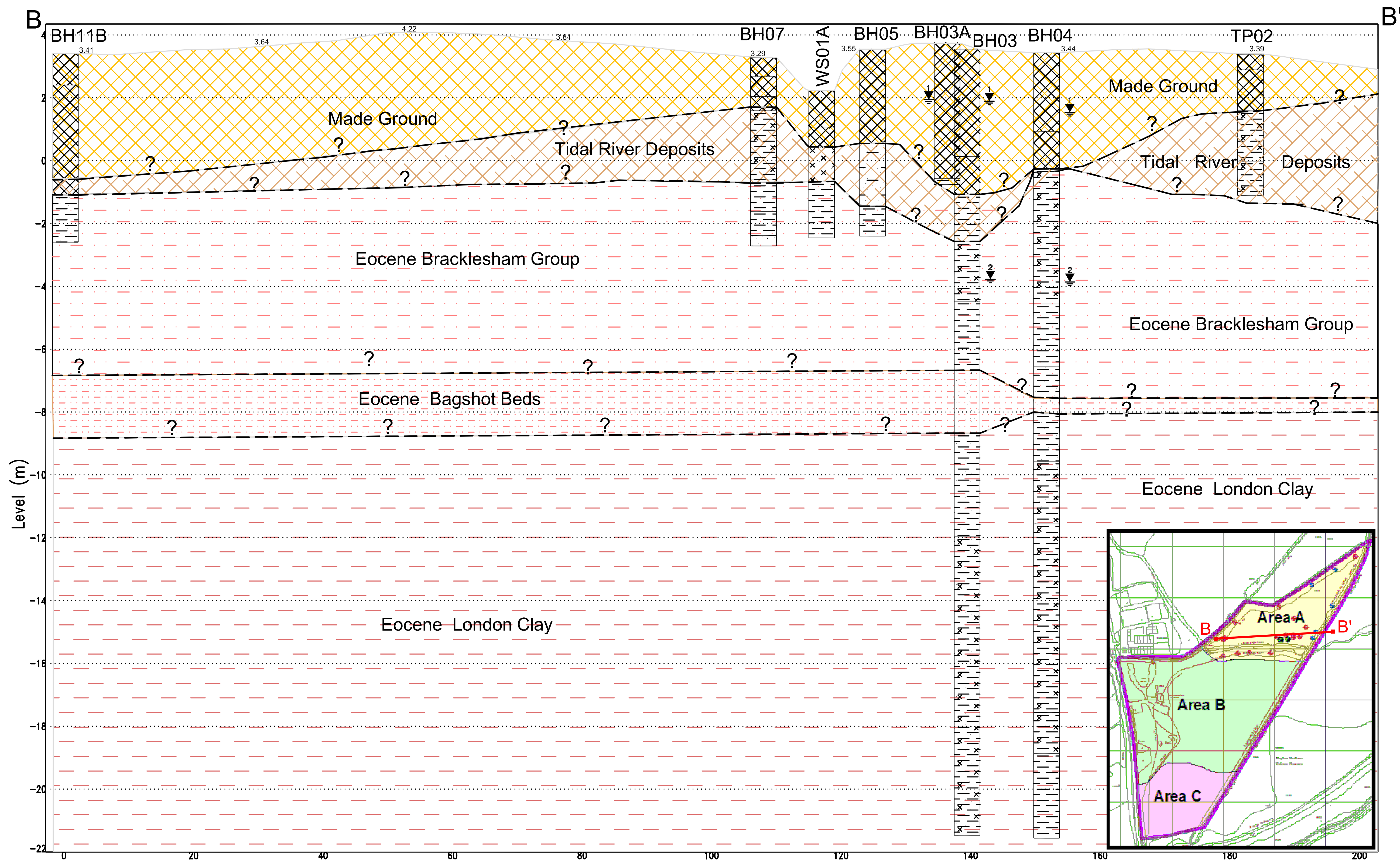
Scale (at A3 size): H 1:568 V1:36

Issuing Office: Bristol

Telephone: 0117 906 2300

Drawing number: 721374/M/04

Version: A



A	IW 25/06/09	OB 25/06/09	RE 25/06/09
Version	Originated by & date	Checked by & date	Approved by & date

mouchel

Purpose: Information

Draft

Issue ●

Scale (at A3 size): H 1:568 V1:36

Client: SEEDA

Project: Pagham Harbour – Phase 2

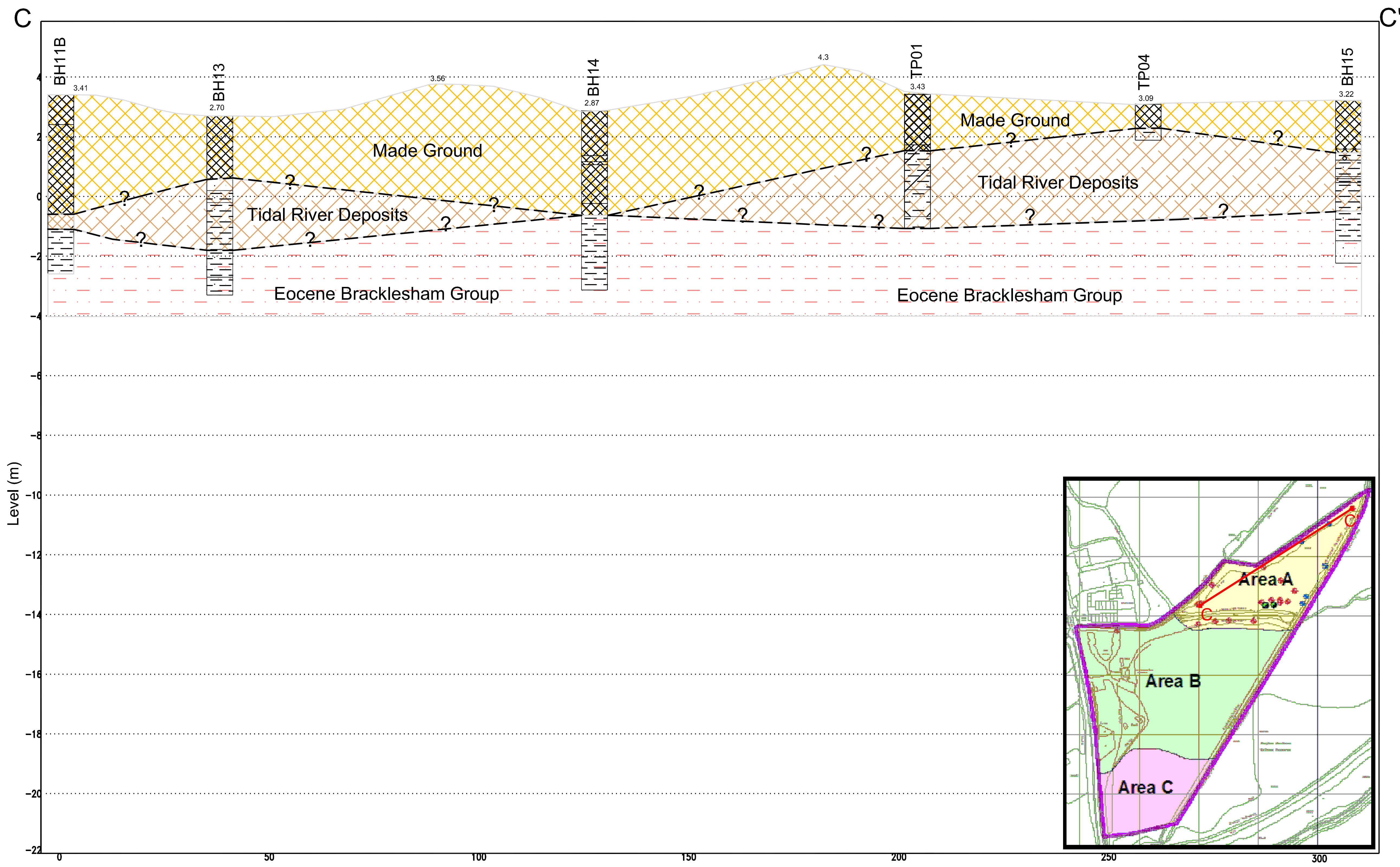
Drawing Title: Cross–section BB'

Issuing Office: Bristol

Telephone: 0117 906 2300

Drawing number: 721374/M/05

Version: A



A	IW 25/06/09	OB 25/06/09	RE 25/06/09
Version	Originated by & date	Checked by & date	Approved by & date

mouchel

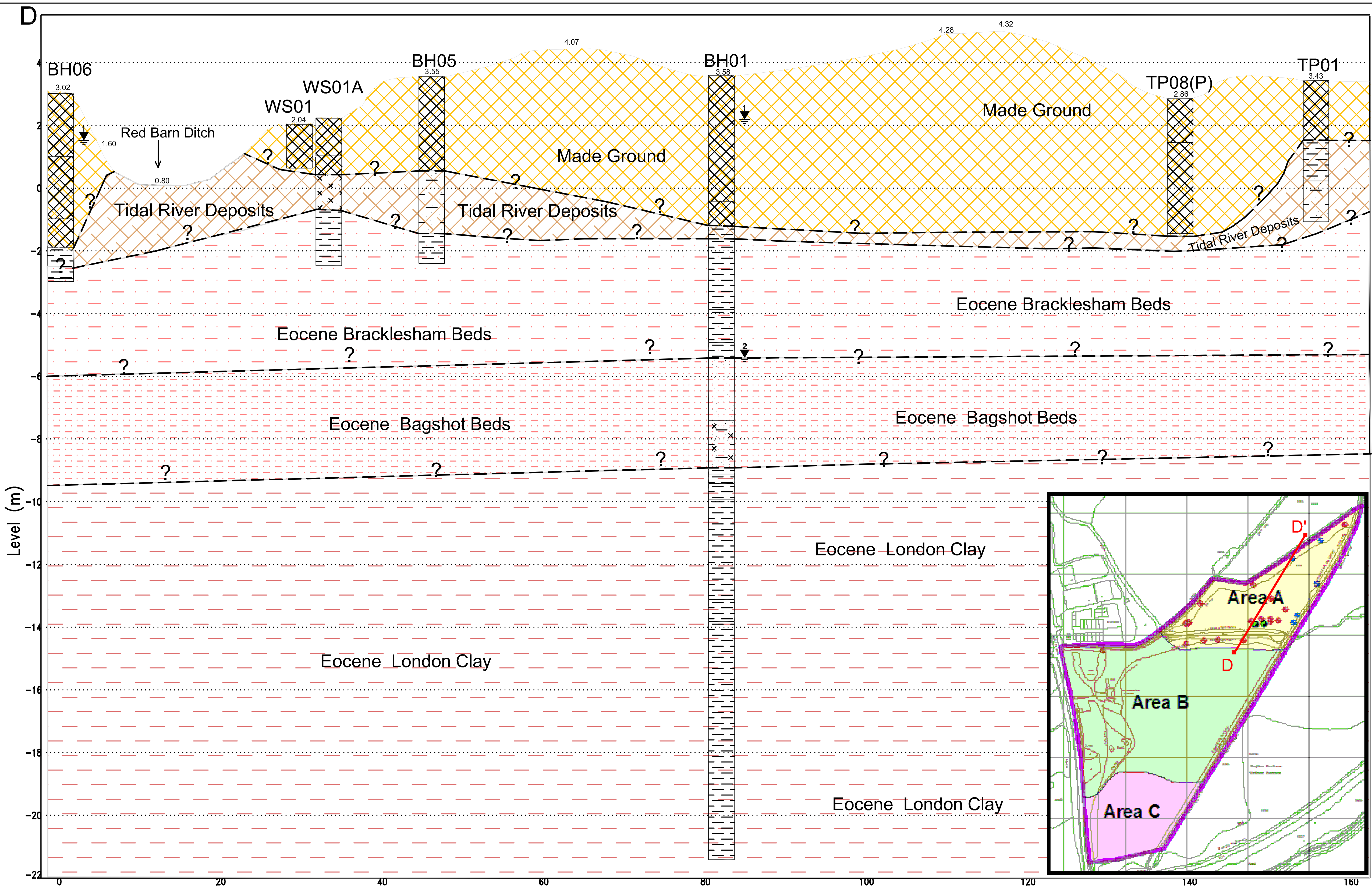
Purpose: Information

Client: SEEDA

Project: Pagham Harbour – Phase 2

Drawing Title: Cross–section CC'

Draft		Scale (at A3 size)	Issuing Office: Bristol	Drawing number: 721374/M/06	Version: A
Issue	●	H 1:881 V1:124	Telephone: 0117 906 2300		



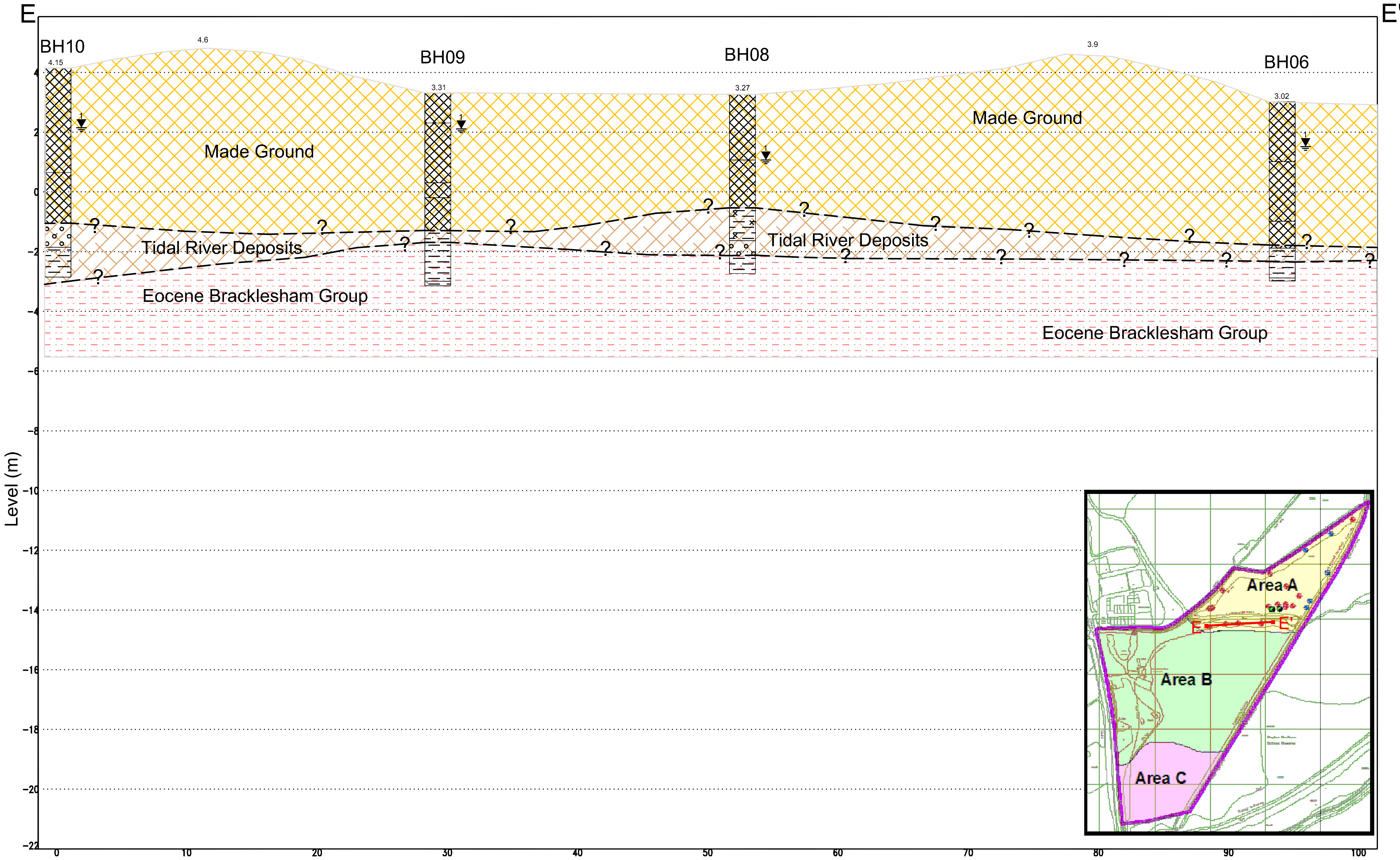
A	IW 25/06/09	OB 25/06/09	RE 25/06/09	
Version	Originated by & date	Checked by & date	Approved by & date	

mouchel

Purpose: Information

Client	SEEDA
Project	Pagham Harbour – Phase 2
Drawing Title	Cross-section DD'

Draft		Scale (at A3 size)	Issuing Office Bristol	Drawing number 721374/M/07	Version A
Issue	●	H 1:568 V1:36	Telephone 0117 906 2300		



Client	SEEDA
Project	Pagham Harbour – Phase 2
Purpose	Information
Drawing Title	Cross–section EE'
Scale (at A3 size)	H 1:284 V1:41
Issuing Office	Bristol
Telephone	0117 906 2300
Drawing number	721374/M/08
Version	A
Draft / Issue	Issue ●

Version	Originated by & date	Checked by & date	Approved by & date
A	IW 25/06/09	OB 25/06/09	RE 25/06/09

mouchel

Appendix C Gas and Groundwater Monitoring Data

Visit 1 — 25/03/2009

Trend from Solent MRSC Weather Station **1005mb Rising**

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	0.6	0.6	0.6
O_2 %	20.3	20.5	20.5
Bal			
H_2S			
CO ppm	0	0	0
BAL	78.8	78.8	79
H_2S ppm	0	0	0
Baro mb	1005	1005	1005

Flow (1/hr)	0.0
Ground Level (m.AOD)	3.58
Depth to water (BGL)	0.92
Water Level (m.AOD)	2.66
Depth to base (BGL)	3.75

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	1.3	1.3	1.3
O_2 %	20.5	20.5	20.4
Bal			
H_2S			
CO ppm	0	0	0
BAL	78.1	78.1	78.2
H_2S	0	0	0
Baro mb	1005	1005	1005

Flow (1/hr)	-0.1 to +0.1
Ground Level (m.AOD)	3.54
Depth to water (BGL)	1.53
Water Level (m.AOD)	2.01
Depth to base (BGL)	4.27

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH_4 %	4	4.2	4.5
CO_2 %	11.7	12	12.1
O_2 %	5.1	4	3.7
Bal			
H_2S			
CO ppm	0	0	0
BAL	79	79.1	79.8
H_2S	0	0	0
Baro mb	1005	1005	1005

Flow (1/hr)	-0.1 to 0.0
Ground Level (m.AOD)	3.53
Depth to water (BGL)	1.79
Water Level (m.AOD)	1.74
Depth to base (BGL)	3.54

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	3.6	3.1	3
O_2 %	16.9	17.4	17.6
Bal			
H_2S			
CO ppm	0	0	0
BAL	79.4	79.4	79.2
H_2S	0	0	0
Baro mb	1005	1005	1005

Flow (1/hr)	0.0 to +0.1
Ground Level (m.AOD)	3.44
Depth to water (BGL)	1.23
Water Level (m.AOD)	2.21
Depth to base (BGL)	10.98

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH_4 %	4.6	4.8	4.7
CO_2 %	5.2	5.2	5.2
O_2 %	16.5	16	15.8
Bal			
H_2S			
CO ppm	0	0	0
BAL	73.5	73.9	74.1
H_2S	0	0	0
Baro mb	1005	1005	1005

Flow (1/hr)	-0.1 to 0.0
Ground Level (m.AOD)	3.02
Depth to water (BGL)	1.12
Water Level (m.AOD)	1.9
Depth to base (BGL)	4.62

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	1.7	1.7	1.7
O_2 %	20	19.8	19.8
Bal			
H_2S			
CO ppm	0	0	0
BAL	78.2	78.3	78.3
H_2S ppm	0	0	0
Baro mb	1005	1005	1005

Flow (1/hr)	0.0 to +0.1
Ground Level (m.AOD)	3.27
Depth to water (BGL)	1.47
Water Level (m.AOD)	1.8
Depth to base (BGL)	3.98

Visit 1 — 25/03/2009

Trend from Solent MRSC Weather Station **1005mb Rising**

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	1.1	1.1	1.1
O_2 %	19.2	19.2	19.1
Bal			
H_2S			
CO ppm	0	0	0
BAL	79.6	79.7	79.6
H_2S	0	0	0
Baro mb	1005	1005	1005

Flow (1/hr)	-0.1 to 0.0
Ground Level (m.AOD)	3.31
Depth to water (BGL)	1.51
Water Level (m.AOD)	1.8
Depth to base (BGL)	3.17

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	0.4	0.4	0.4
O_2 %	19.5	19.6	19.6
Bal			
H_2S			
CO ppm	0	0	0
BAL	80.1	80	80
H_2S ppm	0	0	0
Baro mb	1005	1005	1005

Flow (1/hr)	-0.1 to +0.1
Ground Level (m.AOD)	4.15
Depth to water (BGL)	2.12
Water Level (m.AOD)	2.03
Depth to base (BGL)	4.78

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	9.3	9.2	9.4
O_2 %	12.4	11.8	11.6
Bal			
H_2S			
CO ppm	0	0	0
BAL			79
H_2S ppm	0	0	0
Baro mb	1005	1005	1005

Flow (1/hr)	0.0 to +0.1
Ground Level (m.AOD)	3.41
Depth to water (BGL)	1.53
Water Level (m.AOD)	1.88
Depth to base (BGL)	3.75

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	0.1	0	0
O_2 %	20.8	20.8	20.8
Bal			
H_2S			
CO ppm	0	0	0
BAL	79	79	79
H_2S	0	0	0
Baro mb	1004	1004	1004

Flow (1/hr)	+0.1
Ground Level (m.AOD)	2.32
Depth to water (BGL)	0.47
Water Level (m.AOD)	1.85
Depth to base (BGL)	4.17

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	0.3	0.2	0.1
O_2 %	19.7	19.7	19.7
Bal			
H_2S			
CO ppm	0	0	0
BAL			
H_2S	0	0	0
Baro mb	1006	1006	1006

Flow (1/hr)	-0.2 to -0.1
Ground Level (m.AOD)	2.7
Depth to water (BGL)	0.74
Water Level (m.AOD)	1.96
Depth to base (BGL)	2.14

Visit 2 — 06/04/2009

Trend from Solent MRSC Weather Station **1009mb Falling**

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	0	0	0
O_2 %	20.8	20.8	20.8
Bal			
H_2S			
CO ppm	0	0	0
BAL	79.1	79.1	79.1
H_2S ppm	0	0	0
Baro mb	1008	1008	1008

Flow (1/hr)	0.0 to +0.1
Ground Level (m.AOD)	3.58
Depth to water (BGL)	1
Water Level (m.AOD)	2.58
Depth to base (BGL)	3.76

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	2.4	2.4	2.4
O_2 %	18.2	18.1	18.2
Bal			
H_2S			
CO ppm	0	0	0
BAL	79.4	79.4	79.4
H_2S	0	0	0
Baro mb	1008	1008	1008

Flow (1/hr)	0.0 to +0.1
Ground Level (m.AOD)	3.54
Depth to water (BGL)	1.62
Water Level (m.AOD)	1.92
Depth to base (BGL)	4.3

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	4.8	4.4	4.8
O_2 %	14.4	14.5	14.5
Bal			
H_2S			
CO ppm	0	0	0
BAL	80.6	80.6	80.6
H_2S	0	0	0
Baro mb	1008	1008	1008

Flow (1/hr)	0.0 to +0.1
Ground Level (m.AOD)	3.53
Depth to water (BGL)	1.84
Water Level (m.AOD)	1.69
Depth to base (BGL)	3.55

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	0.7	0.5	0.5
O_2 %	20.2	20.4	20.5
Bal			
H_2S			
CO ppm	0	0	0
BAL	79.2	79.5	79.6
H_2S	0	0	0
Baro mb	1008	1008	1008

Flow (1/hr)	-0.1 to +0.1
Ground Level (m.AOD)	3.44
Depth to water (BGL)	1.4
Water Level (m.AOD)	2.04
Depth to base (BGL)	10.93

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH_4 %	1.4	1.5	1.4
CO_2 %	11	11.3	11.3
O_2 %	8.4	8.3	8.3
Bal			
H_2S			
CO ppm	0	0	0
BAL	78.9	79	79
H_2S	0	0	0
Baro mb	1008	1008	1008

Flow (1/hr)	0.0 to +0.1
Ground Level (m.AOD)	3.02
Depth to water (BGL)	1.18
Water Level (m.AOD)	1.84
Depth to base (BGL)	4.51

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	1.4	1.4	1.4
O_2 %	20.1	20.1	20.1
Bal			
H_2S			
CO ppm	0	0	0
BAL	78.5	78.5	78.4
H_2S ppm	0	0	0
Baro mb	1008	1008	1008

Flow (1/hr)	0.0 to +0.1
Ground Level (m.AOD)	3.27
Depth to water (BGL)	1.5
Water Level (m.AOD)	1.77
Depth to base (BGL)	3.99

Visit 2 — 06/04/2009

Trend from Solent MRSC Weather Station **1009mb Falling**

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	1.3	1.3	1.3
O_2 %	19.5	19.4	19.4
Bal			
H_2S			
CO ppm	0	0	0
BAL	79.1	79.2	79.1
H_2S	0	0	0
Baro mb	1006	1006	1006

Flow (1/hr)	-0.1 to 0.0
Ground Level (m.AOD)	3.31
Depth to water (BGL)	1.52
Water Level (m.AOD)	1.79
Depth to base (BGL)	3.17

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	3.3	3.4	3.4
O_2 %	15.4	15.1	15.1
Bal			
H_2S			
CO ppm	0	0	0
BAL	81.3	81.5	81.5
H_2S ppm	0	0	0
Baro mb	1006	1006	1006

Flow (1/hr)	0.0 to + 0.1
Ground Level (m.AOD)	4.15
Depth to water (BGL)	2.15
Water Level (m.AOD)	2
Depth to base (BGL)	4.78

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	12.3	12.5	12.8
O_2 %	3.4	2.4	2
Bal			
H_2S			
CO ppm	0	0	0
BAL	84.6	85.1	84.8
H_2S ppm	0	0	0
Baro mb	1009	1009	1009

Flow (1/hr)	-0.1 to 0.0
Ground Level (m.AOD)	3.41
Depth to water (BGL)	1.61
Water Level (m.AOD)	1.8
Depth to base (BGL)	3.78

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	0.1	0.1	0.1
O_2 %	20.6	20.6	20.7
Bal			
H_2S			
CO ppm	0	0	0
BAL	79.2	79.1	79.2
H_2S	0	0	0
Baro mb	1009	1009	1009

Flow (1/hr)	0.0 to +0.1
Ground Level (m.AOD)	2.32
Depth to water (BGL)	0.46
Water Level (m.AOD)	1.86
Depth to base (BGL)	4.15

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH_4 %	0	0	0
CO_2 %	0.1	0	0
O_2 %	20.7	20.8	20.8
Bal			
H_2S			
CO ppm	0	0	0
BAL	80	79.1	79.1
H_2S	0	0	0
Baro mb	1009	1009	1009

Flow (1/hr)	-0.1 to +0.1
Ground Level (m.AOD)	2.7
Depth to water (BGL)	0.82
Water Level (m.AOD)	1.88
Depth to base (BGL)	2.14

Visit 3 — 22/04/2009

Trend from Solent MRSC Weather Station **Rising**

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	1.4	1.4	1.4
O2 %	18.8	18.7	18.8
Bal			
H2S			
CO ppm	0	0	0
BAL	79.7	79.7	79.7
H2S ppm	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	-0.1
Ground Level (m.AOD)	3.58
Depth to water (BGL)	1.04
Water Level (m.AOD)	2.54
Depth to base (BGL)	3.75

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	2.8	2.8	2.8
O2 %	16.6	16.4	16.3
Bal			
H2S			
CO ppm	0	0	0
BAL	19.9	80.8	80.9
H2S	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	0
Ground Level (m.AOD)	3.54
Depth to water (BGL)	1.64
Water Level (m.AOD)	1.9
Depth to base (BGL)	4.3

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	8.6	8.6	8.6
O2 %	7.6	7.3	7.5
Bal			
H2S			
CO ppm	2	1	0
BAL	83.9	83.9	83.9
H2S	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	0
Ground Level (m.AOD)	3.53
Depth to water (BGL)	1.9
Water Level (m.AOD)	1.63
Depth to base (BGL)	3.54

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.3	0.2	0.2
O2 %	20.1	20.2	20.2
Bal			
H2S			
CO ppm	0	0	0
BAL			
H2S	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	0
Ground Level (m.AOD)	3.44
Depth to water (BGL)	1.29
Water Level (m.AOD)	2.15
Depth to base (BGL)	10.93

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	10.7	11	11
O2 %	8.5	8.1	8
Bal			
H2S			
CO ppm	0	0	0
BAL	80.8	80.9	80.9
H2S	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	+0.1
Ground Level (m.AOD)	3.02
Depth to water (BGL)	1.26
Water Level (m.AOD)	1.76
Depth to base (BGL)	4.52

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	4.2	4.3	4.3
O2 %	14	13.9	13.7
Bal			
H2S			
CO ppm	0	0	0
BAL	81.8	81.8	81.9
H2S ppm	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	+0.1 - 0.0
Ground Level (m.AOD)	3.27
Depth to water (BGL)	1.56
Water Level (m.AOD)	1.71
Depth to base (BGL)	3.99

Visit 3 — 22/04/2009

Trend from Solent MRSC Weather Station **Rising**

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	2.5	2.6	2.5
O2 %	16.1	16	16
Bal			
H2S			
CO ppm	0	0	0
BAL	81.4	81.2	81.3
H2S	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	+01 - 0.0
Ground Level (m.AOD)	3.31
Depth to water (BGL)	1.54
Water Level (m.AOD)	1.77
Depth to base (BGL)	3.17

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	3.4	3.4	3.5
O2 %	18	17.9	18
Bal			
H2S			
CO ppm	0	0	0
BAL	78.2	78.6	78.2
H2S ppm	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	+0.1
Ground Level (m.AOD)	4.15
Depth to water (BGL)	2.15
Water Level (m.AOD)	2
Depth to base (BGL)	4.85

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH4 %	0	0.1	0.2
CO2 %	10.9	15.3	15.9
O2 %	9.7	2.2	1.2
Bal			
H2S			
CO ppm	0	0	0
BAL	78.7	78.6	82.2
H2S ppm	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	-0.1
Ground Level (m.AOD)	3.41
Depth to water (BGL)	1.59
Water Level (m.AOD)	1.82
Depth to base (BGL)	3.77m (GL)

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0	0	0
O2 %	20.7	20.7	20.7
Bal			
H2S			
CO ppm	0	0	0
BAL	79.2	79.2	79.2
H2S	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	-0.2
Ground Level (m.AOD)	2.32
Depth to water (BGL)	0.655
Water Level (m.AOD)	1.665
Depth to base (BGL)	3.98

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.2	0.2	0.1
O2 %	20.2	20.3	20.3
Bal			
H2S			
CO ppm	0	0	0
BAL	79.5	79.3	79.5
H2S	0	0	0
Baro mb	1028	1028	1028

Flow (1/hr)	-0.2
Ground Level (m.AOD)	2.7
Depth to water (BGL)	0.9
Water Level (m.AOD)	1.8
Depth to base (BGL)	2.14

Visit 4 — 15/05/2009

Trend from Solent MRSC Weather Station 1003**mb falling**

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	1.7	1.7	1.7
O2 %	19.1	18.9	19
Bal			
H2S			
CO ppm	0	0	0
BAL	79.2	79.3	79.3
H2S ppm	0	0	0
Baro mb	1003	1003	1003

Flow (1/hr)	0
Ground Level (m.AOD)	3.58
Depth to water (BGL)	1.11
Water Level (m.AOD)	2.47
Depth to base (BGL)	3.75

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0.1	0.1
CO2 %	2.3	2.4	2.4
O2 %	18	17.7	17.7
Bal			
H2S			
CO ppm	0	0	0
BAL	79.6	79.8	79.8
H2S	0	0	0
Baro mb	1002	1002	1002

Flow (1/hr)	0.4
Ground Level (m.AOD)	3.54
Depth to water (BGL)	1.69
Water Level (m.AOD)	1.85
Depth to base (BGL)	4.3

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0.2	0.2	0.2
CO2 %	3.8	3.9	3.9
O2 %	17.3	17.2	17.1
Bal			
H2S			
CO ppm	0	0	0
BAL	78.7	78.7	78.7
H2S	0	0	0
Baro mb	1002	1002	1002

Flow (1/hr)	0.1
Ground Level (m.AOD)	3.53
Depth to water (BGL)	1.94
Water Level (m.AOD)	1.59
Depth to base (BGL)	3.54

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0.2	0.1
CO2 %	1.4	1.1	1
O2 %	18.9	19.3	19.6
Bal			
H2S			
CO ppm	0	0	0
BAL	79.5	79.4	79.3
H2S	0	0	0
Baro mb	1002	1002	1002

Flow (1/hr)	0.3
Ground Level (m.AOD)	3.44
Depth to water (BGL)	1.48
Water Level (m.AOD)	1.96
Depth to base (BGL)	10.93

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH4 %	8.6	8.5	8.4
CO2 %	12.5	12.4	12.4
O2 %	3.3	3.2	3.2
Bal			
H2S			
CO ppm	0	0	0
BAL	75.7	75.8	75.8
H2S	0	0	0
Baro mb	1001	1001	1001

Flow (1/hr)	0
Ground Level (m.AOD)	3.02
Depth to water (BGL)	1.26
Water Level (m.AOD)	1.76
Depth to base (BGL)	4.52

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH4 %	0.2	0.2	0.2
CO2 %	2.2	2.2	2.2
O2 %	18.5	18.2	18.3
Bal			
H2S			
CO ppm	0	0	0
BAL	79.3	79.3	79.2
H2S ppm	0	0	0
Baro mb	1002	1002	1002

Flow (1/hr)	0
Ground Level (m.AOD)	3.27
Depth to water (BGL)	1.54
Water Level (m.AOD)	1.73
Depth to base (BGL)	3.99

Visit 4 — 15/05/2009

Trend from Solent MRSC Weather Station 1003**mb falling**

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH4 %	0.2	0.2	0.1
CO2 %	1.3	1.3	1.3
O2 %	20	19.9	20
Bal			
H2S			
CO ppm	0	0	0
BAL	78.4	78.6	78.5
H2S	0	0	0
Baro mb	1002	1002	1002

Flow (1/hr)	0
Ground Level (m.AOD)	3.31
Depth to water (BGL)	1.56
Water Level (m.AOD)	1.75
Depth to base (BGL)	3.17

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0.1	0.2
CO2 %	0.3	0.1	0.2
O2 %	20.9	20.9	20.9
Bal			
H2S			
CO ppm	0	0	0
BAL	78.5	78.5	78.5
H2S ppm	0	0	0
Baro mb	1002	1002	1002

Flow (1/hr)	0
Ground Level (m.AOD)	4.15
Depth to water (BGL)	2.26
Water Level (m.AOD)	1.89
Depth to base (BGL)	4.85

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH4 %	0.2	0.1	0.1
CO2 %	15.9	16	16.2
O2 %	4.1	4	3.7
Bal			
H2S			
CO ppm	0	0	0
BAL	78.9	78.7	79.6
H2S ppm	0	0	0
Baro mb	1002	1002	1002

Flow (1/hr)	0
Ground Level (m.AOD)	3.41
Depth to water (BGL)	1.62
Water Level (m.AOD)	1.79
Depth to base (BGL)	3.77

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.1	0.1	0.1
O2 %	20.6	20.7	20.7
Bal			
H2S			
CO ppm	0	0	0
BAL	79.2	79.2	79.1
H2S	0	0	0
Baro mb	1001	1001	1001

Flow (1/hr)	0.1
Ground Level (m.AOD)	2.32
Depth to water (BGL)	0.63
Water Level (m.AOD)	1.69
Depth to base (BGL)	3.98

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0.2	0.1	0.1
CO2 %	0.2	0.1	0.1
O2 %	20.5	20.8	20.9
Bal			
H2S			
CO ppm	0	0	0
BAL	79.2	79	76.8
H2S	0	0	0
Baro mb	1002	1002	1002

Flow (1/hr)	0.1
Ground Level (m.AOD)	2.7
Depth to water (BGL)	0.99
Water Level (m.AOD)	1.71
Depth to base (BGL)	2.14

Visit 5

01/06/2009

Trend from Solent MRSC Weather Station 1022

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	2	2	2
O2 %	17.6	17.5	17.6
Bal	80.3	80.3	80.3
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1021	1021	1021

Flow (1/hr) -1.1
Ground Level (m.AOD) 3.58
Depth to water (BGL) 1.83
Water Level (m.AOD) 1.75
Depth to base (BGL) 3.75

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	3.9	3.9	3.9
O2 %	16	15.9	15.9
Bal	80	80	8
H2S	0	0	0
CO ppm	0 - 2	0	0
BAL			
H2S			
Baro mb	1021	1021	1021

Flow (1/hr) -1.3
Ground Level (m.AOD) 3.54
Depth to water (BGL) 2.5
Water Level (m.AOD) 1.04
Depth to base (BGL) 4.3

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0.2
CO2 %	2.5	2.5	2.5
O2 %	16.2	16.3	16.3
Bal	81.3	81.2	81.1
H2S	0	0	1
CO ppm	1	0	2
BAL			
H2S			
Baro mb	1021	1021	1021

Flow (1/hr)
Ground Level (m.AOD) 3.53
Depth to water (BGL) 2.61
Water Level (m.AOD) 0.92
Depth to base (BGL) 3.54

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.7	0.6	0.5
O2 %	18.4	18.6	18.7
Bal	80.8	80.7	80.7
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1022	1022	1022

Flow (1/hr) -0.2
Ground Level (m.AOD) 3.44
Depth to water (BGL) 2.3
Water Level (m.AOD) 1.14
Depth to base (BGL) 10.93

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH4 %	0.2	0.2	0.2
CO2 %	13.9	13.9	13.9
O2 %	8.6	8.5	8.5
Bal	77.2	77.4	77.4
H2S	0	0	0
CO ppm	2	1	2
BAL			
H2S			
Baro mb	1022	1022	1022

Flow (1/hr) 0.5
Ground Level (m.AOD) 3.02
Depth to water (BGL) 1.84
Water Level (m.AOD) 1.18
Depth to base (BGL) 4.52

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	4.5	4.5	4.5
O2 %	15	14.9	14.8
Bal	80.4	80.5	80.5
H2S	0	0	0
CO ppm	0 - 5	2	1
BAL			
H2S ppm			
Baro mb	1023	1023	1023

Flow (1/hr) 0.4
Ground Level (m.AOD) 3.27
Depth to water (BGL) 2.18
Water Level (m.AOD) 1.09
Depth to base (BGL) 3.99

Visit 5

01/06/2009

Trend from Solent MRSC Weather Station 1022

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	5.7	5.8	5.8
O2 %	13.1	13	12.8
Bal	81.1	81.3	81.3
H2S	0	0	0
CO ppm	0	2	1
BAL			
H2S			
Baro mb	1022	1022	1022

Flow (1/hr) 0.2
Ground Level (m.AOD) 3.31
Depth to water (BGL) 2.3
Water Level (m.AOD) 1.01
Depth to base (BGL) 3.17

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	7.7	7.8	7.9
O2 %	10.8	10.6	10.6
Bal	81.4	81.5	81.5
H2S	0	0	0
CO ppm	1	0	2
BAL			
H2S ppm			
Baro mb	1023	1023	1023

Flow (1/hr) 0.4
Ground Level (m.AOD) 4.15
Depth to water (BGL) 3
Water Level (m.AOD) 1.15
Depth to base (BGL) 4.85

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	14.5	14.6	14.6
O2 %	10.4	10.3	10.2
Bal	75.1	75.1	75.1
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1020	1020	1020

Flow (1/hr) -0.3
Ground Level (m.AOD) 3.41
Depth to water (BGL) 2.06
Water Level (m.AOD) 1.35
Depth to base (BGL) 3.77

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	4.2	4	3.9
O2 %	15.1	15.1	15.1
Bal	80.7	80.9	80.9
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1020	1020	1020

Flow (1/hr) -0.2
Ground Level (m.AOD) 2.32
Depth to water (BGL) 1.53
Water Level (m.AOD) 0.79
Depth to base (BGL) 3.98

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.2	0.1	0.1
O2 %	19.3	19.4	19.4
Bal	80.5	80.4	80.4
H2S	0	0	0
CO ppm	0 - 3	0	0
BAL			
H2S			
Baro mb	1021	1021	1021

Flow (1/hr) -0.6
Ground Level (m.AOD) 2.7
Depth to water (BGL) 1.5
Water Level (m.AOD) 1.2
Depth to base (BGL) 2.14

Visit 6

11/06/2009

Trend from Solent MRSC Weather Station 1022

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH4 %	1.5	3.2	3.6
CO2 %	2.8	3	3.1
O2 %	16.8	16.9	16.7
Bal	77	77	76.6
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1019	1019	1019

Flow (1/hr) 0
Ground Level (m.AOD) 3.58
Depth to water (BGL) 1.22
Water Level (m.AOD) 2.36
Depth to base (BGL) 3.74

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	3.8	3.8	3.8
O2 %	15.2	15.2	15.1
Bal	80.9	80.9	81
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) 0.2
Ground Level (m.AOD) 3.54
Depth to water (BGL) 1.79
Water Level (m.AOD) 1.75
Depth to base (BGL) 4.28

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	3.3	3.3	3.3
CO2 %	15.3	15.5	15.6
O2 %	2.3	1.8	1.8
Bal	77	79	79.2
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) -
Ground Level (m.AOD) 3.53
Depth to water (BGL) 2.03
Water Level (m.AOD) 1.5
Depth to base (BGL) 3.54

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0	0
CO2 %	0.8	0.6	0.6
O2 %	18.6	18.8	18.8
Bal			
H2S	0	0	0
CO ppm	2	0	0
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.44
Depth to water (BGL) 1.57
Water Level (m.AOD) 1.87
Depth to base (BGL) 10.45

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0.2	0
CO2 %	16	16.2	16.2
O2 %	3.8	3.7	3.7
Bal	79.7	80	80
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) 0
Ground Level (m.AOD) 3.02
Depth to water (BGL) 1.37
Water Level (m.AOD) 1.65
Depth to base (BGL) 4.5

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0	0
CO2 %	2.7	2.7	2.7
O2 %	15.4	15.3	15.4
Bal	81.7	81.7	81.7
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1019	1019	1019

Flow (1/hr) -
Ground Level (m.AOD) 3.27
Depth to water (BGL) 1.71
Water Level (m.AOD) 1.56
Depth to base (BGL) 3.98

Visit 6

11/06/2009

Trend from Solent MRSC Weather Station 1022

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0.1	0.1
CO2 %	3.8	3.8	3.8
O2 %	15	14.9	15
Bal	79.9	81	-
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) -
Ground Level (m.AOD) 3.31
Depth to water (BGL) 1.65
Water Level (m.AOD) 1.66
Depth to base (BGL) 3.13

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0.1	0.1
CO2 %	0.9	0.9	0.9
O2 %	19.3	19.5	19.4
Bal	79.5	79.4	79.6
H2S	0	2	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1019	1019	1019

Flow (1/hr) -
Ground Level (m.AOD) 3.54
Depth to water (BGL) 2.4
Water Level (m.AOD) 1.14
Depth to base (BGL) 4.76

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	14.6	15.2	15.4
O2 %	4.1	3.4	3.1
Bal	80.9	81.2	81.6
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1019	1019	1019

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.41
Depth to water (BGL) 1.7
Water Level (m.AOD) 1.71
Depth to base (BGL) 3.76

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0	0
CO2 %	2.2	2.2	2.2
O2 %	18	17.7	17.8
Bal	79.8	79.9	79.9
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) -
Ground Level (m.AOD) 2.32
Depth to water (BGL) 1.02
Water Level (m.AOD) 1.3
Depth to base (BGL) 3.97

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0.5	0
CO2 %	0.2	0.1	0.1
O2 %	19.3	19.4	19.5
Bal	80.1	80.2	80.4
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) -
Ground Level (m.AOD) 2.7
Depth to water (BGL) 1.08
Water Level (m.AOD) 1.62
Depth to base (BGL) 2.7

Visit 7

30/06/2009

Trend from Solent MRSC Weather Station 1022

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	2	2	2
O2 %	17.6	17.5	17.6
Bal	80.3	80.3	80.3
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1021	1021	1021

Flow (1/hr) -1.1
Ground Level (m.AOD) 3.58
Depth to water (BGL) 1.83
Water Level (m.AOD) 1.75
Depth to base (BGL) -

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	3.9	3.9	3.9
O2 %	16	15.9	15.9
Bal	80	80	80
H2S	0	0	0
CO ppm	0	0	0-2
BAL			
H2S			
Baro mb	1021	1021	1021

Flow (1/hr) -1.3
Ground Level (m.AOD) 3.54
Depth to water (BGL) 2.5
Water Level (m.AOD) 1.04
Depth to base (BGL) -

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	2.5	2.5	2.5
O2 %	16.2	16.3	16.3
Bal	81.3	81.2	81.1
H2S	0	0	1
CO ppm	1	0	2
BAL			
H2S			
Baro mb	1021	1021	1021

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.53
Depth to water (BGL) 2.61
Water Level (m.AOD) 0.92
Depth to base (BGL) -

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.7	0.6	0.5
O2 %	18.4	18.6	18.7
Bal	80.8	80.7	80.7
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1022	1022	1022

Flow (1/hr) -0.3
Ground Level (m.AOD) 3.44
Depth to water (BGL) 2.3
Water Level (m.AOD) 1.14
Depth to base (BGL) -

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH4 %	0.2	0.2	0.2
CO2 %	13.9	13.9	13.9
O2 %	8.6	8.5	8.5
Bal	77.2	77.4	77.4
H2S	0	0	0
CO ppm	2	1	2
BAL			
H2S			
Baro mb	1022	1022	1022

Flow (1/hr) 0.5
Ground Level (m.AOD) 3.02
Depth to water (BGL) 1.84
Water Level (m.AOD) 1.18
Depth to base (BGL) -

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	4.5	4.5	4.5
O2 %	15	14.9	14.8
Bal	80.4	80.5	80.5
H2S	0	0	0
CO ppm	5	2	1
BAL			
H2S ppm			
Baro mb	1023	1023	1023

Flow (1/hr) 0.5
Ground Level (m.AOD) 3.27
Depth to water (BGL) 2.18
Water Level (m.AOD) 1.09
Depth to base (BGL) -

Visit 7

30/06/2009

Trend from Solent MRSC Weather Station 1022

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	5.7	5.8	5.8
O2 %	13.1	13	12.8
Bal	81.1	81.3	81.3
H2S	0	0	0
CO ppm	0	2	0
BAL			
H2S			
Baro mb	1022	1022	1022

Flow (1/hr) 0.3
Ground Level (m.AOD) 3.31
Depth to water (BGL) 2.3
Water Level (m.AOD) 1.01
Depth to base (BGL) -

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	7.7	7.8	7.9
O2 %	10.8	10.6	10.6
Bal	81.4	81.5	81.5
H2S	0	0	0
CO ppm	1	0	0
BAL			
H2S ppm			
Baro mb	1023	1023	1023

Flow (1/hr) 0.4
Ground Level (m.AOD) 3.54
Depth to water (BGL) 3
Water Level (m.AOD) 0.54
Depth to base (BGL) -

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	14.5	14.6	14.6
O2 %	10.4	10.3	10.2
Bal	75.1	75.1	75.1
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1020	1020	1020

Flow (1/hr) -0.3
Ground Level (m.AOD) 3.41
Depth to water (BGL) 2.06
Water Level (m.AOD) 1.35
Depth to base (BGL) -

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	4.2	4	3.9
O2 %	15.1	15.1	15.1
Bal	80.7	80.9	80.9
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1020	1020	1020

Flow (1/hr) -0.3
Ground Level (m.AOD) 2.32
Depth to water (BGL) 1.53
Water Level (m.AOD) 0.79
Depth to base (BGL) -

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.2	0.1	0.1
O2 %	19.3	19.4	19.4
Bal	80.5	80.4	80.4
H2S	3	0	0
CO ppm	80	80	80
BAL			
H2S			
Baro mb	1021	1021	1021

Flow (1/hr) -0.6
Ground Level (m.AOD) 2.7
Depth to water (BGL) 1.5
Water Level (m.AOD) 1.2
Depth to base (BGL) -

Visit 8

16/07/2009

Trend from Solent MRSC Weather Station 1022

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH4 %	0.2	0.4	0.4
CO2 %	1.9	1.9	2.1
O2 %	19	18.8	19.1
Bal			
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1017	1017	1017

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.58
Depth to water (BGL) 1.26
Water Level (m.AOD) 2.32
Depth to base (BGL) 3.79

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	9.7	9.7	9.7
O2 %	19	14.9	14.8
Bal			
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1016	1016	1016

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.54
Depth to water (BGL) 2.67
Water Level (m.AOD) 0.87
Depth to base (BGL) 3.98

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0.1	0.1
CO2 %	9.2	9	9.1
O2 %	9.2	9	9.1
Bal			
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1018	1018	1018

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.53
Depth to water (BGL) 2.09
Water Level (m.AOD) 1.44
Depth to base (BGL) 3.53

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.9	0.7	0.7
O2 %	18.9	19.1	19.2
Bal			
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1016	1016	1016

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.44
Depth to water (BGL) 2.37
Water Level (m.AOD) 1.07
Depth to base (BGL) 11.3

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH4 %	0.3	0.4	0.3
CO2 %	13	15.1	15.2
O2 %	9.9	9.7	9.6
Bal			
H2S	0	0	0
CO ppm	1	3	1
BAL			
H2S			
Baro mb	1015	1015	1015

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.02
Depth to water (BGL) 1.87
Water Level (m.AOD) 1.15
Depth to base (BGL) 4.86

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH4 %	0	0.1	0.1
CO2 %	2	2.1	2.1
O2 %	17.4	17.4	17.3
Bal			
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1015	1015	1015

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.27
Depth to water (BGL) 2.21
Water Level (m.AOD) 1.06
Depth to base (BGL) 4.32

Visit 8

16/07/2009

Trend from Solent MRSC Weather Station 1022

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0	0
CO2 %	2	2.1	2.1
O2 %	18.1	18.1	18
Bal			
H2S	1	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1015	1015	1015

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.31
Depth to water (BGL) 2.3
Water Level (m.AOD) 1.01
Depth to base (BGL) 3.6

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.7	0.7	0.7
O2 %	18.7	18.7	18.7
Bal			
H2S	0	0	0
CO ppm	2	0	0
BAL			
H2S ppm			
Baro mb	1016	1016	1016

Flow (1/hr) 0.7
Ground Level (m.AOD) 3.54
Depth to water (BGL) 3.06
Water Level (m.AOD) 0.48
Depth to base (BGL) 5.2

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	17.4	19.8	19.7
O2 %	7.5	5.9	5.6
Bal			
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1018	1018	1018

Flow (1/hr) 0.9
Ground Level (m.AOD) 3.41
Depth to water (BGL) 2.12
Water Level (m.AOD) 1.29
Depth to base (BGL) 3.92

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	3.6	3.6	3.6
O2 %	17.1	16.9	16.9
Bal			
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1031	1031	1031

Flow (1/hr) 0.3
Ground Level (m.AOD) 2.32
Depth to water (BGL) 1.57
Water Level (m.AOD) 0.75
Depth to base (BGL) 4.2

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.1	0.1	0.1
O2 %	20	20	20.1
Bal			
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1017	1017	1017

Flow (1/hr) 0.9
Ground Level (m.AOD) 2.7
Depth to water (BGL) 1.58
Water Level (m.AOD) 1.12
Depth to base (BGL) 2.4

Visit 9 — 31/07/2009

Trend from Solent MRSC Weather Station 1022

BH01 - Cover = 0.55m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	3.1	3.1	3.1
O2 %	16.8	16.8	16.8
Bal	72.4	72	70.2
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1020	1020	1020

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.58
Depth to water (BGL) 1.92
Water Level (m.AOD) 1.66
Depth to base (BGL) -

BH02 - Cover = 0.64m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	4.4	4.4	4.6
O2 %	17.3	17.3	17.2
Bal	68.2	70.5	71
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1020		

Flow (1/hr) 0.2
Ground Level (m.AOD) 3.54
Depth to water (BGL) 2.6
Water Level (m.AOD) 0.94
Depth to base (BGL) -

BH03 - Cover = 0.52m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	4.4	4.4	4.5
O2 %	15.9	16	15.9
Bal	79.5	79.5	79.6
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1018		

Flow (1/hr) 0.3
Ground Level (m.AOD) 3.53
Depth to water (BGL) 2.63
Water Level (m.AOD) 0.9
Depth to base (BGL) -

BH04 - Cover = 0.61m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	0.8	0.6	0.5
O2 %	18.8	19.2	19.2
Bal	80.3	80.1	80.2
H2S	0	0	0
CO ppm	2	4	3
BAL			
H2S			
Baro mb	1019		

Flow (1/hr) 0.2
Ground Level (m.AOD) 3.44
Depth to water (BGL) 2.38
Water Level (m.AOD) 1.06
Depth to base (BGL) -

BH06 - Cover = 0.48m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	13.3	13.7	13.7
O2 %	8.1	8	8
Bal	78.3	78.3	78.3
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1018		

Flow (1/hr) 0.2
Ground Level (m.AOD) 3.02
Depth to water (BGL) 1.87
Water Level (m.AOD) 1.15
Depth to base (BGL) -

BH08 - Cover = 0.44m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	2.4	2.4	2.4
O2 %	18	18	18
Bal	79.5	79.4	79.4
H2S	0	0	0
CO ppm	1	0	2
BAL			
H2S ppm			
Baro mb	1018		

Flow (1/hr) -0.6
Ground Level (m.AOD) 3.27
Depth to water (BGL) 2.2
Water Level (m.AOD) 1.07
Depth to base (BGL) -

Visit 9 — 31/07/2009

Trend from Solent MRSC Weather Station 1022

BH09 - Cover = 0.59m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	1.6	1.6	1.6
O2 %	18.1	18	18.2
Bal	80.3	80.2	80.2
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1018		

Flow (1/hr) 0.2
Ground Level (m.AOD) 3.31
Depth to water (BGL) 2.34
Water Level (m.AOD) 0.97
Depth to base (BGL) -

BH10 - Cover = 0.52m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	0.7	0.7	0.7
O2 %	18.5	18.5	18.5
Bal	80.7	80.7	80.7
H2S	0	0	0
CO ppm	1	0	1
BAL			
H2S ppm			
Baro mb	1018	1018	1018

Flow (1/hr) 0.4
Ground Level (m.AOD) 3.54
Depth to water (BGL) 3.07
Water Level (m.AOD) 0.47
Depth to base (BGL) -

BH11B - Cover = 0.27m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	20.3	20.5	20.5
O2 %	4	3.4	3.4
Bal	75	76.1	75.9
H2S	1	0	0
CO ppm	0	1	1
BAL			
H2S ppm			
Baro mb	1021		

Flow (1/hr) -0.8
Ground Level (m.AOD) 3.41
Depth to water (BGL) 2.18
Water Level (m.AOD) 1.23
Depth to base (BGL) -

BH12 - Cover = 0.35m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	1.7	2.1	2.5
O2 %	18.5	18	17.7
Bal	79.5	79.6	79.6
H2S	1	0	0
CO ppm	2	0	0
BAL			
H2S			
Baro mb	1022		

Flow (1/hr) -0.3
Ground Level (m.AOD) 2.32
Depth to water (BGL) 1.58
Water Level (m.AOD) 0.74
Depth to base (BGL) -

BH13 - Cover = 0.35m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	0.9	0.9	0.9
O2 %	19.1	19.1	19.1
Bal	79.6	79.4	79.5
H2S	1	1	1
CO ppm	1	1	5
BAL			
H2S			
Baro mb	1021		

Flow (1/hr) 0.1
Ground Level (m.AOD) 2.7
Depth to water (BGL) 1.62
Water Level (m.AOD) 1.08
Depth to base (BGL) -

Visit 10 — 12/08/2009

Trend from Solent MRSC Weather Station 1022

BH01 - Cover = 0.55m

	Time (Secs) 30	60	90
CH4 %	0.3	0.3	0.2
CO2 %	1.3	1.3	1.3
O2 %	18.7	18.5	18.4
Bal	79.8	79.8	79.9
H2S	0	0	0
CO ppm	3	1	3
BAL			
H2S ppm			
Baro mb	1020	1020	1020

Flow (1/hr) -0.2
Ground Level (m.AOD) 3.58
Depth to water (BGL) 1.94
Water Level (m.AOD) 1.64
Depth to base (BGL) -

BH02 - Cover = 0.64m

	Time (Secs) 30	60	90
CH4 %	0.1	0	0
CO2 %	5	4.9	4.9
O2 %	16	16	15.9
Bal	78.8	79.2	79
H2S	0	1	0
CO ppm	2	2	1
BAL			
H2S			
Baro mb	1020	1020	1020

Flow (1/hr) 0.1
Ground Level (m.AOD) 3.54
Depth to water (BGL) 2.63
Water Level (m.AOD) 0.91
Depth to base (BGL) -

BH03 - Cover = 0.52m

	Time (Secs) 30	60	90
CH4 %	0	0.1	0.1
CO2 %	8.8	8.8	8.9
O2 %	10.6	10.5	10.4
Bal	80.3	80.6	80.5
H2S	1	0	0
CO ppm	3	0	2
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) -0.4
Ground Level (m.AOD) 3.53
Depth to water (BGL) 2.65
Water Level (m.AOD) 0.88
Depth to base (BGL) -

BH04 - Cover = 0.61m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	0.5	0.4	0.4
O2 %	19.4	19.5	19.5
Bal	80.1	80.1	80
H2S	1	0	1
CO ppm	3	0	1
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) 0.2
Ground Level (m.AOD) 3.44
Depth to water (BGL) 2.4
Water Level (m.AOD) 1.04
Depth to base (BGL) -

BH06 - Cover = 0.48m

	Time (Secs) 30	60	90
CH4 %	0.2	0.2	0.3
CO2 %	16.2	16.2	16.3
O2 %	5.1	4.9	4.9
Bal	78.4	78.6	78.8
H2S	1	1	1
CO ppm	2	3	3
BAL			
H2S			
Baro mb	1019	1019	1019

Flow (1/hr) -0.3
Ground Level (m.AOD) 3.02
Depth to water (BGL) 1.88
Water Level (m.AOD) 1.14
Depth to base (BGL) -

BH08 - Cover = 0.44m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	0	0	0
O2 %	11.9	11.8	11.7
Bal	80.8	80.6	80.6
H2S	0	0	0
CO ppm	0	3	0
BAL			
H2S ppm			
Baro mb	1019	1019	1019

Flow (1/hr) -0.2
Ground Level (m.AOD) 3.27
Depth to water (BGL) 2.22
Water Level (m.AOD) 1.05
Depth to base (BGL) -

Visit 10 — 12/08/2009

Trend from Solent MRSC Weather Station 1022

BH09 - Cover = 0.59m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	5.4	5.4	5.5
O2 %	13.8	13.9	13.9
Bal	80.5	80.6	80.6
H2S	1	1	1
CO ppm	1	1	1
BAL			
H2S			
Baro mb	1018	1018	1018

Flow (1/hr) -0.4
Ground Level (m.AOD) 3.31
Depth to water (BGL) 2.38
Water Level (m.AOD) 0.93
Depth to base (BGL) -

BH10 - Cover = 0.52m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	2.1	2.1	2.1
O2 %	17.2	17.1	17.1
Bal	80.6	80.6	80.6
H2S	0	0	0
CO ppm	1	3	2
BAL			
H2S ppm			
Baro mb	1019	1019	1019

Flow (1/hr) -0.2
Ground Level (m.AOD) 3.54
Depth to water (BGL) 3.1
Water Level (m.AOD) 0.44
Depth to base (BGL) -

BH11B - Cover = 0.27m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	17.8	17.7	17.6
O2 %	4.7	4.5	4.4
Bal	77.5	77.8	77.8
H2S	0	0	0
CO ppm	5	8	2
BAL			
H2S ppm			
Baro mb	1021	1021	1021

Flow (1/hr) -0.3
Ground Level (m.AOD) 3.41
Depth to water (BGL) 2.21
Water Level (m.AOD) 1.2
Depth to base (BGL) -

BH12 - Cover = 0.35m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	5.1	5.1	5.1
O2 %	14.1	14	14
Bal	80.7	80.8	80.9
H2S	0	0	0
CO ppm	5	0	0
BAL			
H2S			
Baro mb	1021	1021	1021

Flow (1/hr) 0.2
Ground Level (m.AOD) 2.32
Depth to water (BGL) 1.6
Water Level (m.AOD) 0.72
Depth to base (BGL) -

BH13 - Cover = 0.35m

	Time (Secs) 30	60	90
CH4 %	0	0	0
CO2 %	2.6	2.6	2.7
O2 %	17	16.9	16.9
Bal	80.3	80.4	80.3
H2S	0	0	0
CO ppm	0	2	3
BAL			
H2S			
Baro mb	1021	1021	1021

Flow (1/hr) -0.8
Ground Level (m.AOD) 2.7
Depth to water (BGL) 1.66
Water Level (m.AOD) 1.04
Depth to base (BGL) -

Visit 11 — 28/08/2009

Trend from Solent MRSC Weather Station 1022

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH4 %	0.1	8	8
CO2 %	2.5	2.4	2.4
O2 %	17.5	17.4	17.5
Bal	79.8	80.1	80.1
H2S	0	0	0
CO ppm	0	1	0
BAL			
H2S ppm			
Baro mb	1013	1013	1013

Flow (1/hr)	-0.6
Ground Level (m.AOD)	3.58
Depth to water (BGL)	1.99
Water Level (m.AOD)	1.59
Depth to base (BGL)	-

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	3.8	3.7	3.6
O2 %	17.4	17.3	17.3
Bal	78.6	78.9	79
H2S	0	0	0
CO ppm	2	2	1
BAL			
H2S			
Baro mb	1013	1013	1013

Flow (1/hr)	-0.1
Ground Level (m.AOD)	3.54
Depth to water (BGL)	2.63
Water Level (m.AOD)	0.91
Depth to base (BGL)	-

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0.2	0.6	0.7
CO2 %	25.2	25	24.8
O2 %	5.3	5.3	5.2
Bal	69.4	69.4	69.2
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1013	1013	1013

Flow (1/hr)	-0.1
Ground Level (m.AOD)	3.53
Depth to water (BGL)	2.6
Water Level (m.AOD)	0.93
Depth to base (BGL)	-

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH4 %	1.6	3.8	5.5
CO2 %	2.6	2.7	2.5
O2 %	17.6	17.6	17.8
Bal	77.1	75.3	74
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1013	1013	1013

Flow (1/hr)	0.1
Ground Level (m.AOD)	3.44
Depth to water (BGL)	2.39
Water Level (m.AOD)	1.05
Depth to base (BGL)	-

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	21.8	22	22
O2 %	13.3	13.1	13.1
Bal	64.8	64.1	65.1
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1013	1013	1013

Flow (1/hr)	-0.6
Ground Level (m.AOD)	3.02
Depth to water (BGL)	1.86
Water Level (m.AOD)	1.16
Depth to base (BGL)	-

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	6.1	6.2	6.2
O2 %	16.2	16	16.1
Bal	77.6	77.8	77.6
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1012	1012	1012

Flow (1/hr)	-0.3
Ground Level (m.AOD)	3.27
Depth to water (BGL)	2.16
Water Level (m.AOD)	1.11
Depth to base (BGL)	-

Visit 11 — 28/08/2009

Trend from Solent MRSC Weather Station 1022

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH4 %	0.6	1.6	3
CO2 %	3.5	3.2	3
O2 %	18.6	18.6	18.6
Bal	77.3	76.1	75.1
H2S	0	0	0
CO ppm	2	1	0
BAL			
H2S			
Baro mb	1012	1012	1012

Flow (1/hr)	-0.4
Ground Level (m.AOD)	3.31
Depth to water (BGL)	2.28
Water Level (m.AOD)	1.03
Depth to base (BGL)	-

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.1	0.1	0.1
O2 %	19.7	19.7	19.6
Bal	80.2	80.3	80.2
H2S	0	0	0
CO ppm	0	1	0
BAL			
H2S ppm			
Baro mb	1012	1012	1012

Flow (1/hr)	0.1
Ground Level (m.AOD)	3.54
Depth to water (BGL)	3.1
Water Level (m.AOD)	0.44
Depth to base (BGL)	-

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	20.3	20.4	20.4
O2 %	3.8	3.1	3
Bal	75.9	76.6	76.7
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S ppm			
Baro mb	1014	1014	1014

Flow (1/hr)	-
Ground Level (m.AOD)	3.41
Depth to water (BGL)	2.18
Water Level (m.AOD)	1.23
Depth to base (BGL)	-

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	7	7	7
O2 %	12.8	12.5	12.5
Bal	79.9	80.4	80.4
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1014	1014	1014

Flow (1/hr)	-0.4
Ground Level (m.AOD)	2.32
Depth to water (BGL)	1.7
Water Level (m.AOD)	0.62
Depth to base (BGL)	-

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	3.5	3.6	3.5
O2 %	17	16.9	16.8
Bal	79.4	79.6	79.7
H2S	0	0	0
CO ppm	1	0	0
BAL			
H2S			
Baro mb	1014	1014	1014

Flow (1/hr)	-0.2
Ground Level (m.AOD)	2.7
Depth to water (BGL)	1.72
Water Level (m.AOD)	0.98
Depth to base (BGL)	-

Visit 12 — 11/09/2009

Trend from Solent MRSC Weather Station 1022

BH01 - Cover = 0.55m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	1.2	1.2	1.2
O2 %	19.2	19.4	19.2
Bal	79.4	79.4	
H2S	0	0	0
CO ppm	3	1	1
BAL			
H2S ppm			
Baro mb	1035	1035	1035

Flow (1/hr)	-0.4
Ground Level (m.AOD)	3.58
Depth to water (BGL)	2.05
Water Level (m.AOD)	1.53
Depth to base (BGL)	-

BH02 - Cover = 0.64m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	4.6	4.6	4.6
O2 %	16.6	16.4	16.5
Bal	78.7	78.8	78.8
H2S	0	0	0
CO ppm	2	0	1
BAL			
H2S			
Baro mb	1034	1034	1034

Flow (1/hr)	-0.8
Ground Level (m.AOD)	3.54
Depth to water (BGL)	2.72
Water Level (m.AOD)	0.82
Depth to base (BGL)	-

BH03 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	5.8	5.9	5.9
CO2 %	19.1	19.4	19
O2 %	1.5	1.2	1.2
Bal	0	0	0
H2S	1	0	0
CO ppm	1	0	0
BAL			
H2S			
Baro mb	1033	1033	1033

Flow (1/hr)	-0.1
Ground Level (m.AOD)	3.53
Depth to water (BGL)	2.68
Water Level (m.AOD)	0.85
Depth to base (BGL)	-

BH04 - Cover = 0.61m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.8	0.6	0.7
O2 %	19.3	19.4	19.4
Bal	79.8	79.9	79.8
H2S	0	0	0
CO ppm	2	2	3
BAL			
H2S			
Baro mb	1034	1034	1034

Flow (1/hr)	-0.2
Ground Level (m.AOD)	3.44
Depth to water (BGL)	2.43
Water Level (m.AOD)	1.01
Depth to base (BGL)	-

BH06 - Cover = 0.48m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	10.6	10.5	10.5
O2 %	14.2	14	14.1
Bal	75.6	75.3	75.3
H2S	0	0	0
CO ppm	0	0	1
BAL			
H2S			
Baro mb	1034	1034	1034

Flow (1/hr)	-1
Ground Level (m.AOD)	3.02
Depth to water (BGL)	1.92
Water Level (m.AOD)	1.1
Depth to base (BGL)	-

BH08 - Cover = 0.44m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	1	1	1
O2 %	19.4	19.4	19.5
Bal	1034	1034	1034
H2S	0	0	0
CO ppm	2	2	0
BAL			
H2S ppm			
Baro mb	1034	1034	1034

Flow (1/hr)	-0.1
Ground Level (m.AOD)	3.27
Depth to water (BGL)	2.24
Water Level (m.AOD)	1.03
Depth to base (BGL)	-

Visit 12 — 11/09/2009

Trend from Solent MRSC Weather Station 1022

BH09 - Cover = 0.59m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	0.4	0.4	0.4
O2 %	19.8	19.9	19.9
Bal	79.8	79.7	79.6
H2S	0	0	0
CO ppm	0	0	0
BAL			
H2S			
Baro mb	1033	1033	1033

Flow (1/hr)	0.2
Ground Level (m.AOD)	3.31
Depth to water (BGL)	2.39
Water Level (m.AOD)	0.92
Depth to base (BGL)	-

BH10 - Cover = 0.52m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	4.1	4.1	4.1
O2 %	16.4	16.4	16.4
Bal	79.5	77.3	79.3
H2S	0	0	0
CO ppm	1	0	2
BAL			
H2S ppm			
Baro mb	1033	1033	1033

Flow (1/hr)	0.4
Ground Level (m.AOD)	3.54
Depth to water (BGL)	3.15
Water Level (m.AOD)	0.39
Depth to base (BGL)	-

BH11B - Cover = 0.27m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	9.1	9.1	9.1
O2 %	13.5	13.1	13.1
Bal	77	77.8	77.6
H2S	0	0	0
CO ppm	1	2	2
BAL			
H2S ppm			
Baro mb	1035	1035	1035

Flow (1/hr)	0.3
Ground Level (m.AOD)	3.41
Depth to water (BGL)	2.27
Water Level (m.AOD)	1.14
Depth to base (BGL)	-

BH12 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0.1	0.1	0.1
CO2 %	8.7	8.7	8.7
O2 %	7.2	6.9	6.8
Bal	83.9	84	
H2S	0	0	0
CO ppm	1	0	0
BAL			
H2S			
Baro mb	1035	1035	1035

Flow (1/hr)	0.1
Ground Level (m.AOD)	2.32
Depth to water (BGL)	1.77
Water Level (m.AOD)	0.55
Depth to base (BGL)	-

BH13 - Cover = 0.35m

	Time (Secs)		
	30	60	90
CH4 %	0	0	0
CO2 %	4	4.1	4.1
O2 %	13.2	12.7	12.7
Bal	82.7	83	83.1
H2S	0	0	0
CO ppm	0	4	1
BAL			
H2S			
Baro mb	1034	1034	1034

Flow (1/hr)	0
Ground Level (m.AOD)	2.7
Depth to water (BGL)	1.78
Water Level (m.AOD)	0.92
Depth to base (BGL)	-

Appendix D Leachate Testing Results & Screening

Scientific Analysis Laboratories is a
limited company registered in England and
Wales (No 2514788) whose address is at
Hadfield House, Hadfield Street, Manchester M16 9FE

Scientific Analysis Laboratories

Certificate of Analysis

Hadfield House
Hadfield Street
Cornbrook
Manchester
M16 9FE
Tel : 0161 874 2400
Fax : 0161 874 2468

Report Number: 160890-1

Date of Report: 20-Apr-2009

Customer: Mouchel Ltd
Severn House
Lime Kiln Close
Stoke Gifford
BRISTOL
BS34 8SQ

Customer Contact: Mr Joe Martin

Customer Job Reference: 721374
Customer Site Reference: Pagham Harbour
Date Job Recieved at SAL: 27-Mar-2009
Date Analysis Started: 03-Apr-2009
Date Analysis Completed: 20-Apr-2009

The results reported relate to samples received in the laboratory
Opinions and interpretations expressed herein are outside the scope of UKAS accreditation
This report should not be reproduced except in full without the written approval of the laboratory
Tests covered by this certificate were conducted in accordance with SAL SOPs

UKAS TESTING
1549

Report checked
and authorised by :
Amelia McVennon
Project Manager

Issued by :

Index to symbols used in this report

Value	Description
AR	As Received
-	Not Required
13	Results have been blank corrected.
W	Analysis was performed at another SAL laboratory
U	Analysis is UKAS accredited
N	Analysis is not accredited

Methods

Value	Description
T4	Colorimetry
T22	Titration
T11	IC
T281	ICP/MS (Filtered)
T7	Probe
T16	GC/MS
T8	GC/FID
T149	GC/MS (SIR)
T54	GC/MS (Headspace)

Accreditation Summary

Determinand	Method	Test Sample	LOD	Units	Symbol	SAL References
Cresols	T16	-	0.5	µg/l	U	001-002
Phenol	T149	-	0.5	µg/l	U	001-002
Xylenols	T16	-	0.5	µg/l	U	001-002
As (Dissolved)	T281	-	0.2	µg/l	U	001-002
Cd (Dissolved)	T281	-	0.02	µg/l	U	001-002
Cr (Dissolved)	T281	-	1.0	µg/l	U	001-002
Pb (Dissolved)	T281	-	0.3	µg/l	U	001-002
Ni (Dissolved)	T281	-	1.0	µg/l	U	001-002
Zn (Dissolved)	T281	-	2.0	µg/l	U	001-002
Chloride	T11	-	0.05	mg/l	WN	001-002
Nitrate	T11	-	0.05	mg/l	WN	001-002
Nitrite	T11	-	0.05	mg/l	WN	001-002
Phosphate	T11	-	0.05	mg/l	WN	001-002
Sulphate ion	T11	-	0.05	mg/l	WN	001-002
Ammonia expressed as NH4	T4	-	0.06	mg/l	U	001-002
Alkalinity expressed as CaCO3	T22	-	20.0	mg/l	U	001-002
Chemical Oxygen Demand	T22	-	20.0	mg/l	N	001-002
Biochemical Oxygen Demand	T7	-	3.0	mg/l	N	001-002
pH	T7	-			U	001-002
Electrical Conductivity	T7	-	1.0	µS/cm	U	001-002
TPH (C8-C10)	T8	-	0.1	mg/l	U	001-002
TPH (C10-C12)	T8	-	0.1	mg/l	U	001-002
TPH (C12-C16)	T8	-	0.1	mg/l	U	001-002
TPH (C16-C21)	T8	-	0.1	mg/l	U	001-002
TPH (C21-C35)	T8	-	0.1	mg/l	U	001-002
1,1,1,2-Tetrachloroethane	T54	-	1.0	µg/l	U	001-002
1,1,1-Trichloroethane	T54	-	1.0	µg/l	U	001-002
1,1,2,2-Tetrachloroethane	T54	-	1.0	µg/l	U	001-002
1,1,2-Trichloroethane	T54	-	1.0	µg/l	U	001-002
1,1,2-Trichloroethylene	T54	-	1.0	µg/l	U	001-002
1,1-Dichloroethane	T54	-	1.0	µg/l	U	001-002
1,1-Dichloroethylene	T54	-	1.0	µg/l	U	001-002
1,1-Dichloropropene	T54	-	1.0	µg/l	U	001-002
1,2,3-Trichloropropane	T54	-	1.0	µg/l	U	001-002
1,2,4-Trimethylbenzene	T54	-	1.0	µg/l	U	001-002
1,2-dibromoethane	T54	-	1.0	µg/l	U	001-002
1,2-Dichlorobenzene	T54	-	1.0	µg/l	U	001-002
1,2-Dichloroethane	T54	-	1.0	µg/l	U	001-002
1,2-Dichloropropane	T54	-	1.0	µg/l	U	001-002
1,3,5-Trimethylbenzene	T54	-	1.0	µg/l	U	001-002
1,3-Dichlorobenzene	T54	-	1.0	µg/l	U	001-002
1,3-Dichloropropane	T54	-	1.0	µg/l	U	001-002

Determinand	Method	Test Sample	LOD	Units	Symbol	SAL References
1,4-Dichlorobenzene	T54	-	1.0	µg/l	U	001-002
2,2-Dichloropropane	T54	-	1.0	µg/l	U	001-002
2-Chlorotoluene	T54	-	1.0	µg/l	U	001-002
4-Chlorotoluene	T54	-	1.0	µg/l	U	001-002
Benzene	T54	-	1.0	µg/l	U	001-002
Bromobenzene	T54	-	1.0	µg/l	U	001-002
Bromochloromethane	T54	-	1.0	µg/l	U	001-002
Bromodichloromethane	T54	-	1.0	µg/l	U	001-002
Bromoform	T54	-	1.0	µg/l	U	001-002
Bromomethane	T54	-	1.0	µg/l	U	001-002
Carbon tetrachloride	T54	-	1.0	µg/l	U	001-002
Chlorobenzene	T54	-	1.0	µg/l	U	001-002
Chlorodibromomethane	T54	-	1.0	µg/l	U	001-002
Chloroethane	T54	-	1.0	µg/l	U	001-002
Chloroform	T54	-	1.0	µg/l	U	001-002
Chloromethane	T54	-	1.0	µg/l	U	001-002
Cis-1,2-Dichloroethylene	T54	-	1.0	µg/l	U	001-002
Cis-1,3-Dichloropropene	T54	-	1.0	µg/l	U	001-002
Dibromomethane	T54	-	1.0	µg/l	U	001-002
Dichlorodifluoromethane	T54	-	1.0	µg/l	U	001-002
Dichloromethane	T54	-	50.0	µg/l	N	001-002
EthylBenzene	T54	-	1.0	µg/l	U	001-002
Isopropyl benzene	T54	-	1.0	µg/l	U	001-002
M/P Xylene	T54	-	1.0	µg/l	U	001-002
n-Propylbenzene	T54	-	1.0	µg/l	U	001-002
O Xylene	T54	-	1.0	µg/l	U	001-002
p-Isopropyltoluene	T54	-	1.0	µg/l	U	001-002
S-Butylbenzene	T54	-	1.0	µg/l	U	001-002
Styrene	T54	-	1.0	µg/l	U	001-002
T-Butylbenzene	T54	-	1.0	µg/l	U	001-002
Tetrachloroethylene	T54	-	1.0	µg/l	U	001-002
Toluene	T54	-	1.0	µg/l	U	001-002
Trans-1,2-Dichloroethene	T54	-	1.0	µg/l	U	001-002
Trans-1,3-Dichloropropene	T54	-	1.0	µg/l	U	001-002
Trichlorofluoromethane	T54	-	1.0	µg/l	U	001-002
Vinyl chloride	T54	-	1.0	µg/l	U	001-002

SAL Reference: 160890
Project Site: Pagham Harbour
Customer Reference: 721374

Water Analysed as Water
Suite A

				SAL Reference	160890 001	160890 002
				Customer Sample Reference	BH11 1.53m	BH13 0.74m
Determinand	**Method**	**Test Sample**	**LOD**	**Units**		
As (Dissolved)	T281	-	0.2	µg/l	**4.7**	**3.4**
Cd (Dissolved)	T281	-	0.02	µg/l	**0.03**	**0.66**
Cr (Dissolved)	T281	-	1	µg/l	**39**	**32**
Pb (Dissolved)	T281	-	0.3	µg/l	**3.4**	**0.6**
Ni (Dissolved)	T281	-	1	µg/l	**21**	**45**
Zn (Dissolved)	T281	-	2	µg/l	**97**	**310**
Chloride	T11	-	0.05	mg/l	**290**	**350**
Nitrate	T11	-	0.05	mg/l	**5.4**	<4.0
Nitrite	T11	-	0.05	mg/l	**6.0**	**7.4**
Phosphate	T11	-	0.05	mg/l	<0.50	<0.50
Sulphate ion	T11	-	0.05	mg/l	**72**	**32**
Ammonia expressed as NH4	T4	-	0.06	mg/l	**32**	**34**
Alkalinity expressed as CaCO3	T22	-	20	mg/l	**1100**	**920**
Chemical Oxygen Demand	T22	-	20	mg/l	**100**	**110**
Biochemical Oxygen Demand	T7	-	3	mg/l	**230**	**6**
pH	T7	-			**6.8**	**7.1**
Electrical Conductivity	T7	-	1	µS/cm	**2100**	**2500**

SAL Reference: 160890
Project Site: Pagham Harbour
Customer Reference: 721374

Water Analysed as Water
Total Petroleum Hydrocarbons Banded (C8-C10, C10-C12, C12-C16, C16-C21, C21-C35)

				SAL Reference	160890 001	160890 002
				Customer Sample Reference	BH11 1.53m	BH13 0.74m
Determinand	**Method**	**Test Sample**	**LOD**	**Units**		
TPH (C8-C10)	T8	-	0.1	mg/l	<0.1	<0.1
TPH (C10-C12)	T8	-	0.1	mg/l	<0.1	<0.1
TPH (C12-C16)	T8	-	0.1	mg/l	<0.1	<0.1
TPH (C16-C21)	T8	-	0.1	mg/l	<0.1	<0.1
TPH (C21-C35)	T8	-	0.1	mg/l	<0.1	<0.1

SAL Reference: 160890
Project Site: Pagham Harbour
Customer Reference: 721374

Water Analysed as Water
Phenol and Cresol

				SAL Reference	160890 001	160890 002
				Customer Sample Reference	BH11 1.53m	BH13 0.74m
Determinand	**Method**	**Test Sample**	**LOD**	**Units**		
Cresols	T16	-	0.5	µg/l	<0.5	<0.5
Phenol	T149	-	0.5	µg/l	<0.5	**0.5**
Xylenols	T16	-	0.5	µg/l	<0.5	<0.5

SAL Reference: 160890
Project Site: Pagham Harbour
Customer Reference: 721374

Water Analysed as Water
Volatile Organic Compounds (USEPA 624)

				SAL Reference	160890 001	160890 002
				Customer Sample Reference	BH11 1.53m	BH13 0.74m
Determinand	**Method**	**Test Sample**	**LOD**	**Units**		
1,1,1,2-Tetrachloroethane	T54	-	1	µg/l	<1	<1
1,1,1-Trichloroethane	T54	-	1	µg/l	<1	<1
1,1,2,2-Tetrachloroethane	T54	-	1	µg/l	<1	<1
1,1,2-Trichloroethane	T54	-	1	µg/l	<1	<1
1,1,2-Trichloroethylene	T54	-	1	µg/l	<1	<1
1,1-Dichloroethane	T54	-	1	µg/l	<1	<1
1,1-Dichloroethylene	T54	-	1	µg/l	<1	<1
1,1-Dichloropropene	T54	-	1	µg/l	<1	<1
1,2,3-Trichloropropane	T54	-	1	µg/l	<1	<1
1,2,4-Trimethylbenzene	T54	-	1	µg/l	<1	<1
1,2-dibromoethane	T54	-	1	µg/l	<1	<1
1,2-Dichlorobenzene	T54	-	1	µg/l	<1	<1
1,2-Dichloroethane	T54	-	1	µg/l	<1	<1
1,2-Dichloropropane	T54	-	1	µg/l	<1	<1
1,3,5-Trimethylbenzene	T54	-	1	µg/l	<1	<1
1,3-Dichlorobenzene	T54	-	1	µg/l	<1	<1
1,3-Dichloropropane	T54	-	1	µg/l	<1	<1
1,4-Dichlorobenzene	T54	-	1	µg/l	<1	<1
2,2-Dichloropropane	T54	-	1	µg/l	<1	<1
2-Chlorotoluene	T54	-	1	µg/l	<1	<1
4-Chlorotoluene	T54	-	1	µg/l	<1	<1
Benzene	T54	-	1	µg/l	(13) <1	(13) <1
Bromobenzene	T54	-	1	µg/l	<1	<1
Bromochloromethane	T54	-	1	µg/l	<1	<1
Bromodichloromethane	T54	-	1	µg/l	<1	<1
Bromoform	T54	-	1	µg/l	<1	<1
Bromomethane	T54	-	1	µg/l	<1	<1
Carbon tetrachloride	T54	-	1	µg/l	<1	<1
Chlorobenzene	T54	-	1	µg/l	<1	<1
Chlorodibromomethane	T54	-	1	µg/l	<1	<1
Chloroethane	T54	-	1	µg/l	<1	<1
Chloroform	T54	-	1	µg/l	<1	<1
Chloromethane	T54	-	1	µg/l	<1	<1
Cis-1,2-Dichloroethylene	T54	-	1	µg/l	<1	<1
Cis-1,3-Dichloropropene	T54	-	1	µg/l	<1	<1
Dibromomethane	T54	-	1	µg/l	<1	<1
Dichlorodifluoromethane	T54	-	1	µg/l	<1	<1
Dichloromethane	T54	-	50	µg/l	<50	<50
EthylBenzene	T54	-	1	µg/l	<1	<1
Isopropyl benzene	T54	-	1	µg/l	<1	<1
M/P Xylene	T54	-	1	µg/l	<1	<1
n-Propylbenzene	T54	-	1	µg/l	<1	<1
O Xylene	T54	-	1	µg/l	<1	<1
p-Isopropyltoluene	T54	-	1	µg/l	<1	<1
S-Butylbenzene	T54	-	1	µg/l	<1	<1
Styrene	T54	-	1	µg/l	<1	<1
T-Butylbenzene	T54	-	1	µg/l	<1	<1
Tetrachloroethylene	T54	-	1	µg/l	<1	<1
Toluene	T54	-	1	µg/l	<1	<1
Trans-1,2-Dichloroethene	T54	-	1	µg/l	<1	<1
Trans-1,3-Dichloropropene	T54	-	1	µg/l	<1	<1
Trichlorofluoromethane	T54	-	1	µg/l	<1	<1
Vinyl chloride	T54	-	1	µg/l	<1	<1

Report Number: 160890-1
Client Job Reference: 721374
Project Site: Pagham Harbour

Exceedances shown in yellow

							SAL Ref: 160890 001	160890 002
							Client Ref: BH11 1.53m	BH13 0.74m
							Type: -	-
Determinand	Method	Units	SV	SV Source	LOD	Symbol		
Ammonia expressed as NH4	Colorimetry	mg/l	1		0.06	U	32	34
Total Petroleum Hydrocarbons (C10-C12)	GC/FID	mg/l	-		0.1	U	<0.1	<0.1
Total Petroleum Hydrocarbons (C12-C16)	GC/FID	mg/l	-		0.1	U	<0.1	<0.1
Total Petroleum Hydrocarbons (C16-C21)	GC/FID	mg/l	-		0.1	U	<0.1	<0.1
Total Petroleum Hydrocarbons (C21-C35)	GC/FID	mg/l	-		0.1	U	<0.1	<0.1
Total Petroleum Hydrocarbons (C8-C10)	GC/FID	mg/l	-		0.1	U	<0.1	<0.1
Cresols	GC/MS	ug/l	-		0.5	U	<0.5	<0.5
Xylenols	GC/MS	ug/l	-		0.5	U	<0.5	<0.5
1,1,1,2-Tetrachloroethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,1,1-Trichloroethane	GC/MS (Headspace)	ug/l	0.1	EQS List II - Annual Ave	1	U	<1	<1
1,1,2,2-Tetrachloroethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,1,2-Trichloroethane	GC/MS (Headspace)	ug/l	0.3	EQS List II - Annual Ave	1	U	<1	<1
1,1,2-Trichloroethylene	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,1-Dichloroethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,1-Dichloroethylene	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,1-Dichloropropene	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,2,3-Trichloropropane	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,2,4-Trimethylbenzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,2-dibromoethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,2-Dichlorobenzene	GC/MS (Headspace)	ug/l	0.042	Interim-Canadian EQG-2	1	U	<1	<1
1,2-Dichloroethane	GC/MS (Headspace)	ug/l	0.01	EQS List I	1	U	<1	<1
1,2-Dichloropropane	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,3,5-Trimethylbenzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,3-Dichlorobenzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,3-Dichloropropane	GC/MS (Headspace)	ug/l			1	U	<1	<1
1,4-Dichlorobenzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
2,2-Dichloropropane	GC/MS (Headspace)	ug/l			1	U	<1	<1
2-Chlorotoluene	GC/MS (Headspace)	ug/l			1	U	<1	<1
4-Chlorotoluene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Benzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Bromobenzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Bromochloromethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
Bromodichloromethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
Bromoform	GC/MS (Headspace)	ug/l			1	U	<1	<1
Bromomethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
Carbon tetrachloride	GC/MS (Headspace)	ug/l			1	U	<1	<1
Chlorobenzene	GC/MS (Headspace)	ug/l	0.025	Interim-Canadian EQG-2	1	U	<1	<1
Chlorodibromomethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
Chloroethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
Chloroform	GC/MS (Headspace)	ug/l	0.012	EQS List I	1	U	<1	<1
Chloromethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
Cis-1,2-Dichloroethylene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Cis-1,3-Dichloropropene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Dibromomethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
Dichlorodifluoromethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
Dichloromethane	GC/MS (Headspace)	ug/l			50	N	<50	<50
EthylBenzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Isopropyl benzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Meta/Para-Xylene	GC/MS (Headspace)	ug/l			1	U	<1	<1
n-Propylbenzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Ortho-Xylene	GC/MS (Headspace)	ug/l			1	U	<1	<1
p-Isopropyltoluene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Sec-Butylbenzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Styrene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Tert-Butylbenzene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Tetrachloroethylene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Toluene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Trans-1,2-Dichloroethylene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Trans-1,3-Dichloropropene	GC/MS (Headspace)	ug/l			1	U	<1	<1
Trichlorofluoromethane	GC/MS (Headspace)	ug/l			1	U	<1	<1
Vinyl chloride monomer	GC/MS (Headspace)	ug/l			1	U	<1	<1
Phenol	GC/MS (SIR)	ug/l			0.5	U	<0.5	0.5
Chloride	IC	mg/l			0.05	N	290	350
Nitrate	IC	mg/l	50	EA	0.05	N	5.4	<4.0
Nitrite	IC	mg/l	0.5	UK DWS	0.05	N	6	7.4
Phosphate	IC	mg/l			0.05	N	<0.50	<0.50
Sulphate ion	IC	mg/l			0.05	N	72	32
Arsenic	ICP/MS (Filtered)	ug/l	25	EQS List II - Annual Ave	0.2	U	4.7	3.4
Cadmium	ICP/MS (Filtered)	ug/l	2.5	EQS List I	0.02	U	0.03	0.66
Chromium	ICP/MS (Filtered)	ug/l	15	EQS List II - Annual Ave	1	U	39	32
Lead	ICP/MS (Filtered)	ug/l	25	EQS List II - Annual Ave	0.3	U	3.4	0.6
Nickel	ICP/MS (Filtered)	ug/l	30	EQS List II - Annual Ave	1	U	21	45
Zinc	ICP/MS (Filtered)	ug/l	40	EQS List II - Annual Ave	2	U	97	310
Biochemical Oxygen Demand	Probe	mg/l			3	N	230	6
Electrical Conductivity	Probe	uS/cm			1	U	2100	2500
pH	Probe					U	6.8	7.1
Alkalinity expressed as Calcium Carbonate	Titration	mg/l			20	U	1100	920
Chemical Oxygen Demand	Titration	mg/l			20	N	100	110