# Seddon Construction

# Ground Investigation Report

**For**

## Land adjacent to Hope and Anchor Pub, Cellarhead, Stoke-on-Trent

**July 2013**

**REPORT NO: 13SEC001/GI**

- *Desk Studies and Site Walkovers*
- *Intrusive Contaminated Land Investigations*
- *Geotechnical Appraisals and Ground Investigations*
- *Landfill Gas Assessments and Remedial Design*
- *Remediation Design and Implementation*
- *Remediation Project Management and Supervision*
- *Site Abnormal Assessments (Foundations and Contaminated Land)*
- *Ecological Surveys (Bats, Badgers, Newts, Japanese Knotweed etc)*

**GEOTECHNICAL - CONTAMINATED LAND - ECOLOGY - FLOOD RISK**

BETTS ASSOCIATES
GEO ENVIRONMENTAL

## DOCUMENT ISSUE RECORD

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| Prepared by: | B Bryant |
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## REVISION RECORD

| Revision | Date | Description | Prepared by |
|---|---|---|---|
| 0 | July 2013 | Draft for comment with partial gas results | B Bryant |
| | | | |
| | | | |
| | | | |

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# 1 EXECUTIVE SUMMARY

**1. Site Location:**
The site is located east of Land adjacent to Hope and Anchor Pub, Cellarhead, Stoke-on-Trent, ST9 0JQ (coordinates for centre of site 395750, 347515).

**Site Description:**
**On Site**: The site is irregular in shape and is located to the rear (east) of the former Hope and Anchor Public House which is located on the junction of Cellarhead Road (A52) and Leek Road (A520). The site comprises the former car park and hardstanding areas immediately surrounding the former pub itself, the pub buildings are not within this proposed development area. It is understood that the pub buildings are to be renovated possibly into a residential dwelling; however no formal planning permission is currently available on the Staffordshire county council website. The area immediately east of the pub are 2 No walls and a concrete slab which may be indicative of a former building in this locality however this area is largely overgrown with various flagstones and other debris contained within. The remainder of the site is predominantly tarmac hardstanding and grassed open areas lined with hedgerows. The site level at its highest in the southeast corner of site and slopes gently to the roads to the north and west; the car park level is generally approximately 0.5m-1.0m above the road level, the hardstanding areas immediately east of the former pub building are at road levels.

**Surrounding Land** uses are as follows**:**
The surrounding land use is predominantly farmland, fields and residential in all directions.

**2. Proposed Development:**
The proposed development is construction of 28 units (6 flats and 28 No 2 or 3 bed houses) with associated roads, gardens, infrastructure, landscaping and a retention pond.

**Site History:**
**On Site**

- **1880-** Hope and Anchor pub shown immediately west of site, site is generally undeveloped with some pitting outbuildings associated with the pub to the north west of site
- **1925-** Possible earthworks/unlabelled pit shown towards the east of site- no longer shown from the map of 1970
- **1989-1990-** The subject site is shown as per the current site layout (car park and outside space associated with the pub)

**Surrounding Area**

- **1880-** Well 20m west (associated with pub)
- **1880-** Brick field shown 180m west of site- labelled as old brickworks from 1925 and the area is regenerated as a school circa 1991
- **1925-** Various earthworks shown 20m east, 10m south and 40m west of site
- **1970-** Buildings across Leek Road from the pub labelled as an abattoir on this map only
- **1970-** Garage shown 70m east of site- redeveloped into houses within the last 5 years

**3. Summary of Environmental Data:**
The exiting/former pub, outbuildings and car park on site provide a potential for localised heavy metals, TPH/PAH and asbestos risk within made ground. The unlabelled pit SE of the site and various other infilled pits within 250m of the site including brick pits, offer the potential for ground gas/contamination risk associated with the unknown nature of the material used to infill the pit.

**Published Geology:**
The BGS map shows the geology beneath the following:

- **Bedrock – Hawksmoor Formation-** Interbedded Sandstone and Conglomerate

**Hydrogeology and Hydrology:**

- The bedrock deposits of interbedded Sandstone and Conglomerate are classed as a Principal Aquifer (High Permeability).
- The site lies within a Groundwater Source Protection Zone 3 as defined by the Environment Agency.
- The site lies within a flood risk Zone 1, Extent of Extreme Flooding from Rivers or Seas without Defences as defined by the Environment Agency.
- The nearest surface water feature is a unnamed series of land drains/steams 141m northeast of site.
- There are no licensed groundwater/surface water abstractions within 500m of the site.

**4. Scope of Investigation**

- The fieldwork was carried out on the 22nd to 29th May 2013.
- Fifty (50 No) machine excavated trial pit holes.
- Six (6 No) window sampling small diameter boreholes.
- Six (6 No) small diameter gas and groundwater monitoring boreholes.
- Six (6 No) cable percussive boreholes.
- Chemical analysis of thirty (30No) samples.
- Geotechnical analysis of ten (10 No) samples.

**5. Ground Conditions Encountered:**

- TOPSOIL: With occasional fragments of gravel and cobbles of brick.
- MADE GROUND: A total of 6 types of made ground were encountered as follows;
    1. Tarmac and subbase.
    2. Topsoil with some gravel.
    3. Sand and gravel with occasional pot and brick.
    4. Gravel of brick and coal.
    5. Topsoil with occasional gravel of brick, coal and pockets of soft-firm clay.
    6. Relict Topsoil
- SAND – Loose-medium dense becoming medium dense oranginsh brown/reddish brown SAND.

**6. Contamination Encountered:**

Elevated levels of Benzo(a)pyrene above relavent guidance was encountered within the Made Ground of TP4 and in the Topsoil of TP5.
Chrysotile asbestos fibres were detected within the topsoil to the north of site.

**7. Remedial Actions:**

The levels of Benzo(a)pyrene were analysed and Double Ratio Plots have been undertaken on the samples, this confirms the elevated levels are of coal origin. Bap is insoluble and as such the risk to the underlying aquifer from this source is negligible. Given the depth of fill in the vicinity (to circa 1.90mbgl) removal of this source is not deemed viable; a soil cover system within proposed garden areas will provide sufficient mitigation of residual risk to human health.
Chrysotile asbestos fibres were detected within the topsoil to the north of site. By its nature, asbestos is not deemed a risk to the underlying aquifer, however there is a potential risk to site end users within garden areas. Given the depth of topsoil in this area (circa 0.50mbgl), removal of the topsoil within proposed garden areas should mitigate against any residual risk, however should be topsoil remain in place, a clean cover capping layer will be required. Based on the proposed site layout, this area is primarily driveways and pathways, should this area be hardstanding only, no additional remediation will be required should the material stay in situ, however if garden/landscaped areas are proposed, and the material is to stay in situ, then remediation will be required.

**8. Off-Site Disposal of Surplus Soil:**
It is recommended that the results of the contamination testing (including the history of the site) be presented to the proposed landfills, to obtain their acceptance of the information to date and to determine the actual WAC limits used by them, (see Appendix H for further guidance). Segregation of made ground and natural should be possible given the chemical analysis and very different visual identification. Site waste management plans will be required due to the size and cost of the proposed scheme.

**9. Specialist Ground Gas Measures:**
The site is surrounded by peat and therefore holes were targeted to see if there is any migration of ground gas within the site. On the basis of existing data the ground gas regime is anticipated as Green conditions. Gas monitoring is currently on going however therefore pricing for Amber 1 should be adopted until monitoring is completed.
BRE211 (2007) Radon:
Guidance on protective measures for new buildings that <1% of the properties are affected by Radon and therefore no radon protection measures are necessary.

**10. Foundations:**
Strip/trench foundations may be suitable upon the natural medium dense sand strata with an allowable bearing pressure of 125kN/m$^2$.
Localised deepening of cohesive founded foundations is likely to be required in the vicinity of existing trees, hedgerows and former ditches.

**Concrete Design:**
It is considered for concrete design purposes that brownfield site and static groundwater conditions are applicable and the results indicate a Design Sulphate Class of DS-1, ACEC class of AC-1s and Design Chemical Class of DC-1 as defined by BS8500-1:2006. This is subject to review upon import of fill to site.

**11. Ground Floor Construction**:
Suspended floor construction e.g. either in situ RC slabs or block and beam flooring is recommended as per NHBC guidance.

**12. Control of Groundwater:** No significant shallow groundwater was encountered during the fieldwork. Surface flooding and ponding was noted during the fieldwork and subsequent monitoring visits and is suspected to influence the monitored levels for the water within the boreholes. It is likely that provision of pumping/shuttering will be necessary during excavation of foundation trenches during wet weather, close to existing ditches and to deeper excavations for sewers etc. It is good practice to have such equipment on standby in case of seasonal / abnormal weather conditions.

# 2 SITE DESCRIPTION

## 2.1 Introduction

This investigation was carried out on the instruction of Seddon Construction. The purpose of the work was to carry out a ground investigation to provide geotechnical and contamination risk information for the proposed construction of 28 units (6 flats and 28 No 2 or 3 bed houses) with associated roads, gardens, infrastructure, landscaping and a retention pond.


*Hope and Anchor PH Proposed Site Plan @ 1:1500 Rev. B by John McCall Architects*

## 2.2 Site Location

The site is located east of Land adjacent to Hope and Anchor Pub, Cellarhead, Stoke-on-Trent, ST9 0JQ (coordinates for centre of site 395750,347515). The site area is approximately 0.61 hectares. See Site Location Plan in Appendix A.

## 2.3 Site Description

### 2.3.1 On Site

The site is irregular in shape and is located to the rear (east) of the former Hope and Anchor Public House which is located on the junction of Cellarhead Road (A52) and Leek Road (A520).

The site comprises the former car park and hardstanding areas immediately surrounding the former pub itself, the pub buildings are not within this proposed development area. It is understood that the pub buildings are to be renovated possibly into a residential dwelling; however no formal planning permission is currently available on the Staffordshire county council website.

The area immediately east of the pub are 2 No walls and a concrete slab which may be indicative of a former building in this locality however this area is largely overgrown with various flagstones and other debris contained within.

The remainder of the site is predominantly tarmac hardstanding and grassed open areas lined with hedgerows.

The site level at its highest in the southeast corner of site and slopes gently to the roads to the north and west; the car park level is generally approximately 0.5m-1.0m above the road level, the hardstanding areas immediately east of the former pub building are at road levels.

### 2.3.2 Surrounding Area

The surrounding land use is predominantly farmland, fields and residential in all directions.

# 3 ENVIRONMENTAL SETTING AND DATA

## 3.1 Summary of Site History

The following data is summarised using the Betts Geoenvironmental Desk Study (13SEC001/DS). The desk study should be referred to in full, however where relevant, summaries have been included for completeness.

### 3.1.1 On Site

Below is a summary of on-site changes;

| Date | Site |
|---|---|
| **1880** | Hope and Anchor pub shown immediately W, site is generally undeveloped with some pitting outbuildings associated with the pub to the NW |
| **1925** | Possible earthworks/unlabelled pit shown towards the E - no longer shown from the map of 1970 |
| **1989-1990** | The subject site is shown as per the current site layout (car park and outside space associated with the pub) |

### 3.1.2 Surrounding Area

The following table below shows the changes in historical use surrounding the site:

| Date | Site |
|---|---|
| **1880** | Well 20m W (associated with pub).<br>Brick field shown 180m W - labelled as Old Brickworks from 1925 and the area is regenerated as a school circa 1991. |
| **1925** | Various earthworks shown 20m E, 10m S and 40m W |
| **1970** | Buildings across Leek Road from the pub labelled as an abattoir on this map only<br>Garage shown 70m E - redeveloped into houses within the last 5 years. |

## 3.2 Geology

The documented geology of the site is summarised on British Geological Survey map principally and extracts of the BGS maps can be seen below:

| Geology | Drift | Solid |
|---|---|---|
| 1:50,000 - 123 Stoke-on-Trent (1994) | **None Recorded** | **Hawksmoor Formation-** Interbedded Sandstone and Conglomerate |

## 3.3 Mining, Extraction and Natural Cavities

There is one recorded mineral extractions or natural cavities within 500m of site, details are as follows

| Map ID | Details | Quadrant Reference (Compass Direction) | Estimated Distance From Site | Contact | NGR |
|---|---|---|---|---|---|
| 10 | **BGS Recorded Mineral Sites**<br>Site Name: Cellarhead Brick Works<br>Location: , Cellarhead, Stoke-On-Trent, Staffordshire<br>Source: British Geological Survey, National Geoscience Information Service<br>Reference: 63241<br>Type: Opencast<br>**Status: Ceased**<br>Operator: Unknown Operator<br>Operator Location: Unknown Operator<br>Periodic Type: Carboniferous<br>Geology: Pennine Lower Coal Measures Formation<br>Commodity: Common Clay and Shale<br>Positional Accuracy: Located by supplier to within 10m | A13NW (NW) | 253 | 3 | 395505 347683 |

### 3.3.1 Coal Mining

***Underground coal mining***
***Past-*** *According to the records in our possession, the property is not within the zone of likely physical influence on the surface from past underground workings.*
***Present-*** *The property is not in the likely zone of influence of any present underground coal workings.*
***Future-*** *The property is not in an area for which the Coal Authority is determining whether to grant a licence to remove coal using underground methods.*
*The property is not in an area for which a licence has been granted to remove or otherwise work coal using underground methods.*
*The property is not in an area that is likely to be affected at the surface from any planned future workings.*
*However, reserves of coal exist in the local area which could be worked at some time in the future.*
*No notice of the risk of the land being affected by subsidence has been given under section 46 of the Coal Mining Subsidence Act 1991.*
***Mine entries-****There are no known coal mine entries within, or within 20 metres of, the boundary of the property.*

## 3.4 Environmental Permits, Incidents and Registers

There is one Local Authority Pollution Prevention and Control licence <250m from the site as follows:

| Map ID | Details | Quadrant Reference (Compass Direction) | Estimated Distance From Site | Contact | NGR |
|---|---|---|---|---|---|
| 5 | **Local Authority Pollution Prevention and Controls**<br>Name: The Mount Garage<br>Location: Leek Road, Cellarhead, Werrington, Staffordshire, ST9 0DQ<br>Authority: Staffordshire Moorlands District Council, Environmental Health Department<br>Permit Reference: PPC/SS/1/008<br>Dated: Not Supplied<br>Process Type: Local Authority Pollution Prevention and Control<br>Description: PG1/14 Petrol filling station<br>**Status: Application Not Yet Authorised**<br>Positional Accuracy: Manually positioned to the address or location | A13SW (SW) | 238 | 2 | 395607 347257 |

There are no other significant Integrated Pollution Controls, Integrated Pollution Prevention and Control, or Pollution Incident to Controlled Waters or any other incidents within 250m of the site.

### 3.4.1 Discharge Consents

There is one Discharge Consent within 250m of the site as detailed below;

| Map ID | Details | Quadrant Reference (Compass Direction) | Estimated Distance From Site | Contact | NGR |
|---|---|---|---|---|---|
| 1 | **Discharge Consents**<br>Operator: T L Godbehere<br>Property Type: Not Given<br>Location: Gate House, Harvester Farm, Cellarhead, STOKE-ON-TRENT, Staffordshire<br>Authority: Environment Agency, Midlands Region<br>Catchment Area: Not Given<br>Reference: 3/28/06/1700/1<br>Permit Version: Not Supplied<br>Effective Date: Not Supplied<br>Issued Date: 14th July 1971<br>Revocation Date: Not Supplied<br>Discharge Type: Sewage Effluent<br>Discharge Environment: Groundwater<br>Receiving Water: Not Supplied<br>**Status: Not Supplied**<br>Positional Accuracy: Located by supplier to within 100m | A13NE (E) | 201 | 1 | 396000 347600 |

## 3.5 Landfill and Other Waste Sites

There are no current or historic registered landfills or other waste sites within 500m of the subject site

## 3.6 Contemporary Trade Directory Entries

A Contemporary Trade Directory entry states that there is an active dairy 10m east of site, however this appears to be a residential dwelling. It may be that this was a dairy until fairly recently, hence the records have not been updated.

## 3.7 Hydrogeology and Hydrology

- The bedrock deposits of interbedded Sandstone and Conglomerate are classed as a Principal Aquifer (High Permeability).
- The site lies within a Groundwater Source Protection Zone III as defined by the Environment Agency.
- The site lies within a Flood Risk Zone 1, Extent of Extreme Flooding from Rivers or Seas without Defences as defined by the Environment Agency. A standalone Flood Risk Assessment maybe required.
- The nearest surface water feature is a unnamed series of land drains/steams 141m northeast of site.
- There are no licensed groundwater/surface water abstractions within 500m of the site

## 3.8 Radon

The property is in a lower probability area, as less than 1% of homes are above the action level. Therefore no Radon protective measures are necessary in the construction of new dwellings or extensions.

# 4 SUMMARY OF ENVIRONMENTAL SENSITIVITY

The following section is a review of the environmentally sensitivity of the site as discussed in Sections 2-4. Significant potential risks are discussed in the following subsections and will then be evaluated as part of the Site Conceptual Model in Section 5.

Sources are defined as where pollution comes from, pathways are a route in which the pollution travels and receptors are anything affected by a pollutant. Further details on Source-Pathway-Receptor methodology can be found in Appendix G.

The table below focuses on significant site specific sources, pathways and receptors. More 'generic' pathways and receptors (such as site end uses) will be covered as part of the full Site Conceptual Model in Section 5.

## 4.1 Sources

| Source | Distance/ Direction | Details | Significant Risk |
|---|---|---|---|
| Existing/former land uses on site- pub outbuildings/car park | On site | Potential localised heavy metals, TPH/PAH and asbestos risk within made ground associated with the former land uses on site- intrusive ground investigation will be required to confirm | **Possible** |
| Existing/former land uses on site- Unlabelled pit | SE of site | Potential ground gas/contamination risk associated with the unknown nature of material used to infill this pit. | **Yes** |
| Former abattoir | 10m west | Potential ground gas risk associated with the former abattoir- given that the abattoir is situated lower than the subject site, the risk of contamination migration from this source is lowered | **Unlikely** |
| Former dairy | 10m east | Potential ground gas risk associated with the former dairy- given that the dairy is situated lower than the subject site, the risk of contamination migration from this source is lowered | **Unlikely** |
| Various infilled pits (including brick pits) | <250m from site | Potential ground gas/contamination risk associated with the unknown nature of material used to infill this pit. | **Possible** |

# 5 INITIAL CONCEPTUAL SITE MODEL

For details on how the conceptual model is evaluated please refer to Appendix G

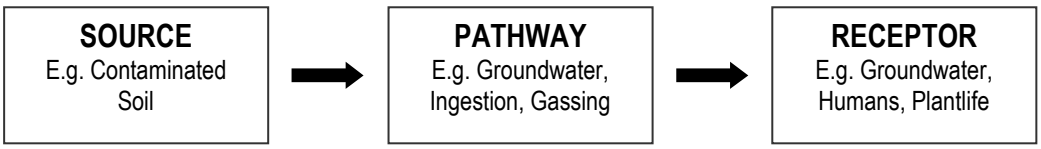
This section of the report aims to identify land which could potentially be affected by contamination, such that it could affect the value or re-use of the land, or such that mitigation would be required for certain proposed end uses of the land.

Potential contamination sources and environmentally sensitive receptors have been discussed in Section 4. Potentially significant risks are evaluated as part of the subsequent sub-sections.

## 5.1 Source-Pathway-Receptor Linkages

The risk assessment uses a 'Source-Pathway-Receptor' methodology for assessing whether a source of contamination could potentially lead to harmful consequences. This means that there needs to be a pollutant linkage from source to receptor for harm to be caused, this linkage consisting of: a source of pollution; a pathway for the pollutant to move along; a receptor that is affected by the pollutant.

The current potential risks to site arising from various source-pathway-receptor linkages are assessed below. A risk may be considered significant if all three of the stages are present and therefore providing a pollution linkage. The various sources, pathways and receptors are considered separately. The assessment is based on the future use, which is understood to be predominantly residential with garden areas and hard standing.



| Type of Contamination | Potential Sources | Potential Pathway | Potential Receptors | Pollution Linkage | Comment | Estimated Level of Risk |
|---|---|---|---|---|---|---|
| Ground Gas | Potential infilled ground on site and <250m from site<br><br>Potential made ground on site | Inhalation of Vapours | Construction/ Maintenance Workers | **Potentially Active** | Potential ground gas risk associated with made ground and infilled ground on site, gas monitoring should be undertaken | **Moderate** |
| | | Vapours Penetrating Unprotected Buildings | Future Site Users | **Potentially Active** | Potential ground gas risk associated with made ground on site, gas monitoring should be undertaken | **Moderate** |
| Surface and near surface Contaminants within soils | Potential infilled ground on site and <250m from site<br><br>Potential made ground on site | Ingestion, inhalation, dermal contact | Current site Users | **Potentially Active** | Site is predominantly hardstanding therefore risk to current site users is negligible. PPE to minimise risk. Risk lowered in areas of hard-standing. | **Low/ Moderate** |
| | | | Construction workers | **Potentially Active** | Localised potential for Made Ground within the site. Ground Investigation to confirm. PPE to minimise risk. Risk lowered in areas of hard-standing. | **Low** |
| | | Ingestion, inhalation, dermal contact | Future site users | **Potentially Active** | Possible localised Made Ground. Future site users at risk within proposed garden areas, SI required to confirm. | **Moderate** |
| | | | Adjacent land users | **Potentially Active** | Possible contamination from Made Ground, however the anticipated determinants are likely to be low mobility, ground investigation to confirm | **Low** |
| | | Direct contact | Structures | **Potentially Active** | Significant contamination is not anticipated on site; however ground investigation is required to confirm this. | **Low** |
| | | Absorption in root zone | Plants | **Potentially Active** | Possible contamination from Made Ground, ground investigation to confirm | **Low/ Moderate** |
| Mobile Contaminants, leachables e.g. from pollution sources adjacent to site/on site | Potential infilled ground on site and <250m from site<br><br>Potential made ground on site | Leaching into groundwater | Groundwater | **Potentially Active** | Potential risk due to the unknown nature of the material used to infill the pit on site and the underlying Principal Aquifer- ground investigation to confirm | **Low** |
| | | Off site migration in groundwater | Abstractions | **Potentially Active** | No current abstractions <500m from site therefore the risk level is low | **Low** |
| | | | Controlled waters | **Potentially Active** | Nearest controlled waters 150m from site therefore the risk level is low | **Low** |
| Organic and Inorganic contaminants within soils / groundwater | Potential infilled ground on site and <250m from site<br><br>Potential made ground on site | Potable water supply pipes | Utilities workers | **Potentially Active** | Possible contamination from Made Ground, ground investigation to confirm | **Low** |

## 5.2 Summary

In this qualitative risk assessment, a **Low-Moderate** risk implies that localised remedial action is likely to be necessary at the site, however an intrusive ground investigation is required to confirm this.

## 5.3 Geotechnical Constraints

- Localised deepening of proposed foundations due to existing/former foundations and former pit on site
- Potential for existing services.
- Site level varies across the whole area - cut and fill exercises are likely to be required depending on proposed site levels

# 6 FIELDWORK

## 6.1 Fieldwork Objectives

The objectives of the intrusive ground investigation will be to:

- Clarify the 'Initial Contamination Conceptual Model'.
- Clarify the Initial Risk Assessment.
- Benchmark the contamination status of the site.
- Provide data for the design of any remedial works that may be required.
- Provide geotechnical information to be used for the design and specification of foundations and substructure requirements.

## 6.2 Fieldwork Scope

The fieldwork was carried out on 10th June 2013 and comprised the following:

- Five (5 No) machine excavated trial pit holes.
- Four (4 No) window sampling small diameter boreholes installed with gas and groundwater monitoring wells.
- Five (5 No.) trial pits for infiltration testing.
- Chemical analysis of ten (10 No) samples.

The exploratory hole positions were selected and set out by Betts Geo Environmental Ltd (BGE) as shown on the Exploratory Hole Location Plan in Appendix B.
Prior to any intrusive works, each location was checked for services using a cable avoidance tool (CAT) and review of statutory service plans.

## 6.3 Targeted Investigation

A possible former unlabelled pit as seen on the historic maps was targeted to the southeast of site

## 6.4 Access Constraints

- 15m easement required for services within the road along the western site boundary.
- Several other services on site were identified with the GPRS survey, and exploratory holes moved where necessary.
- Japanese Knotweed exclusion zone to the northeast of site.

All service exclusion zones and easement details are shown within the Exploratory Hole Location plan within Appendix B of this report.

# 7 GROUND CONDITIONS

## 7.1 General

The exploratory holes were logged by an Engineer in general accordance with the recommendations of BS5930:1999+A2:2010 Detailed descriptions, together with relevant comments, are given in the exploratory hole logs included in Appendix C.

## 7.2 Ground Conditions Summary

| Strata | General Description | Thickness m | | No of Holes Located |
|---|---|---|---|---|
| | | Top | Base | |
| Grass over TOPSOIL | TOPSOIL with occasional coal fragments and gravel and cobbles of brick | 0.0 | 0.6 | WS1, WS2, TP5, SA3, SA4, SA5 |
| MADE GROUND (1) | Tarmac and subbase | 0.0 | 0.5 | WS4, TP1, TP2, TP3, SA1, SA2 |
| MADE GROUND (2) | Topsoil with some gravel | 0.0 | 0.3 | WS4, TP3, SA1- immediately below the sub base layer |
| MADE GROUND (3) | Sand and gravel with occasional pot and brick | 0.0 | 0.4 | WS3 only- sub layer for former flags in the vicinity |
| MADE GROUND (4) | Gravel of brick and coal | 0.2 | 0.4 | SA4 only |
| MADE GROUND (5) | Topsoil with occasional gravel of brick and coal and pockets of soft-firm clay | 0.0 | 1.9 | WS2, TP4, SA4 |
| MADE GROUND (6) | Relict Topsoil | 1.7 | 1.8 | WS2 only |
| SAND | Loose-medium dense becoming medium dense orangish brown/reddish brown SAND | 0.2 | 3.0+ | All |

## 7.3 Visual and Olfactory Contamination

There was no visual or olfactory contamination recorded within any of the trial pits or window samples boreholes with the exception of the made ground recorded.

## 7.4 Groundwater - Fieldwork

All exploratory holes were recorded as dry during the fieldwork with the exception of the following:

## 7.5 Groundwater – Post-Field Work Monitoring – ON GOING (1 visit)

The table below indicates groundwater encountered during the monitoring post fieldwork. It is suspected that some of the groundwater is from surface water runoff collecting within the cohesive clay stratum below within the monitoring station.

| Exploratory Hole | Depth (mbgl) | | Borehole Depth (mbgl) |
|---|---|---|---|
| | Min | Max | |
| WS1 | Dry | Dry | 1.64 |
| WS2 | Dry | Dry | 1.76 |

| | | | |
|---|---|---|---|
| WS3 | Dry | Dry | 1.68 |
| WS4 | Dry | Dry | 1.60 |

# 8 LABORATORY TESTING

## 8.1 General

An assessment of potential determinands associated with the former uses and previous investigations has been undertaken.

Determinands originating from the former site uses may include metals, polycyclic aromatic hydrocarbons and total petroleum hydrocarbons. No significant determinands associated with former or current *surrounding* land uses are anticipated. A general suite of testing should detect most potential contaminants.

## 8.2 Scheduled Chemical Testing: Soils

Soil was sent to a UKAS accredited laboratory, and were generally analysed in accordance with ISO 17025 and/or MCERTS accreditation. The results are summarised in tabular and/or graphical form in Appendix D.

| Chemical Test | No. of samples | Comment/Method |
|---|---|---|
| pH Values | 10 | Determination of pH (using Cyberscan pH meter). |
| Sulphate - Soluble 2:1 Extract | 10 | Dionex. |
| Arsenic, Cadmium, Chromium VI, Chromium III, Total Chromium, Lead, Mercury, Selenium, Copper, Nickel, Complex and Free Cyanide and Zinc. | 10 | Soil samples were analysed in accordance with UKAS/MCERTS standards<br>Inductively coupled plasma atomic emission spectroscopy (ICP-OES)<br>The results are tabulated in the Summary of Contamination Analysis.<br>The number of samples to be tested was specified by the engineer. |
| Speciated Polycyclic Aromatic Hydrocarbons (PAH), | 10 | Determination of Polycyclic Aromatic Hydrocarbons by GC-MS. End/end extraction using DCM on as received sample. In house method modified USEPA 8270. Include coronene if required. |
| TPH CWG | 10 | TPH CWG (Aliphatics C5-6,>6-8,>8-10,>10-12,>12-16,>16-21,>2-35) (aromatics >C5-7,>7-8,>8-10,>10-12,>12-16,>16-21,>21-35)<br>C5-8 fractions by Headspace GC-MS (003S). C8-35 fractions on as received sample extracted with hexane/acetone, aliphatic/aromatic splits run by GC-FID (005S), banded as listed above. |
| GRO/BTEX/MTBE by GC-FID (C5-10; C10-C12) | 10 | Determination of Gasoline Range Hydrocarbons (GRO) and BTEX (MTBE) compounds by Headspace GC-FID (C4-C12). |
| Organic Matter | 10 | Determination of Organic Matter by combustion. |
| Asbestos Screen | 8 | Visual Screening for Fibres |

# 9 CONTAMINATION ASSESSMENT

## 9.1 General

Contaminants of concern recorded at concentrations above relevant screening values are summarised below. For ease of description, the identification of contaminant sources and possible re-use of material, Made Ground, Natural Strata and Groundwater will be dealt with in separate sub-headings in this section of the report where required.

Our assessment is based on the following assumptions:

- The proposed site end use in of a high risk rating (residential housing with gardens). For analysis purposes, 'residential with home grown produce' is deemed most appropriate end use.
- It is deemed that some statistical analysis is appropriate. Where sample data numbers are low and/or targeted, each determinant result is however reviewed further as an individual result as opposed to an average across the site.
- Site history has indicated a **Low - Moderate** risk of contamination.
- Statistical analysis of the chemical test results has been undertaken in general accordance with Environment Agency 2009 SGV Guidance and LQM/CIEH GAC's using the combined assessment criterion given by CLEA (Note: all SSVs for EA derivation are for a SOM of 6%, in line with Environment Agency Report SC050021/SR4 – this figure is deemed representative as an average value for a sandy loam soil). LQM/CIEH 2009 GAC's are used to the nearest SOM percentage deemed appropriate.
- No free product was noted within the exploratory holes.
- Following the withdrawal of CLR 7-10 Guidance documents by the Environment Agency, statistical analysis has been undertaken in accordance with the CIEH/CL:AIRE 'Guidance on Comparing Soil Contamination Data with a Critical Concentration' (May 2008). As such, the use of the mean value test alone is not considered.

A full risk assessment is detailed within Section 10 of this report.

## 9.2 Topsoil

All determinants for TPH's, PAH's and Metals fall below the residential home grown produce guidance levels within the topsoil, however asbestos was detected within a sample of topsoil within TP5 only as follows:

| Determinant | Location | Depth (mbgl) | Asbestos type |
|---|---|---|---|
| Asbestos | TP5 | 0.50 | Chrysotile fibres |

This level is above the standard guidance levels and therefore additional risk assessment is required and will be dealt with in Section 10 of this report

## 9.3 Made Ground (1-4 and 6)

All determinants for TPH's, PAH's and Metals fall below the residential home grown produce guidance levels within the Made Grounds 1-4 and 6 as described within Section 7.2 of this report.

## 9.4 Made Ground (5 - Reworked Clay and Topsoil Fill)

An elevated level of Benzo(a)pyrene was encountered within the reworked clay/topsoil fill within TP5 only as follows

| Determinant | Location | Depth (mbgl) | Concentration (mg/kg) | SGV for 6% SOM (mg/kg) |
|---|---|---|---|---|
| Benzo(a)pyrene | TP4 | 0.5 | 3.19 | 0.83 |

This level is above the standard guidance levels and therefore additional risk assessment is required and will be dealt with in Section 10 of this report.

## 9.5 Natural Strata

All determinants for TPH's, PAH's and Metals fall below the residential home grown produce guidance levels within the natural strata.

## 9.6 Groundwater

No significant visual or olfactory contamination was identified within the fieldwork. No significantly elevated total soils levels were identified. No ground water testing has therefore been deemed necessary.

# 10 ENVIRONMENTAL RISK ASSESSMENT

## 10.1 General

This section assesses likely risks to the identified receptors, arising from potential contamination sources. It provides a final qualitative assessment of the risks involved, indicating whether (where appropriate) any immediate action is required to mitigate certain risks.

In assessing the risk qualitatively, it is appropriate to use the methods outlined in the CIRIA document C552, "Contaminated Land Risk Assessment a Guide to Good Practice". It uses a classification of risk based on the magnitude of the potential consequence or severity of risk occurring, compared with the magnitude of the probability or likelihood of the risk occurring. These are indicated on the attached tables in Appendix G.

## 10.2 Assessment of Contamination Analytical Results

There were no elevated levels that exceeded the guidance of 'Residential with Homegrown Produce' (ATrisk 2009); no additional risk assessment is required.

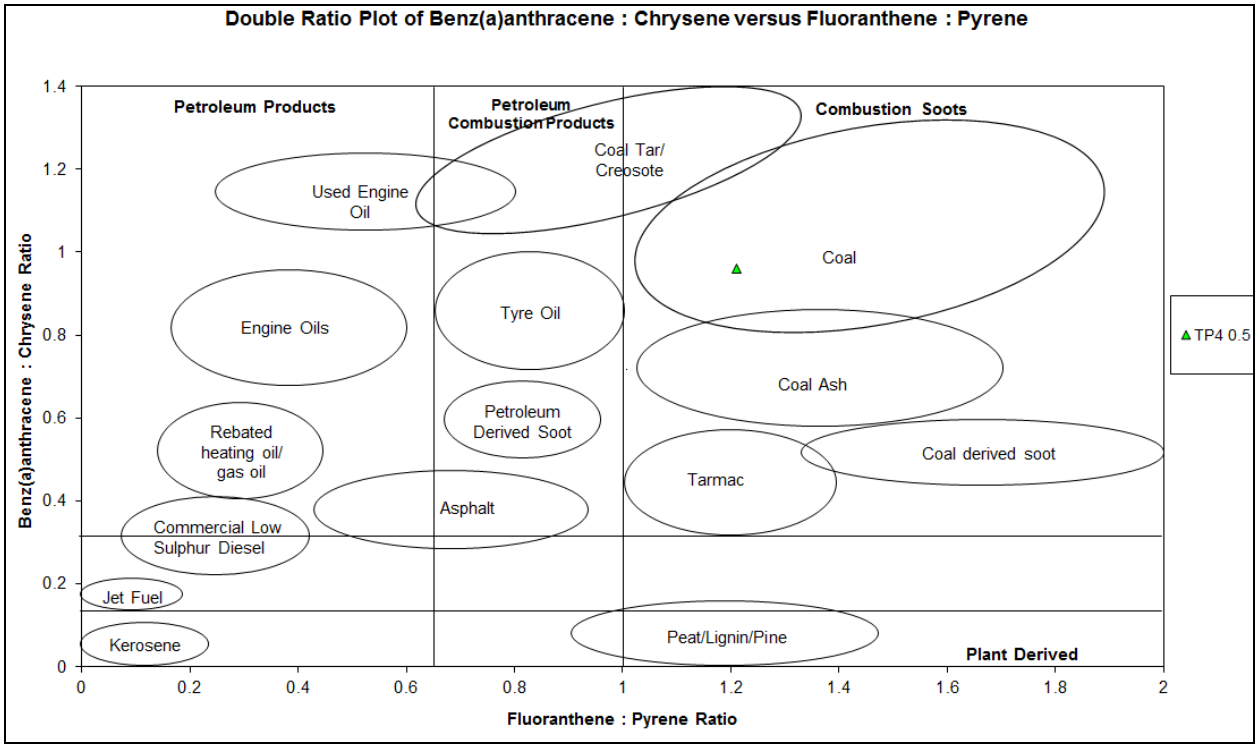
As discussed in Section 9, elevated levels of Benzo(a)pyrene above relevant guidance was encountered within the Made Ground at TP4 at 0.50m (within an area of made ground to the southeast of site) and chrysotile asbestos was encountered in TP5 within the topsoil at 0.5m. Therefore, consideration must be given to the site's environmental setting and the proposed end use.

The soils beneath the site are Hard-standing/Topsoil/Made Ground over sand with some gravel. The sands and gravels are classed as a Principal Aquifer (high permeability). There are no sensitive water courses on or adjacent to the site. The site is in a Zone III of the Groundwater Source Protection Zones as defined by the Environment Agency. There are no sensitive water abstractions within 500m of the site.

With respect to human health, the proposed end use (residential with gardens) is of high sensitivity. Transient risks to construction workers can be addressed by the adoption of appropriate health and safety measures.

### 10.2.1 Benzo(a)pyrene

Analysis of the statistics of the elevated levels of Benzo(a)pyrene showed that it is not a statistical outlier. Double Ratio Plots undertaken on the samples, confirm the elevated level is of coal origin the Double Ratio Plot is displayed below:




Bap is insoluble and as such the risk to the underlying aquifer from this source is negligible. Given the depth of fill in the vicinity (to circa 1.90mbgl) removal of this source is not deemed viable; a soil cover system within proposed garden areas will provide sufficient mitigation of residual risk to human health (full details within Section 12).

### 10.2.2 Chrysotile Asbestos Fibres

Chrysotile asbestos fibres were detected within the topsoil to the north of site. No asbestos sheeting or visual evidence of asbestos was recorded in the logs suggesting that the amount of asbestos is likely to be low; however quantitative testing should be undertaken to confirm this.

By its nature, asbestos is not deemed a risk to the underlying aquifer, however there is a potential risk to site end users within garden areas. Given the depth of topsoil in this area (circa 0.50mbgl), removal of the topsoil within proposed garden areas should mitigate against any residual risk, however should be topsoil remain in place, a clean cover capping layer will be required.

Based on the proposed site layout, this area is primarily driveways and pathways, should this area be hardstanding only, no additional remediation will be required should the material stay in situ, however if garden/landscaped areas are proposed, and the material is to stay in situ, then remediation will be required (full details within Section 12).

# 11 GROUND GAS ASSESSMENT- ONGOING (1 VISIT)

## 11.1 Ground Gas Requirements – Radon

BRE211 (2007) Radon: guidance on protective measures for new buildings that <1% of the properties are affected by Radon and therefore no radon protection measures are necessary.

## 11.2 Ground Gas Assessment

### 11.2.1 Summary of Results

The following summaries of ground gas results are preliminary, there have only been one visit (1 No) at the time of writing this report:

| Borehole Number | Methane (%) | Carbon Dioxide (%) | Oxygen (%) | Atmospheric Pressure (mB) | Flow (l/hr) | GSV $CH_4$ | GSV $CO^2$ | No. of Visits |
|---|---|---|---|---|---|---|---|---|
| WS1 | 0.2 | 1.0 | 19.7 | 1009 | 0.0 | 0.000 | 0.001 | 1 |
| WS2 | 0.2 | 0.7 | 19.8 | 1009 | 0.0 | 0.000 | 0.001 | 1 |
| WS3 | 0.2 | 0.3 | 19.9 | 1009 | 0.1 | 0.000 | 0.000 | 1 |
| WS4 | 0.2 | 0.2 | 20.4 | 1009 | 0.0 | 0.000 | 0.000 | 1 |

### 11.2.2 Guidance

Three recent publications are used for ground gas risk assessment:

- 'Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present', Report Edition No.04 March 2007 NHBC – designed for use with low rise residential properties
- CIRIA C665 'Assessing risks posed by hazardous ground gases for buildings' 2007 - for high rise residential / flats
- BS8485:2007 'Code of practice for the characterization and remediation from ground gas in affected developments'

Further details / accompanying notes for the following gas risk assessment are enclosed in Appendix G. The proposed development at the site is private residential two-storey houses, therefore assessments using the NHBC Guidance are deemed most appropriate.

### 11.2.3 Gas Recommendations - ONGOING

The site is surrounded by peat and holes were targeted to see if there is any migration of ground gas too within the site.

On the basis of existing data the following gas regime is anticipated.

| Site Area | Site Classification | Recommended Ground Gas Protection Measures |
|---|---|---|
| Whole Site | Green | No Specialist Ground Gas Protection Measures required. |

However, due to the limited current dataset for pricing purposes Amber 1 gas conditions should be adopted until proved otherwise via monitoring.

# 12 REVISED CONCEPTUAL SITE MODEL

## 12.1 General

The Initial Conceptual Site Model has been amended in light of data obtained during the ground investigation, most notably the absence of any contaminated soil in relation to the screening criteria for the proposed end use.

## 12.2 Final Conceptual Site Model

This section reassesses likely risks to the identified receptors, arising from potential contamination sources. It provides a final qualitative assessment of the risks involved, indicating whether (where appropriate) any immediate action is required to mitigate certain risks. It also discusses (where appropriate) what longer term measures or remedial works may be required in the future if the site were to be developed. It is considered that the site has not been assessed by the Local Authority as a contaminated site under the terms of the Environmental Protection Act 1990 Part IIa.

| Target (Receptor) | Potential Source-Pathway Linkage | Remedial Action Required (where appropriate) | Estimated Degree of Risk to Target Following Remedial Action Where Necessary |
|---|---|---|---|
| Site End Users | Inhalation of soil gases, odours or dust. | Clean cover requirements as per Section 13.3 | Low |
| Site End Users | Ingestion of, and skin contact with, contaminated soil. | Clean cover requirements as per Section 13.3 | Low |
| Site End Users | Ingestion of contaminants in vegetables etc. or in soils adhering to vegetables, etc | Clean cover requirements as per Section 13.3 | Low |
| Construction/ Maintenance Workers. | Inhalation of soil gases, odours or dust. | PPE | Low ** |
| Construction/ Maintenance Workers. | Ingestion of, and skin contact with, contaminated soil | PPE | Low ** |
| Plants | Adverse effects on growth caused by presence of contaminants in soil | Clean cover requirements as per Section 13.3 | Low |
| Buildings and Structures | Flow of ground gas into buildings. Asphyxiation, toxicity, explosion and fire hazards | Ground gas solution as per Section 11 | Low |
| Foundations | Sulphate attack of foundations | Foundations to be designed as per section 14.4 | Low |
| Water Supplies | Hydrocarbons penetrating plastic water supply pipes. | No remedial action anticipated- liaison required with supplier to confirm | Low |
| Groundwater | Migration of soluble contaminants into groundwater on or off site | No remedial action required | Low |
| Surface Water | Migration of soluble contaminants and/or direct run-off of contaminants | No remedial action required | Low |

** assumes basic PPE is used

# 13 OUTLINE STRATEGY FOR RISK REDUCTION/REMEDIATION STRATEGY

## 13.1 General

The following section details any recommendations and to reduce risk on site and recommended remedial actions (as per the previous sections of this report). For clarity, the section is split into sub-sections as per the conceptual site model (Section 12).

## 13.2 Construction/Maintenance Workers

Though no significant contamination was encountered on site, the following recommendations should be adhered to during site works:

- Site workers should wear gloves, boots and overalls and wash their hands before eating, drinking and smoking. Excessive dust generation should be avoided.
- It is recommended that during all excavations adequate ventilation should be maintained. If man entry is required, gas monitoring should be carried out as a precaution.
- If areas of suspected contamination are found then a suitably qualified person should undertake appropriate sampling, testing and further risk assessment.

## 13.3 Site-End Users

As per the findings of Section 11, clean cover should be applied to some plots impacted by contaminated soils on some areas of the site. The sketch below indicates the proposed remedial actions based on the proposed site layout which is discussed in further detail overleaf.

### 13.3.1 Area Affected by Chrysotile Asbestos

Given the depth of topsoil (0.50mbgl) it may be deemed viable that this topsoil material is removed from proposed garden areas to remove any residual risk to site end users. It is anticipated that site levels in this area are likely to drop, making it more likely that impacted soil is likely to be removed rather than remaining in situ.

It may be viable to place this Topsoil at a depth >600mm in proposed gardens and forming a no dig layer with a granular or geotextile membrane.

Based on the proposed site layout, this area is primarily driveways and pathways, should this area be hardstanding only, no additional remediation will be required should the material stay in situ. However if garden/landscaped areas are proposed, and the material is to stay in situ, then a clean cover system will be required.

Should a clean cover system be required in this area, this should comprise of 150mm topsoil above 450mm of subsoil. Soils should be chemically and physically assessed by a suitably qualified engineer either within a stockpile prior to placement or post placement to confirm suitability.

### 13.3.2 Area Affected by Benzo(a)pyrene

Given the depth of the made ground in this area (circa 1.90mbgl), removal of this source is not deemed viable.

Based on this proposed site layout the area TP4 lies beneath a proposed plot (low risk to site end users), and no elevated determinants were encountered within WS2 further north. An exclusion zone due to Japanese knotweed meant that further sampling where rear gardens were proposed was not possible at the time of the investigation.

It would be prudent to undertake additional sampling of the made ground in this area to assess the risk of Benzo(a)pyrene within garden areas; should the levels encountered be below standard guidance levels, a reduction or removal of the requirement for a clean cover system in this area may be applicable.

Should a clean cover system be required in this area, this should comprise of 150mm topsoil above 450mm of subsoil. Soils should be chemically and physically assessed by a suitably qualified engineer either within a stockpile prior to placement or post placement to confirm suitability.

### 13.3.3 Remaining Plots and General Notes

Following removal of hardstanding/sub base within garden areas, a minimum thickness of 300mm of debris-free soil (usually 150mm topsoil 150mm subsoil) within garden areas will be required as per NHBC guidance; this is likely to be made up using site-won topsoil and subsoil.

Site vigilance will need to be maintained during site works should any unforeseen evidence of contamination on site. Assistance should be sought from a suitable qualified engineer should any differences in strata/evidence of contamination be encountered.

Should imported soils will be required on site, testing for contamination will be required to ensure that they are suitable for the proposed use. It is generally advisable to test a minimum of three samples, or one sample per 150m$^3$ so that representative mean value can be calculated for greenfield sourced material. Should residential garden levels be exceeded with imported material further risk assessment and adoption of a cover system will be required.

### 13.4 Piped Drinking Water Supplies

The use of Protect-a-Line is not anticipated on site; further liaison with the water provider is required.

### 13.6 Off-Site Disposal of Surplus Soil

It is recommended that the results of the contamination testing (including the history of the site) be presented to the proposed landfills, to obtain their acceptance of the information to date and to determine the actual WAC limits used by them, (see Appendix H for further guidance).

Segregation of made ground and natural should be possible given the chemical analysis and very different visual identification.

Site waste management plans will be required due to the size and cost of the proposed scheme.

# 14 GEOTECHNICAL ASSESSMENT

## 14.1 Introduction

It is understood that the proposed development will consist of construction of residential properties with associated rear gardens, associated infrastructure, public open space and new highway.

## 14.2 Site Preparation and Excavation

All excavations should be planned and due consideration should be given to providing temporary support or suitable battering. Excavations should be regularly inspected by a competent person to ensure continued safety. Further advice on the safety of excavations is given *in Health and Safety in Construction.* Shallow (<1.2mbgl) excavations for service trenches should be straightforward.

## 14.3 Control of Groundwater

No significant shallow groundwater was encountered during the fieldwork. Surface flooding and ponding was noted during the fieldwork and subsequent monitoring visits and is suspected to influence the monitored levels for the water within the boreholes. It is likely that provision of pumping/shuttering will be necessary during excavation of foundation trenches during wet weather, close to existing ditches and to deeper excavations for sewers etc. It is good practice to have such equipment on standby in case of seasonal / abnormal weather conditions.

## 14.4 Foundations

### 14.4.1 Plots affected by made ground/infilled area

The sketch above shows the houses likely to be affected by deeper made ground/infilled area based on the exploratory holes undertaken by Betts. However the full extent of the fill area was not delineated completely, therefore this data is indicative.

Should the proposed levels be similar to the current site levels, a piled solution to the underlying sands may provide the most viable solution for these plots, if a piled solution is preferred, detailed design and liaison with a piling contractor should be undertaken.

It is likely, however, that site levels will be reduced in the proposed area, and if this is the case then a trench foundation solution may be the most viable. Trench foundations may be suitable upon the natural medium dense sand strata with an allowable bearing pressure of 125kN/m$^2$).

#### 14.4.2 Remaining plots

Strip/trench foundations may be suitable upon the natural medium dense sand strata with an allowable bearing pressure of 125kN/m$^2$.

Calculations on the allowable bearing capacity indicate settlements of less than 25mm for a square pad using the above allowable bearing capacity.

### 14.5 Ground Floor Construction

Suspended floor construction e.g. either in-situ RC slabs or block and beam flooring is recommended as per NHBC guidance.

### 14.6 Soakaways

Five No. soakaway tests were undertaken on the site during the fieldwork, full test results are located within Appendix C of this report. Infiltration rates of 1.2$^{x10-5m}$/sec to 3.3$^{x10-5}$m/sec were recorded indicating that soakways may be a suitable surface water drainage option subject to specialist design.

### 14.7 Highway

According to the criteria of Highways Agency HD 25/95 Volume 7 Section 2 Part 2 HD 25/94, a CBR value of >15% on the sand can be done, however confirming in-situ CBR's should be undertaken. Placement of geotextiles within the areas of roads / parking could also be designed to minimise the subgrade thickness.

### 14.8 Protection of Buried Concrete

It is considered for concrete design purposes that brownfield site and static groundwater conditions are applicable, the results are summarised below:

| Concrete Classification | |
|---|---|
| **Design Sulphate Class** | DS-1 |
| **ACEC Class** | AC-1s |
| **Design Chemical Class** | DC-1 |

# 15 REFERENCES

**15.1** *BS 5930:1999+A2 Code of Practice for Site Investigation.*

**15.2** *BS1377: 1990 Methods of Test for Soils for Civil Engineering Purposes.*

**15.3** Assessment of risks to human health from land contamination: an overview of the development of guideline values and related research. EA, 2002

**15.4** *Contaminated Land Risk Assessment; A Guide to Good Practice; CIRIA C552: 2001.*

**15.5** *Health and Safety in Construction, HSG150, HSE, 1996.*

**15.6** *Hazardous Waste: Interpretation of the Definition and Classification of Hazardous Waste, Environment Agency, WM2 Version 1.0, June 2003.*

**15.7** *DoE (1991), The Building Regulations Approved Document C, Site Preparation and Resistance to Moisture, HMSO*

**15.8** *Baker W (1987), Investigation Strategy - lecture at City of Birmingham Development Department Symposium on Methane Generating Sites, 9 December 1987, Industrial Research Laboratories, Birmingham*

**15.9** *NHBC Standards, Chapter 4.2, 2003 Building Near Trees*

**15.10** *Highways Agency HD 25/95 volume 7 section 2 Part 2 HD 25/94*

**15.11** *Water Regulations Advisory Scheme (2002) The selection of materials for water supply pipes to be laid in contaminated land*

**15.12** *Anon (1997) Dutch in Policy Retreat on Contaminated Land ENDS (Environmental Data Services), 269, 46*

**15.13** *Water Regulations Advisory Scheme (2002) The selection of materials for water supply pipes to be laid in contaminated land*

**15.14** *Piling In Layered Ground: Risks to Groundwater and Archaeology Science Report SC020074/SR Environment Agency October 2006*

**15.15** *Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention National Groundwater & Contaminated Land Centre report NC/99/73 F J Westcott, C M B Lean & M L Cunningham May 2001*

**15.16** *'Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present', Report Edition No.04 March 2007 NHBC – designed for use with low rise residential properties*

**15.17** *CIRIA C665 'Assessing risks posed by hazardous ground gases for buildings' 2007 - for high rise residential / flats*

**15.18** *BS8485:2007 'Code of practice for the characterization and remediation from ground gas in affected developments'*

**15.19** *BRE 414 'Protective measures for housing on gas-contaminated land' Roger Johnson, Parkman Environment 2001*

**15.20** *BS 8500- 1:2006 'Concrete – Complementary British Standard to BS EN 206-1 – Part 1: Method of specifying and guidance for the specifier' November 2006*

**15.21** *'Planning Policy 23:Planning and Pollution Control' Office of the Deputy Prime Minister 2004*

**15.22** *CLR11 'Model Procedures for the Management of Land Contamination' DEFRA 2004*

**15.23** *BRE 465 'Cover Systems for Land Regeneration' 2004*

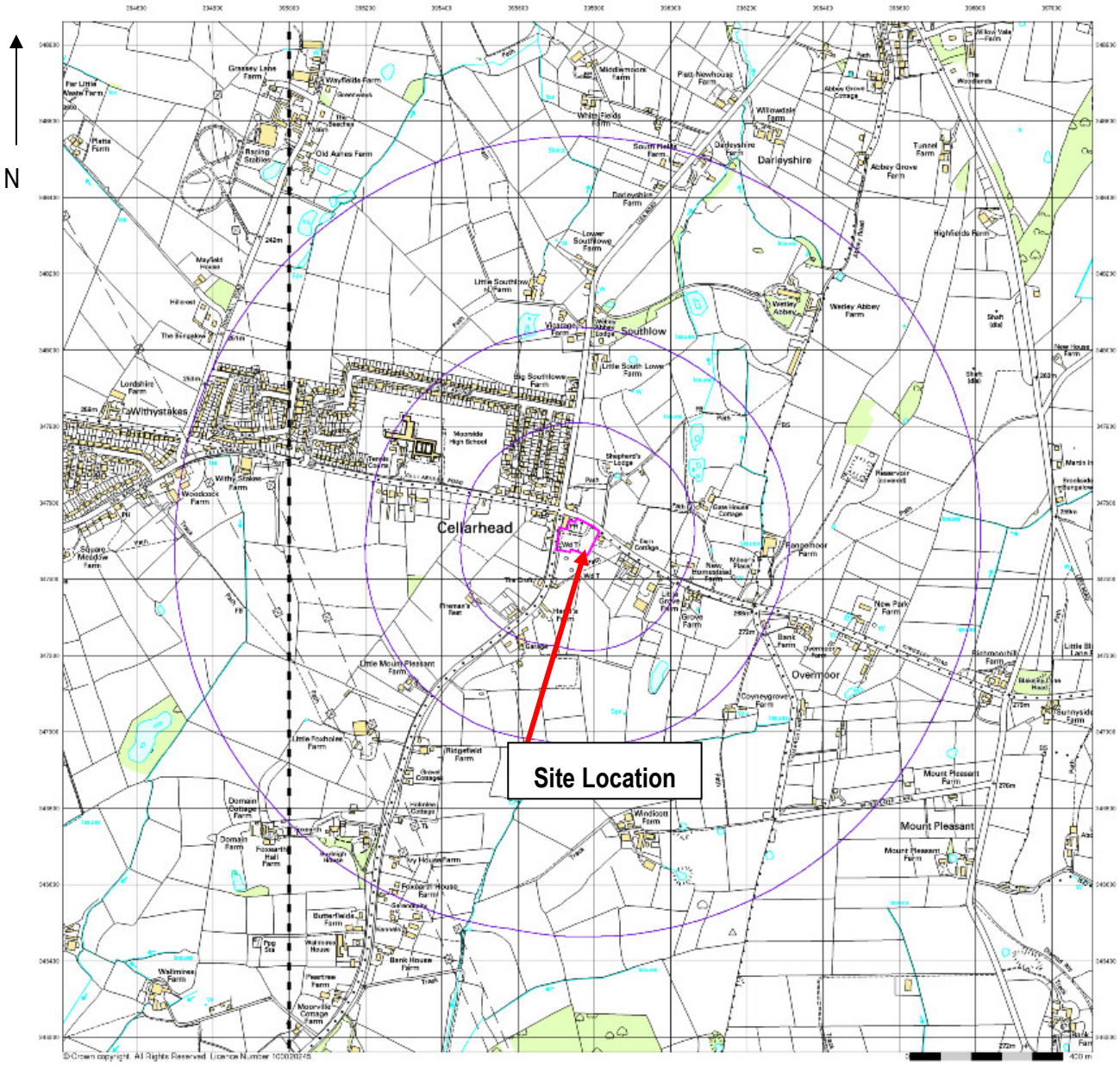
**15.24** *'The UK Approach for Evaluating the Human Health Risks from Petroleum Hydrocarbons in Soils, Environment Agency Science Report P5-080/TR3', Environment Agency (May 2005)*

**15.25** *TOX12- Contaminants in Soil: Collation of Toxicological Data and Intake Values for Humans. Dioxins, Furans and Dioxin-like PCBs' Environment Agency 2003*

**15.26** *The LQM/CIEH GAC for Human Health Risk Assessment 2009 second edition*

## APPENDIX A

(i) Site Location Plan




**Site Location Plan**
Land adjacent to Hope and Anchor Pub, Cellarhead, Stoke-on-Trent, ST9 0JQ (coordinates for centre of site 395750,347515).

## APPENDIX B

(i) Betts Exploratory Hole Location Plan


# DO NOT SCALE

NOTES

THIS DRAWING SHOWS THE INDICATIVE LOCATION OF EXPLORATORY HOLES UNDERTAKEN BY BETTS GEO-ENVIRONMENTAL LTD IN 2013 OVERLAYING THE EXISTING TOPOGRAPHICAL SURVEY.

KEY

AREA OF JAPANESE KNOTWEED

JAPANESE KNOTWEED EXCLUSION ZONE

EXISTING SERVICES 15m EXCLUSION ZONE

SA1 INDICATIVE LOCATION OF SOAKAWAY TEST

WS1 INDICATIVE LOCATION OF WINDOW SAMPLE

TP1 INDICATIVE LOCATION OF MACHINE EXCAVATED TRIAL PIT

| REV | DATE | BY | DESCRIPTION | CHK |
|---|---|---|---|---|

DRAWING STATUS: DRAFT

BETTS ASSOCIATES
CIVIL AND STRUCTURAL ENGINEERS
Unit 6, Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire CH5 2LY
Tel: 01244 288178 Fax: 01244 288516 enquiries@betts-associates.co.uk

SEDDON CONSTRUCTION

PROJECT: HOPE & ANCHOR CELLERHEAD

TITLE: EXPLORATORY HOLE LOCATION PLAN

| DATE: | SCALE @ SIZE: | DRAWN: | CHECKED: |
|---|---|---|---|
| 10/06/13 | 1:500 @ A3 | PH | |

| PROJECT No: | DRAWING No: | REV: |
|---|---|---|
| 13SEC001 | 001 | - |

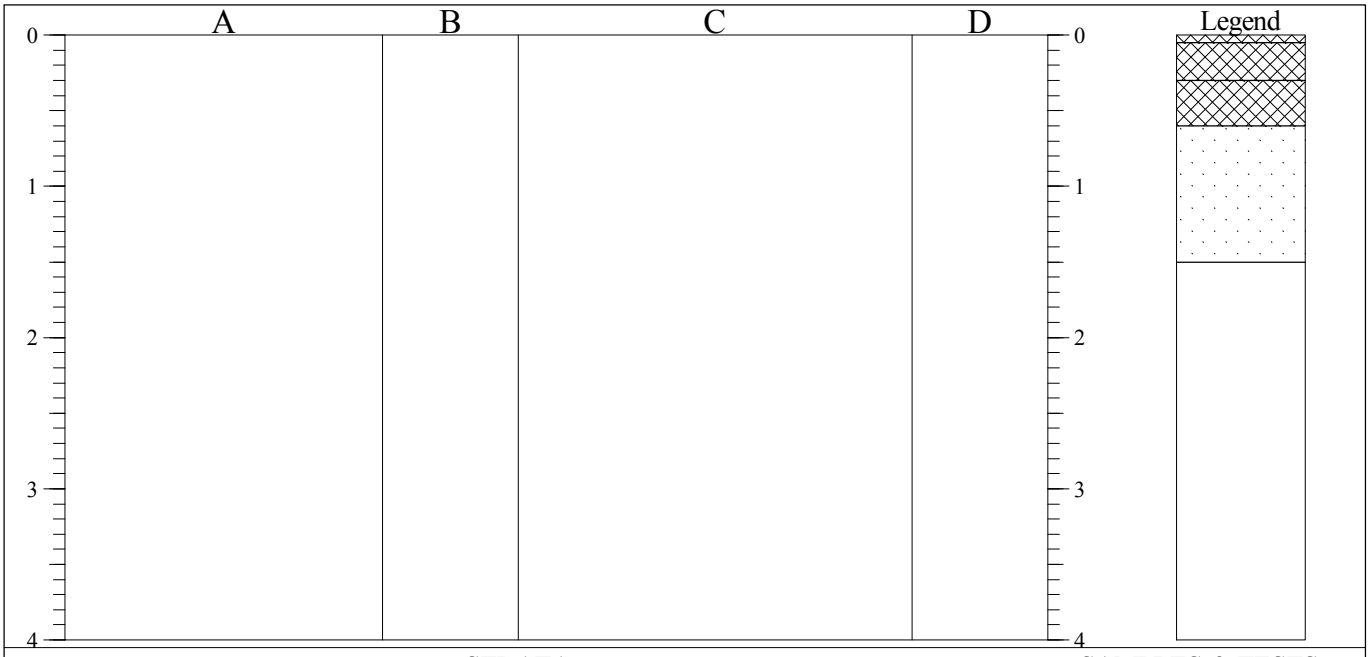
## APPENDIX C

(i) Betts Exploratory Hole Logs

Betts Geo Environmental
Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire
CH5 2LY
Telephone: 01244 398118
Fax: 01244 398119

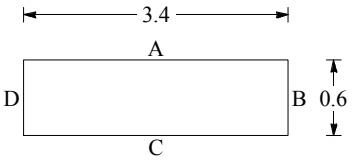
# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | SA1 |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |




| STRATA | | | SAMPLES & TESTS | | |
|---|---|---|---|---|---|
| Depth | No | DESCRIPTION | Depth | No | Remarks/Tests |
| 0.00-0.05 | | MADE GROUND: Tarmac. | | | |
| 0.05-0.30 | | MADE GROUND: Gravel sub-base. | | | |
| 0.30-0.60 | | MADE GROUND: Topsoil, sand and gravel. | | | |
| 0.60-1.50 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | | | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

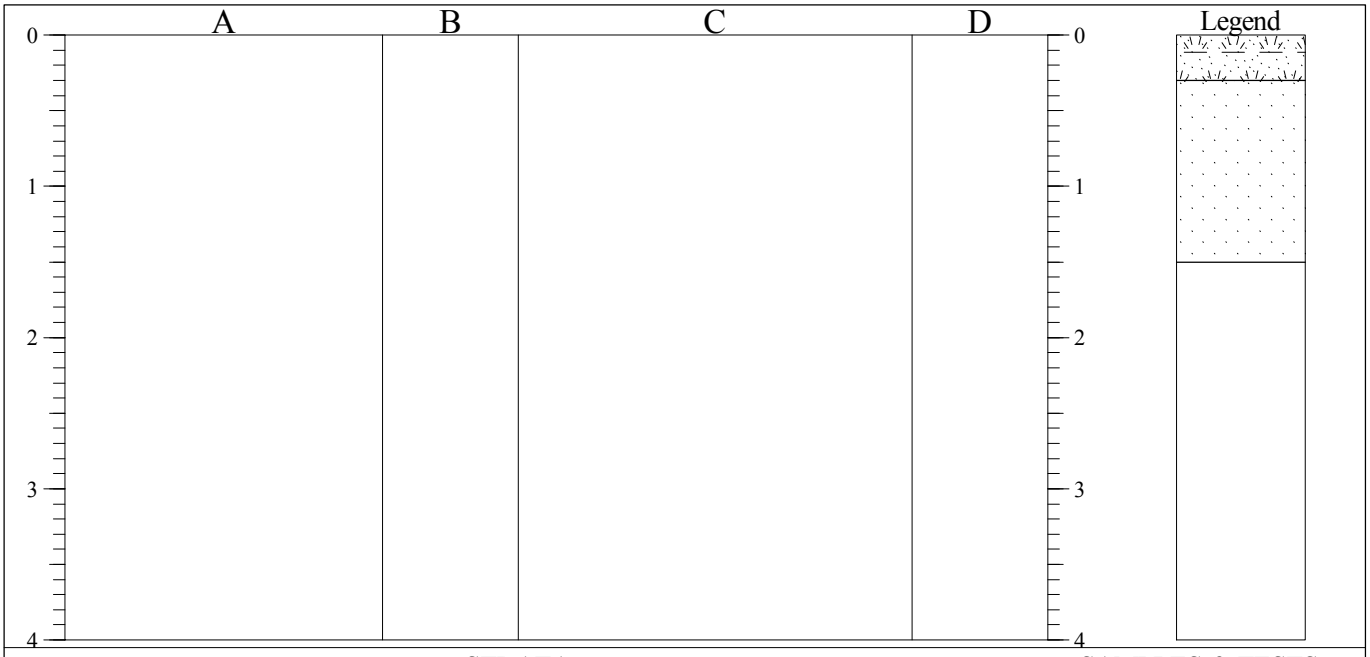
| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

AGS3 UK TP 13SEC001 - HOPE AND ANCHOR.GPJ GINT STD AGS 3_1.GDT 27/6/13

Betts Geo Environmental
Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire
CH5 2LY
Telephone: 01244 398118
Fax: 01244 398119

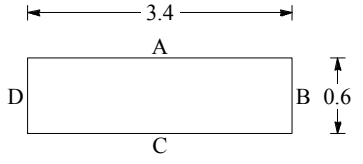
# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | SA2 |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |




| STRATA | | | SAMPLES & TESTS | | |
|---|---|---|---|---|---|
| Depth | No | DESCRIPTION | Depth | No | Remarks/Tests |
| 0.00-0.30 | | MADE GROUND: Tarmac over gravel sub-base. | | | |
| 0.30-1.50 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | | | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

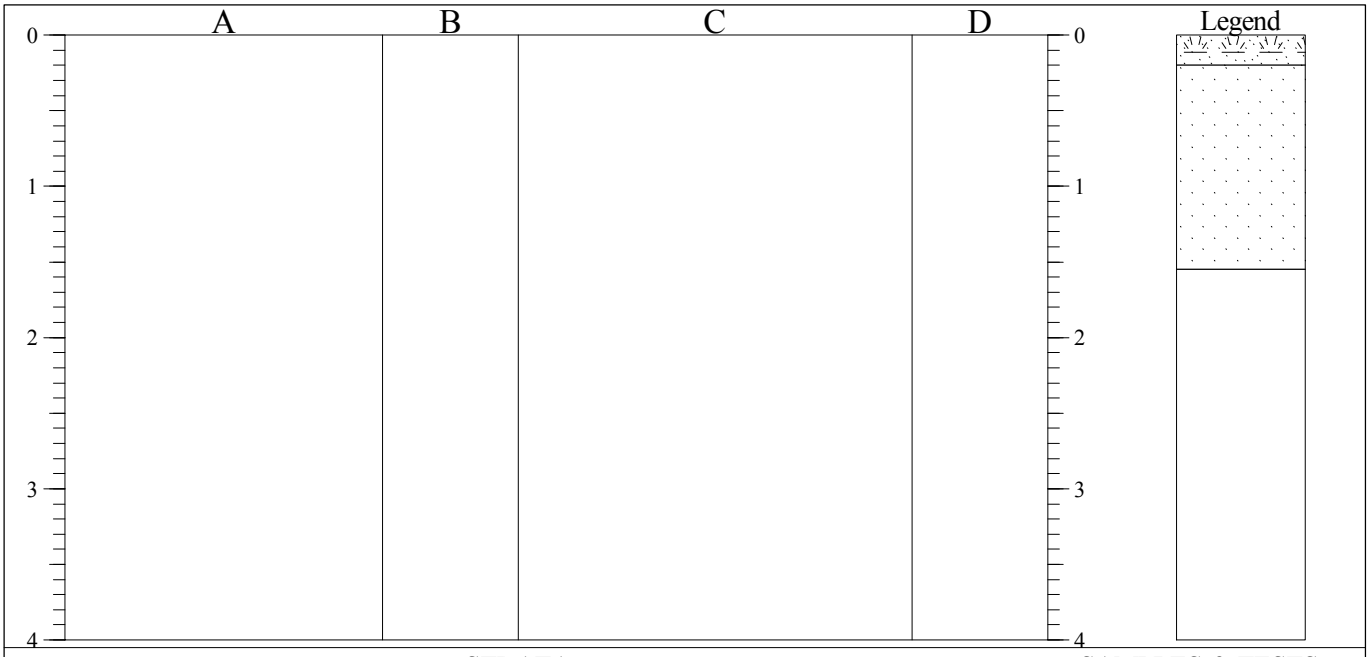
| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

AGS3 UK TP 13SEC001 - HOPE AND ANCHOR.GPJ GINT STD AGS 3_1.GDT 27/6/13

Betts Geo Environmental
Old Marsh Farm Barns, Welsh Road, Sealand, Flintshire
CH5 2LY
Telephone: 01244 398118
Fax: 01244 398119

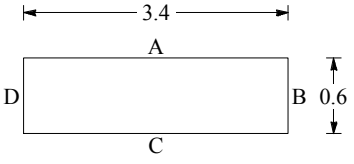
# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | SA3 |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |




| STRATA | | | SAMPLES & TESTS | | |
|---|---|---|---|---|---|
| Depth | No | DESCRIPTION | Depth | No | Remarks/Tests |
| 0.00-0.20 | | Grass over TOPSOIL. | | | |
| 0.20-1.55 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | | | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

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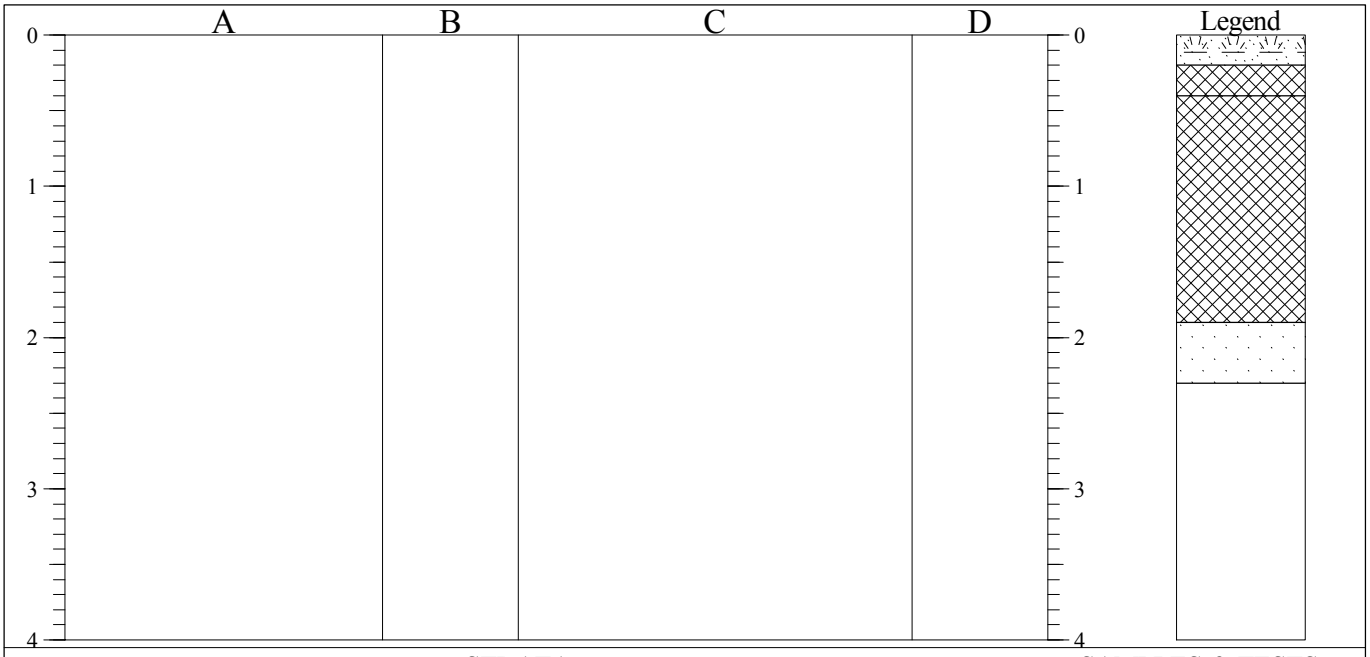
Fax: 01244 398119

# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | SA4 |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |

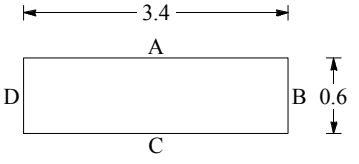



STRATA

SAMPLES & TESTS

| Depth | No | DESCRIPTION | Depth | No | Remarks/Tests |
|---|---|---|---|---|---|
| 0.00-0.20 | | Grass over TOPSOIL. | | | |
| 0.20-0.40 | | MADE GROUND: Brick and coal. | | | |
| 0.40-1.90 | | MADE GROUND: Firm clayey TOPSOIL: Occasional gravel of coal and brick. Pockets of clay and brick. (Reworked). | | | |
| 1.90-2.30 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | | | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

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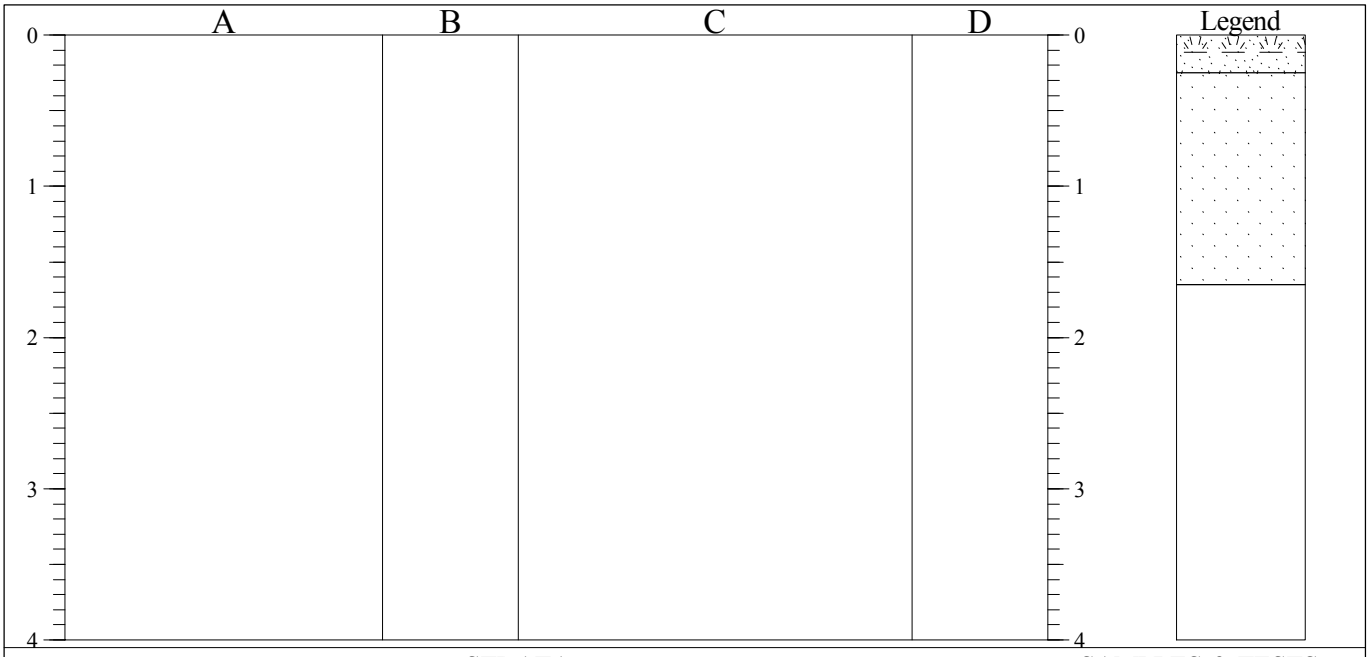
# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | SA5 |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |



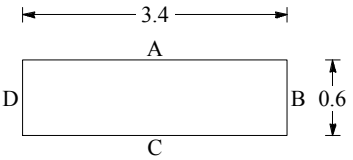

STRATA

| Depth | No | DESCRIPTION |
|---|---|---|
| 0.00-0.25 | | Grass over TOPSOIL. |
| 0.25-1.65 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. |

SAMPLES & TESTS

| Depth | No | Remarks/Tests |
|---|---|---|
| | | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

AGS3 UK TP 13SEC001 - HOPE AND ANCHOR.GPJ GINT STD AGS 3_1.GDT 27/6/13

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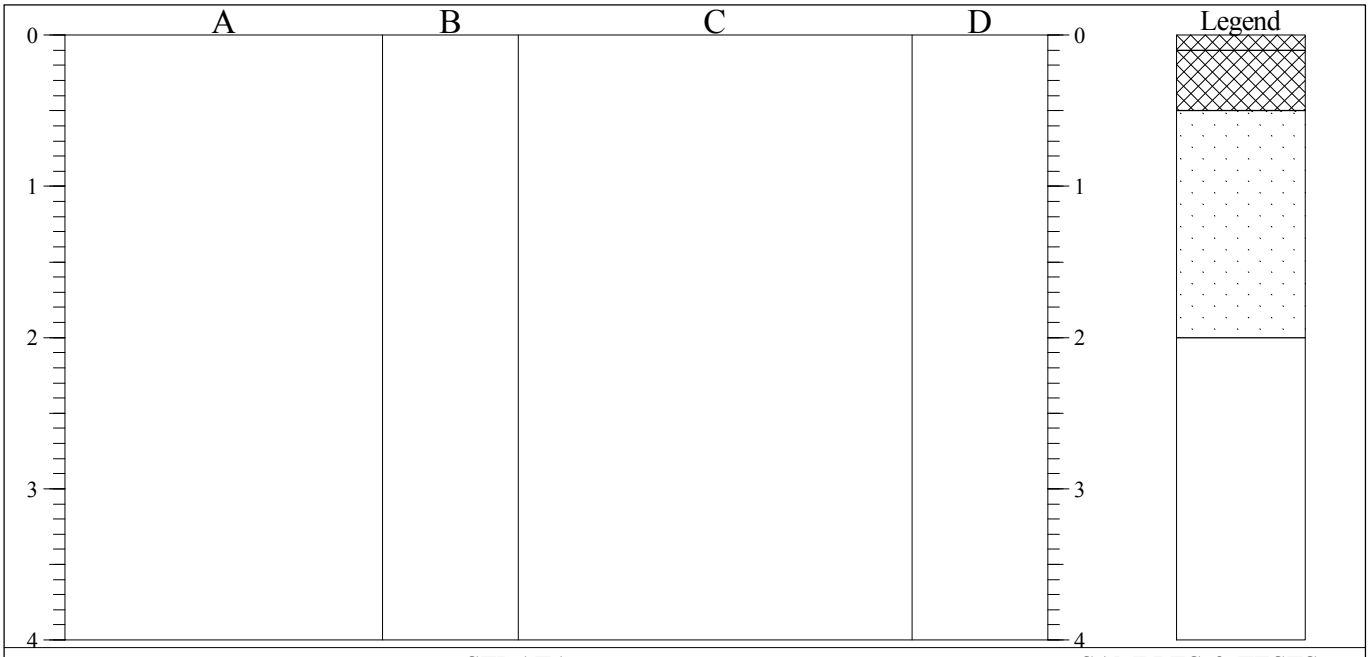
Fax: 01244 398119

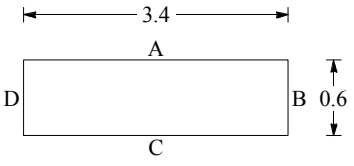
# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | **TP1** |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |




| STRATA | | | SAMPLES & TESTS | | |
|---|---|---|---|---|---|
| Depth | No | DESCRIPTION | Depth | No | Remarks/Tests |
| 0.00-0.10 | | MADE GROUND: Tarmac. | | | |
| 0.10-0.50 | | MADE GROUND: Gravel sub-base. | | | |
| 0.50-2.00 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | 0.70 | ES | |
| | | 1.40 Becomes medium dense. | | | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

AGS3 UK TP 13SEC001 - HOPE AND ANCHOR.GPJ GINT STD AGS 3_1.GDT 27/6/13

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CH5 2LY
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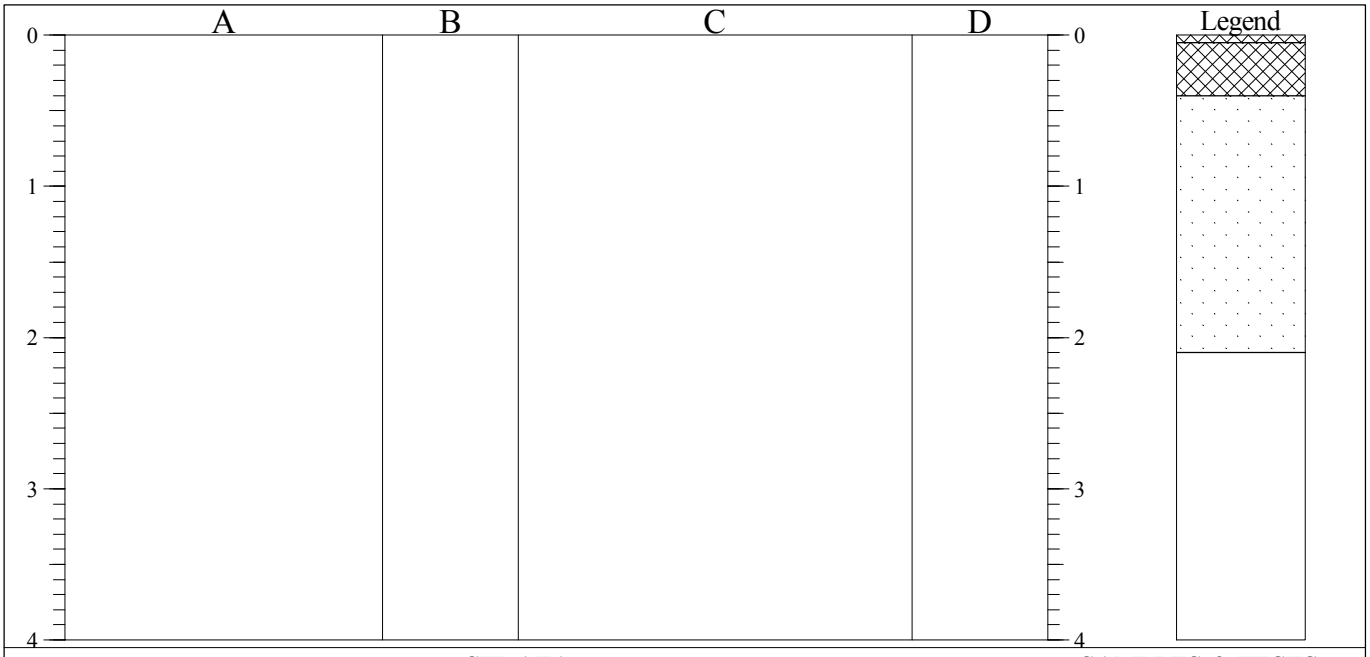
Fax: 01244 398119

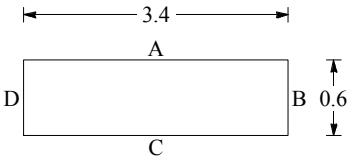
# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | **TP2** |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |




| STRATA | | | SAMPLES & TESTS | | |
|---|---|---|---|---|---|
| Depth | No | DESCRIPTION | Depth | No | Remarks/Tests |
| 0.00-0.05 | | MADE GROUND: Tarmac. | | | |
| 0.05-0.40 | | MADE GROUND: Gravel sub-base. | | | |
| 0.40-2.10 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | | | |
| | | | 0.70 | ES | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

AGS3 UK TP 13SEC001 - HOPE AND ANCHOR.GPJ GINT STD AGS 3_1.GDT 27/6/13

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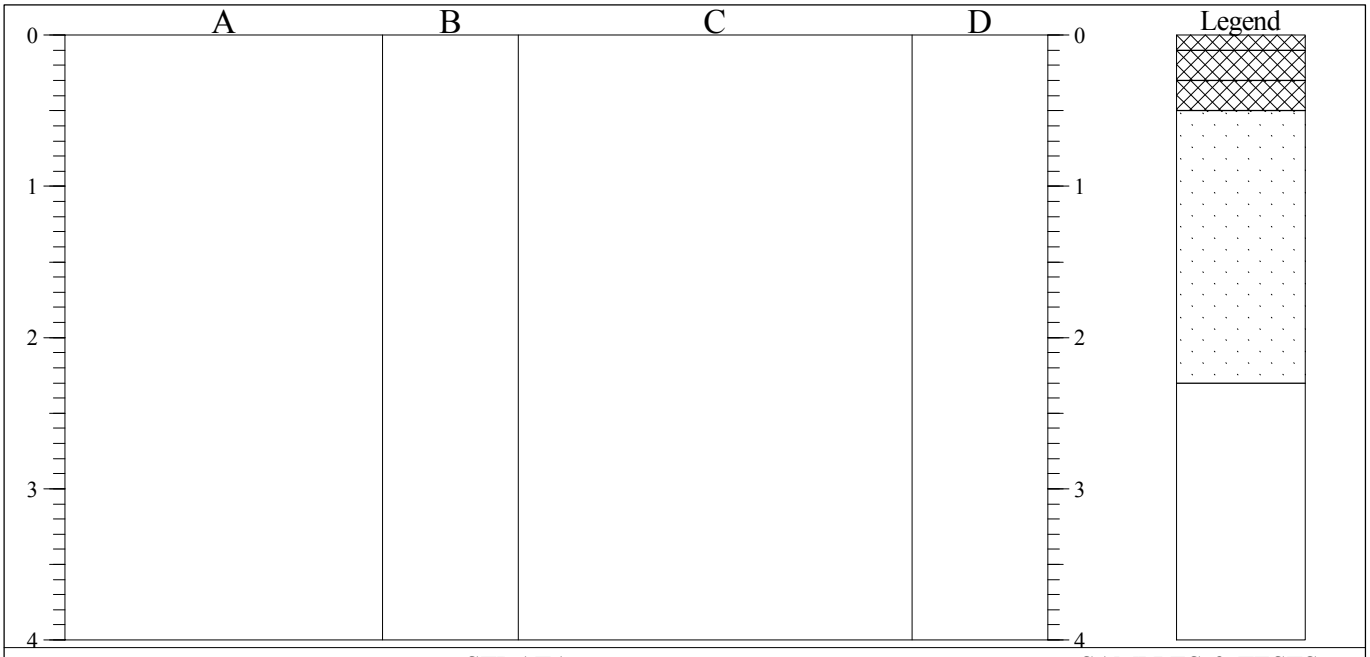
CH5 2LY
Telephone: 01244 398118
Fax: 01244 398119

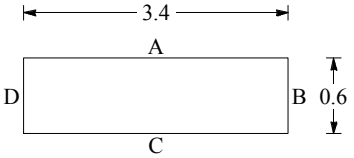
# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | **TP3** |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |




| STRATA | | | SAMPLES & TESTS | | |
|---|---|---|---|---|---|
| Depth | No | DESCRIPTION | Depth | No | Remarks/Tests |
| 0.00-0.10 | | MADE GROUND: Tarmac. | | | |
| 0.10-0.30 | | MADE GROUND: Gravel sub-base. | | | |
| 0.30-0.50 | | MADE GROUND: Topsoil and gravel. | 0.40 | ES | |
| 0.50-2.30 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | 1.00 | ES | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

AGS3 UK TP 13SEC001 - HOPE AND ANCHOR.GPJ GINT STD AGS 3_1.GDT 27/6/13

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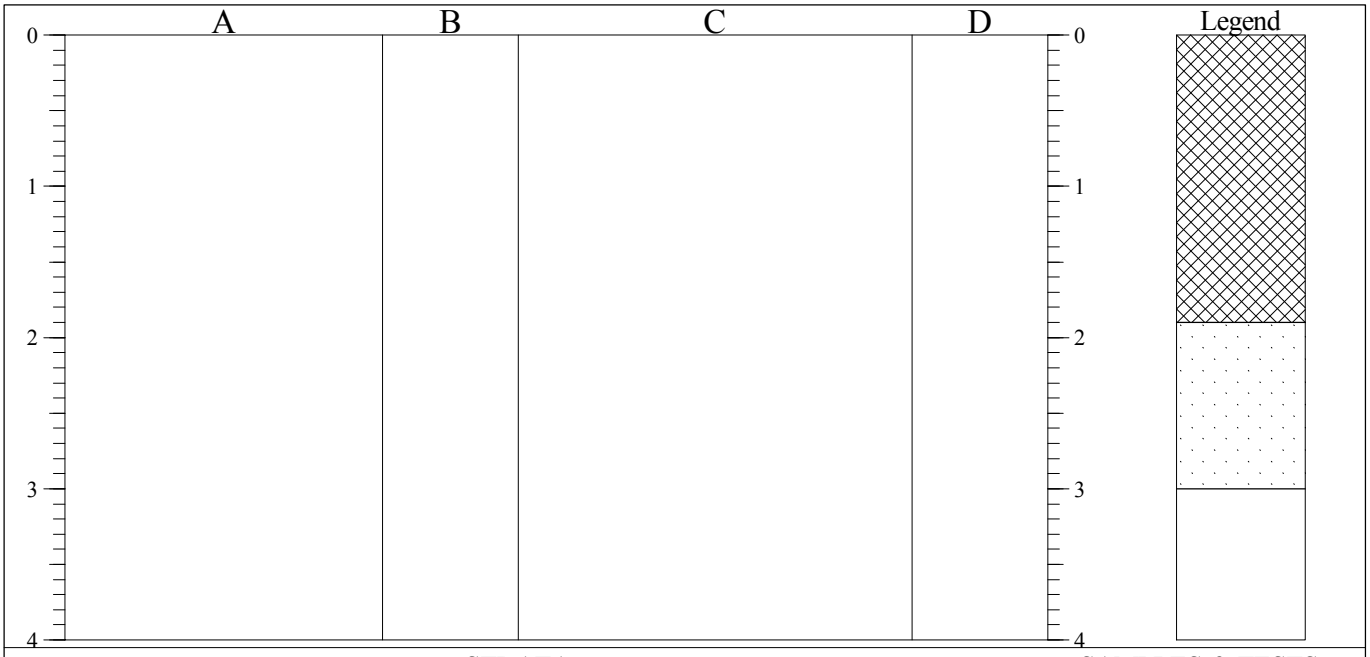
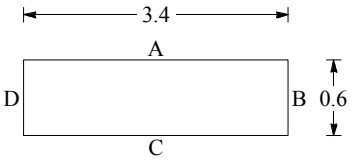
# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | **TP4** |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |




| STRATA | | | SAMPLES & TESTS | | |
|---|---|---|---|---|---|
| Depth | No | DESCRIPTION | Depth | No | Remarks/Tests |
| 0.00-1.90 | | MADE GROUND: Fill comprising topsoil, sand, gravel, bricks, pot and occasional pockets of clay. | 0.50 | ES | |
| 1.90-3.00 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | 3.00 | ES | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

AGS3 UK TP 13SEC001 - HOPE AND ANCHOR.GPJ GINT STD AGS 3_1.GDT 27/6/13

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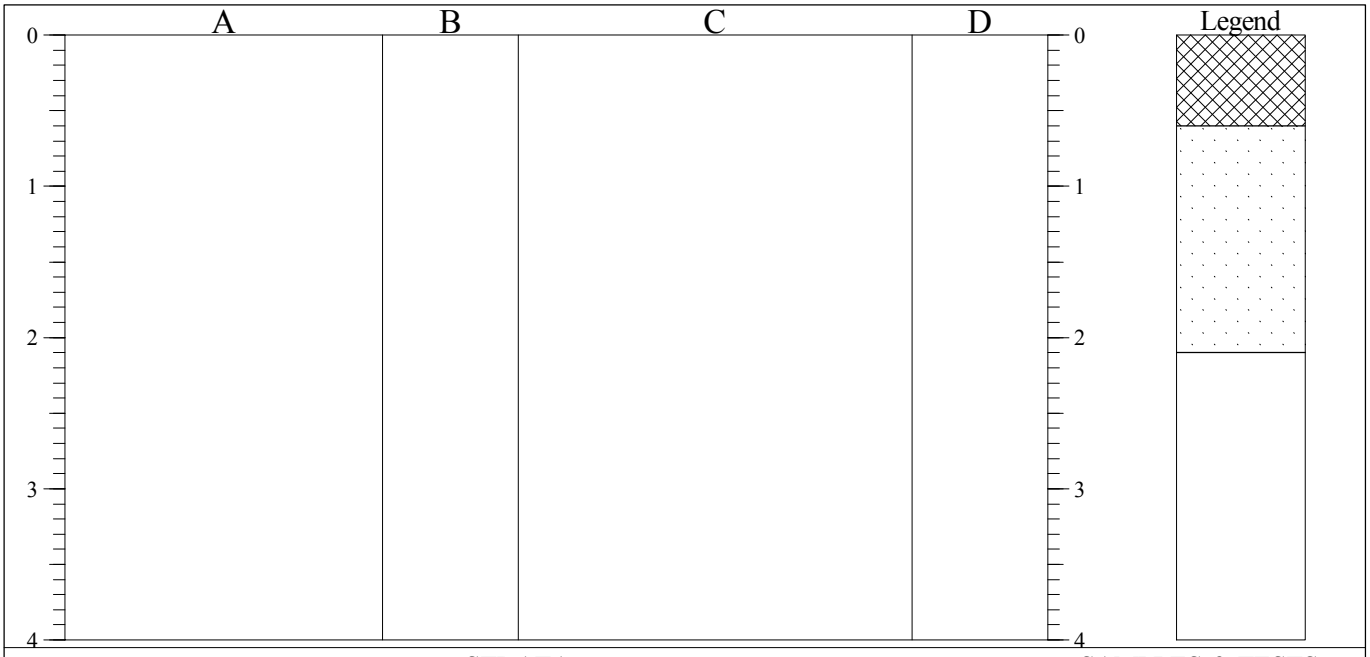
CH5 2LY
Telephone: 01244 398118
Fax: 01244 398119

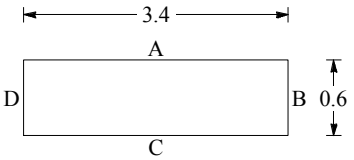
# TRIAL PIT LOG

| Project | | | | TRIAL PIT No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | **TP5** |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |




| STRATA | | | SAMPLES & TESTS | | |
|---|---|---|---|---|---|
| Depth | No | DESCRIPTION | Depth | No | Remarks/Tests |
| 0.00-0.60 | | Grass over TOPSOIL: Occasional gravel. | | | |
| 0.60-2.10 | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | 0.50 | ES | |

Shoring/Support:
Stability: Stable.





GENERAL REMARKS

Dry.

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used JCB 3CX | Logged By BB |
|---|---|---|---|

AGS3 UK TP 13SEC001 - HOPE AND ANCHOR.GPJ GINT STD AGS 3_1.GDT 27/6/13

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CH5 2LY
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Fax: 01244 398119

# BOREHOLE LOG

| Project | | | | BOREHOLE No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | WS1 |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |

| SAMPLES & TESTS | | | Water | STRATA | | | | Geology | Instrument/ Backfill |
|---|---|---|---|---|---|---|---|---|---|
| Depth | Type No | Test Result | | Reduced Level | Legend | Depth (Thick-ness) | DESCRIPTION | | |
| | | | | | | (0.40) 0.40 | TOPSOIL: Occasional coal fragments. | | |
| 0.30 | ES | | | | | | Loose to medium dense orangish brown SAND. Occasional gravel. | | |
| 1.00 | | N31 | | | | (1.60) | 1.00 - 2.00 Becomes medium dense to dense. | | |
| | | | | | | 2.00 | | | |
| 2.00 | | N50/ 80 mm | | | | | | | |

| Boring Progress and Water Observations | | | | | | Chiselling | | | Water Added | | GENERAL REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Time | Depth | Casing Depth | Casing Dia. mm | Water Dpt | From | To | Hours | From | To | |
| | | | | | | | | | | | Dry.<br>Refusal at 2.00m. |

| All dimensions in metres<br>Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used Competitor Rig | Logged By BB |
|---|---|---|---|

Betts Geo Environmental
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CH5 2LY
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# BOREHOLE LOG

| Project | | | | BOREHOLE No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | WS2 |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |

| SAMPLES & TESTS | | | Water | STRATA | | | | | Geology | Instrument/ Backfill |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth | Type No | Test Result | | Reduced Level | Legend | Depth (Thick-ness) | | DESCRIPTION | | |
| | | | | | | (0.40) | 0.40 | TOPSOIL: Occasional sand and gravel. Occasional brick and coal. Occasional cobble of brick. | | |
| 0.50 | ES | | | | | (1.30) | 1.70 | MADE GROUND: Firm clayey TOPSOIL: Occasional gravel of coal and brick (Reworked). | | |
| 1.00 | | N24 | | | | | 1.80 | Relict TOPSOIL. | | |
| 2.00 | | N50/ 70 mm | | | | | 2.10 | Orangish brown SAND. (Weathered Sandstone). | | |

| Boring Progress and Water Observations | | | | | | Chiselling | | | Water Added | | GENERAL REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Time | Depth | Casing Depth | Casing Dia. mm | Water Dpt | From | To | Hours | From | To | |
| | | | | | | | | | | | Dry. Refusal at 2.10m. |

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used Competitor Rig | Logged By BB |
|---|---|---|---|

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CH5 2LY
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# BOREHOLE LOG

| Project | | | | BOREHOLE No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | WS3 |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |

| SAMPLES & TESTS | | | Water | STRATA | | | | Geology | Instrument/ Backfill |
|---|---|---|---|---|---|---|---|---|---|
| Depth | Type No | Test Result | | Reduced Level | Legend | Depth (Thick-ness) | DESCRIPTION | | |
| 0.20 | ES | | | | | (0.40) 0.40 | MADE GROUND: Sand and gravel of pot and brick (possible sub layer). | | |
| 1.00 | ES | | | | | (1.40) | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | | |
| 1.00 | | N18 | | | | | | | |
| 1.80 | | N50/ 100 mm | | | | 1.80 | | | |

| Boring Progress and Water Observations | | | | | | Chiselling | | | Water Added | | GENERAL REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Time | Depth | Casing Depth | Casing Dia. mm | Water Dpt | From | To | Hours | From | To | |
| | | | | | | | | | | | Dry. Refusal at 1.80m. |

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used Competitor Rig | Logged By BB |
|---|---|---|---|

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CH5 2LY
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# BOREHOLE LOG

| Project | | | | BOREHOLE No |
|---|---|---|---|---|
| HOPE AND ANCHOR | | | | **WS4** |
| Job No | Date | Ground Level (m) | Co-Ordinates () | |
| 13SEC001 | 10-06-13 | | | |
| Contractor | | | | Sheet |
| BETTS GEOENVIRONMENTAL LTD | | | | 1 of 1 |

| SAMPLES & TESTS | | | Water | STRATA | | | | | Geology | Instrument/ Backfill |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth | Type No | Test Result | | Reduced Level | Legend | Depth (Thick-ness) | DESCRIPTION | | | |
| | | | | | | 0.10 | MADE GROUND: Tarmac. | | | |
| | | | | | | 0.45 | MADE GROUND: Gravel sub-base. | | | |
| 0.50 | ES | | | | | 0.60 | MADE GROUND: Topsoil and gravel. | | | |
| | | | | | | | Medium dense reddish orange fine to coarse SAND. Occasional gravel. | | | |
| 1.00 | | N34 | | | | (1.20) | | | | |
| | | | | | | 1.80 | | | | |
| 1.80 | | N50/ 150 mm | | | | | | | | |

| Boring Progress and Water Observations | | | | | | Chiselling | | | Water Added | | GENERAL REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Time | Depth | Casing Depth | Casing Dia. mm | Water Dpt | From | To | Hours | From | To | Dry. Refusal at 1.80m. |
| | | | | | | | | | | | |

| All dimensions in metres Scale 1:50 | Client SEDDON CONSTRUCTION | Method/ Plant Used Competitor Rig | Logged By BB |
|---|---|---|---|

AGS3 UK BH 13SEC001 - HOPE AND ANCHOR.GPJ GINT STD AGS 3_1.GDT 27/6/13

## APPENDIX D

(i) Contamination Test Results

(ii) Geotechnical Test Results

# Jones Environmental Laboratory

Unit 3 Deeside Point
Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

Tel: +44 (0) 1244 833780
Fax: +44 (0) 1244 833781

Betts Geo
Unit 6-7
Old Marsh Farm Barns
Welsh Road
Sealand
CH5 2LY

No.4225

| | |
|---|---|
| **Attention :** | Beverley Bryant |
| **Date :** | 19th June, 2013 |
| **Your reference :** | 13SEC001 |
| **Our reference :** | Test Report 13/5374 |
| **Location :** | HOPE AND ANCHOR |
| **Date samples received :** | 11th June, 2013 |
| **Status :** | Final report |
| **Issue :** | 1 |

Twelve samples were received for analysis on 11th June, 2013. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

**Compiled By:**

**Phil Sommerton B.Sc**
**Project Manager**

**Bob Millward B.Sc FRSC**
**Principal Chemist**

*Jones Environmental Laboratory*

***Client Name:*** Betts Geo

***Reference:*** 13SEC001

***Location:*** HOPE AND ANCHOR

***Contact:*** Beverley Bryant

***JE Job No.:*** 13/5374

**Report : Solid**

**Solids:** V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

| J E Sample No. | 1-2 | 3-4 | 5-6 | 7-8 | 9-10 | 11-12 | 13-14 | 15-16 | 17-18 | 19-20 | LOD | Units | Method No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | TP1 | TP2 | TP3 | TP5 | TP3 | TP4 | TP4 | WS1 | WS2 | WS3 | | | |
| Depth | 0.7 | 0.6 | 0.4 | 0.5 | 1.0 | 0.5 | 3.0 | 0.3 | 0.5 | 0.2 | | | |
| COC No / misc | | | | | | | | | | | | | |
| Containers | V J | V J | V J | V J | V J | V J | V J | V J | V J | V J | | | |
| Sample Date | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | | | |
| Sample Type | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | | | |
| Batch Number | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| Date of Receipt | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | | | |
| Arsenic # | 2.5 | 3.8 | 6.7 | - | 7.7 | 10.5 | 11.5 | 8.1 | 7.9 | 18.5 | <0.5 | mg/kg | TM30/PM15 |
| Arsenic | - | - | - | 9.3 | - | - | - | - | - | - | <0.5 | mg/kg | TM30/PM62 |
| Cadmium # | 0.5 | <0.1 | 0.1 | - | <0.1 | 0.1 | <0.1 | 0.5 | 0.2 | 0.3 | <0.1 | mg/kg | TM30/PM15 |
| Cadmium | - | - | - | 0.3 | - | - | - | - | - | - | <0.1 | mg/kg | TM30/PM62 |
| Copper # | 8 | 12 | 15 | - | 12 | 7 | 17 | 16 | 14 | 25 | <1 | mg/kg | TM30/PM15 |
| Copper | - | - | - | 20 | - | - | - | - | - | - | <1 | mg/kg | TM30/PM62 |
| Lead # | 8 | <5 | 82 | - | <5 | 28 | 15 | 73 | 46 | 44 | <5 | mg/kg | TM30/PM15 |
| Lead | - | - | - | 97 | - | - | - | - | - | - | <5 | mg/kg | TM30/PM62 |
| Mercury # | 0.1 | <0.1 | 0.5 | - | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM30/PM15 |
| Mercury | - | - | - | <0.1 | - | - | - | - | - | - | <0.1 | mg/kg | TM30/PM62 |
| Nickel # | 4.8 | 6.7 | 7.9 | - | 11.2 | 24.0 | 11.1 | 9.1 | 16.6 | 22.6 | <0.7 | mg/kg | TM30/PM15 |
| Nickel | - | - | - | 11.4 | - | - | - | - | - | - | <0.7 | mg/kg | TM30/PM62 |
| Selenium # | <1 | <1 | <1 | - | <1 | <1 | 1 | 1 | <1 | 2 | <1 | mg/kg | TM30/PM15 |
| Selenium | - | - | - | <1 | - | - | - | - | - | - | <1 | mg/kg | TM30/PM62 |
| Zinc # | 33 | 10 | 24 | - | 16 | 61 | 38 | 70 | 66 | 78 | <5 | mg/kg | TM30/PM15 |
| Zinc | - | - | - | 105 | - | - | - | - | - | - | <5 | mg/kg | TM30/PM62 |
| | | | | | | | | | | | | | |
| **PAH MS** | | | | | | | | | | | | | |
| Naphthalene # | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | 0.09 | <0.04 | mg/kg | TM4/PM8 |
| Acenaphthylene | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | mg/kg | TM4/PM8 |
| Acenaphthene # | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.07 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | mg/kg | TM4/PM8 |
| Fluorene # | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | 0.07 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | mg/kg | TM4/PM8 |
| Phenanthrene # | <0.03 | <0.03 | <0.03 | 0.46 | <0.03 | 1.83 | <0.03 | <0.03 | 0.14 | 0.36 | <0.03 | mg/kg | TM4/PM8 |
| Anthracene # | <0.04 | <0.04 | <0.04 | 0.11 | <0.04 | 0.71 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | mg/kg | TM4/PM8 |
| Fluoranthene # | <0.03 | <0.03 | <0.03 | 0.99 | <0.03 | 6.75 | 0.03 | 0.06 | 0.23 | 0.03 | <0.03 | mg/kg | TM4/PM8 |
| Pyrene # | <0.03 | <0.03 | <0.03 | 0.79 | <0.03 | 5.58 | 0.03 | 0.06 | 0.21 | <0.03 | <0.03 | mg/kg | TM4/PM8 |
| Benzo(a)anthracene # | <0.06 | <0.06 | <0.06 | 0.56 | <0.06 | 3.11 | <0.06 | <0.06 | 0.16 | <0.06 | <0.06 | mg/kg | TM4/PM8 |
| Chrysene # | <0.02 | <0.02 | <0.02 | 0.45 | <0.02 | 3.24 | <0.02 | 0.06 | 0.16 | 0.03 | <0.02 | mg/kg | TM4/PM8 |
| Benzo(bk)fluoranthene # | <0.07 | <0.07 | <0.07 | 0.57 | <0.07 | 4.73 | <0.07 | <0.07 | 0.16 | <0.07 | <0.07 | mg/kg | TM4/PM8 |
| Benzo(a)pyrene # | <0.04 | <0.04 | <0.04 | 0.38 | <0.04 | 3.19 | <0.04 | <0.04 | 0.08 | <0.04 | <0.04 | mg/kg | TM4/PM8 |
| Indeno(123cd)pyrene # | <0.04 | <0.04 | <0.04 | 0.18 | <0.04 | 1.95 | <0.04 | <0.04 | 0.07 | <0.04 | <0.04 | mg/kg | TM4/PM8 |
| Dibenzo(ah)anthracene # | <0.04 | <0.04 | <0.04 | 0.06 | <0.04 | 0.47 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | mg/kg | TM4/PM8 |
| Benzo(ghi)perylene # | <0.04 | <0.04 | <0.04 | 0.18 | <0.04 | 1.67 | <0.04 | <0.04 | 0.06 | <0.04 | <0.04 | mg/kg | TM4/PM8 |
| PAH 16 Total | <0.6 | <0.6 | <0.6 | 4.7 | <0.6 | 33.4 | <0.6 | <0.6 | 1.3 | <0.6 | <0.6 | mg/kg | TM4/PM8 |
| Benzo(b)fluoranthene | <0.05 | <0.05 | <0.05 | 0.41 | <0.05 | 3.41 | <0.05 | <0.05 | 0.12 | <0.05 | <0.05 | mg/kg | TM4/PM8 |
| Benzo(k)fluoranthene | <0.02 | <0.02 | <0.02 | 0.16 | <0.02 | 1.32 | <0.02 | <0.02 | 0.04 | <0.02 | <0.02 | mg/kg | TM4/PM8 |
| PAH Surrogate % Recovery | 104 | 103 | 103 | 110 | 107 | 109 | 114 | 108 | 108 | 113 | <0 | % | TM4/PM8 |

## *Jones Environmental Laboratory*

***Client Name:*** Betts Geo

***Reference:*** 13SEC001

***Location:*** HOPE AND ANCHOR

***Contact:*** Beverley Bryant

***JE Job No.:*** 13/5374

**Report : Solid**

**Solids:** V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

| J E Sample No. | 1-2 | 3-4 | 5-6 | 7-8 | 9-10 | 11-12 | 13-14 | 15-16 | 17-18 | 19-20 | LOD | Units | Method No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | TP1 | TP2 | TP3 | TP5 | TP3 | TP4 | TP4 | WS1 | WS2 | WS3 | | | |
| **Depth** | 0.7 | 0.6 | 0.4 | 0.5 | 1.0 | 0.5 | 3.0 | 0.3 | 0.5 | 0.2 | | | |
| **COC No / misc** | | | | | | | | | | | | | |
| **Containers** | V J | V J | V J | V J | V J | V J | V J | V J | V J | V J | | | |
| **Sample Date** | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | | | |
| **Sample Type** | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | | | |
| **Batch Number** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| **Date of Receipt** | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | | | |
| **TPH CWG** | | | | | | | | | | | | | |
| **Aliphatics** | | | | | | | | | | | | | |
| >C5-C6 # | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM36/PM12 |
| >C6-C8 # | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM36/PM12 |
| >C8-C10 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM36/PM12 |
| >C10-C12 # | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | mg/kg | TM5/PM16 |
| >C12-C16 # | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | mg/kg | TM5/PM16 |
| >C16-C21 # | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | mg/kg | TM5/PM16 |
| >C21-C35 # | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | mg/kg | TM5/PM16 |
| Total aliphatics C5-35 | <19 | <19 | <19 | <19 | <19 | <19 | <19 | <19 | <19 | <19 | <19 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics >C5-C10 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | mg/kg | TM3/PM12 |
| Total aliphatics >C10-C16 # | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics >C16-C35 # | <14 | <14 | <14 | <14 | <14 | <14 | <14 | <14 | <14 | <14 | <14 | mg/kg | TM5/TM36/PM12/PM16 |
| **Aromatics** | | | | | | | | | | | | | |
| >C5-EC7 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM36/PM12 |
| >EC7-EC8 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM36/PM12 |
| >EC8-EC10 # | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM36/PM12 |
| >EC10-EC12 # | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | mg/kg | TM5/PM16 |
| >EC12-EC16 # | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | mg/kg | TM5/PM16 |
| >EC16-EC21 # | <7 | <7 | <7 | <7 | <7 | 17 | <7 | <7 | <7 | <7 | <7 | mg/kg | TM5/PM16 |
| >EC21-EC35 # | <7 | <7 | <7 | <7 | <7 | 22 | <7 | <7 | 25 | <7 | <7 | mg/kg | TM5/PM16 |
| Total aromatics C5-35 | <19 | <19 | <19 | <19 | <19 | 39 | <19 | <19 | 25 | <19 | <19 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aromatics >C5-C10 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | mg/kg | TM3/PM12 |
| Total aromatics >C10-C16 # | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | <4.2 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aromatics >C16-C35 # | <14 | <14 | <14 | <14 | <14 | 39 | <14 | <14 | 25 | <14 | <14 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics and aromatics(C5-35) | <38 | <38 | <38 | <38 | <38 | 39 | <38 | <38 | <38 | <38 | <38 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics and aromatics >C5-C10 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | <0.6 | mg/kg | TM3/PM12 |
| Total aliphatics and aromatics >C10-C16 # | <8.4 | <8.4 | <8.4 | <8.4 | <8.4 | <8.4 | <8.4 | <8.4 | <8.4 | <8.4 | <8.4 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics and aromatics >C16-C35 # | <28 | <28 | <28 | <28 | <28 | 39 | <28 | <28 | <28 | <28 | <28 | mg/kg | TM5/TM36/PM12/PM16 |
| | | | | | | | | | | | | | |
| GRO (>C4-C8) # | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM36/PM12 |
| GRO (>C8-C12) # | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM36/PM12 |
| GRO (>C4-C12) # | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | mg/kg | TM36/PM12 |
| MTBE # | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | mg/kg | TM31/PM12 |
| Benzene # | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | mg/kg | TM31/PM12 |
| Toluene # | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | mg/kg | TM31/PM12 |
| Ethylbenzene # | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | mg/kg | TM31/PM12 |
| m/p-Xylene # | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | mg/kg | TM31/PM12 |
| o-Xylene # | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | mg/kg | TM31/PM12 |
| | | | | | | | | | | | | | |
| Hexavalent Chromium | <0.3 | <0.3 | <0.3 | <0.3 | 0.3 | <0.3 | <0.3 | <0.3 | 1.7 | <0.3 | <0.3 | mg/kg | TM38/PM20 |
| Sulphate as SO4 (2:1 Ext) # | 0.0065 | 0.0057 | 0.0163 | - | 0.0091 | 0.0188 | 0.0114 | <0.0015 | 0.0349 | 0.1583 | <0.0015 | g/l | TM38/PM20 |
| Sulphate as SO4 (2:1 Ext) # | - | - | - | <0.0015 | - | - | - | - | - | - | <0.0015 | g/l | TM38/PM60 |

*Jones Environmental Laboratory*

**Client Name:** Betts Geo

**Reference:** 13SEC001

**Location:** HOPE AND ANCHOR

**Contact:** Beverley Bryant

**JE Job No.:** 13/5374

**Report : Solid**

**Solids:** V=60g VOC jar, J=250g glass jar, T=plastic tub

| J E Sample No. | 1-2 | 3-4 | 5-6 | 7-8 | 9-10 | 11-12 | 13-14 | 15-16 | 17-18 | 19-20 | LOD | Units | Method No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | TP1 | TP2 | TP3 | TP5 | TP3 | TP4 | TP4 | WS1 | WS2 | WS3 | | | |
| Depth | 0.7 | 0.6 | 0.4 | 0.5 | 1.0 | 0.5 | 3.0 | 0.3 | 0.5 | 0.2 | | | |
| COC No / misc | | | | | | | | | | | | | |
| Containers | V J | V J | V J | V J | V J | V J | V J | V J | V J | V J | | | |
| Sample Date | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | 10/06/2013 | | | |
| Sample Type | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | | | |
| Batch Number | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| Date of Receipt | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | 11/06/2013 | | | |
| Organic Matter | <0.2 | <0.2 | 3.4 | NDP | <0.2 | 1.4 | 1.2 | 5.0 | 2.4 | 1.9 | <0.2 | % | TM21/PM24 |
| pH # | 8.77 | 8.53 | 7.55 | 7.99 | 6.01 | 7.52 | 7.86 | 5.41 | 7.34 | 8.42 | <0.01 | pH units | TM73/PM11 |

Please see attached notes for all abbreviations and acronyms





All solid results are expressed on a dry weight basis unless stated otherwise.

***Client Name:*** Betts Geo

***Reference:*** 13SEC001

***Location:*** HOPE AND ANCHOR

***Contact:*** Beverley Bryant

***JE Job No.:*** 13/5374

**Report : Solid**

**Solids:** V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

| J E Sample No. | 21-22 | 23-24 | | | | | | | | | LOD | Units | Method No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | WS3 | WS4 | | | | | | | | | | | |
| Depth | 1.0 | 0.5 | | | | | | | | | | | |
| COC No / misc | | | | | | | | | | | | | |
| Containers | V J | V J | | | | | | | | | | | |
| Sample Date | 10/06/2013 | 10/06/2013 | | | | | | | | | | | |
| Sample Type | Soil | Soil | | | | | | | | | | | |
| Batch Number | 1 | 1 | | | | | | | | | | | |
| Date of Receipt | 11/06/2013 | 11/06/2013 | | | | | | | | | | | |
| Arsenic # | 1.8 | 2.7 | | | | | | | | | <0.5 | mg/kg | TM30/PM15 |
| Arsenic | - | - | | | | | | | | | <0.5 | mg/kg | TM30/PM62 |
| Cadmium # | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM30/PM15 |
| Cadmium | - | - | | | | | | | | | <0.1 | mg/kg | TM30/PM62 |
| Copper # | 9 | 7 | | | | | | | | | <1 | mg/kg | TM30/PM15 |
| Copper | - | - | | | | | | | | | <1 | mg/kg | TM30/PM62 |
| Lead # | <5 | 24 | | | | | | | | | <5 | mg/kg | TM30/PM15 |
| Lead | - | - | | | | | | | | | <5 | mg/kg | TM30/PM62 |
| Mercury # | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM30/PM15 |
| Mercury | - | - | | | | | | | | | <0.1 | mg/kg | TM30/PM62 |
| Nickel # | 4.8 | 3.5 | | | | | | | | | <0.7 | mg/kg | TM30/PM15 |
| Nickel | - | - | | | | | | | | | <0.7 | mg/kg | TM30/PM62 |
| Selenium # | <1 | <1 | | | | | | | | | <1 | mg/kg | TM30/PM15 |
| Selenium | - | - | | | | | | | | | <1 | mg/kg | TM30/PM62 |
| Zinc # | 6 | 17 | | | | | | | | | <5 | mg/kg | TM30/PM15 |
| Zinc | - | - | | | | | | | | | <5 | mg/kg | TM30/PM62 |
| | | | | | | | | | | | | | |
| **PAH MS** | | | | | | | | | | | | | |
| Naphthalene # | <0.04 | 0.07 | | | | | | | | | <0.04 | mg/kg | TM4/PM8 |
| Acenaphthylene | <0.03 | <0.03 | | | | | | | | | <0.03 | mg/kg | TM4/PM8 |
| Acenaphthene # | <0.05 | <0.05 | | | | | | | | | <0.05 | mg/kg | TM4/PM8 |
| Fluorene # | <0.04 | <0.04 | | | | | | | | | <0.04 | mg/kg | TM4/PM8 |
| Phenanthrene # | <0.03 | 0.13 | | | | | | | | | <0.03 | mg/kg | TM4/PM8 |
| Anthracene # | <0.04 | 0.07 | | | | | | | | | <0.04 | mg/kg | TM4/PM8 |
| Fluoranthene # | <0.03 | 0.23 | | | | | | | | | <0.03 | mg/kg | TM4/PM8 |
| Pyrene # | <0.03 | 0.21 | | | | | | | | | <0.03 | mg/kg | TM4/PM8 |
| Benzo(a)anthracene # | <0.06 | 0.13 | | | | | | | | | <0.06 | mg/kg | TM4/PM8 |
| Chrysene # | <0.02 | 0.17 | | | | | | | | | <0.02 | mg/kg | TM4/PM8 |
| Benzo(bk)fluoranthene # | <0.07 | 0.18 | | | | | | | | | <0.07 | mg/kg | TM4/PM8 |
| Benzo(a)pyrene # | <0.04 | 0.09 | | | | | | | | | <0.04 | mg/kg | TM4/PM8 |
| Indeno(123cd)pyrene # | <0.04 | 0.04 | | | | | | | | | <0.04 | mg/kg | TM4/PM8 |
| Dibenzo(ah)anthracene # | <0.04 | <0.04 | | | | | | | | | <0.04 | mg/kg | TM4/PM8 |
| Benzo(ghi)perylene # | <0.04 | 0.05 | | | | | | | | | <0.04 | mg/kg | TM4/PM8 |
| PAH 16 Total | <0.6 | 1.4 | | | | | | | | | <0.6 | mg/kg | TM4/PM8 |
| Benzo(b)fluoranthene | <0.05 | 0.13 | | | | | | | | | <0.05 | mg/kg | TM4/PM8 |
| Benzo(k)fluoranthene | <0.02 | 0.05 | | | | | | | | | <0.02 | mg/kg | TM4/PM8 |
| PAH Surrogate % Recovery | 107 | 111 | | | | | | | | | <0 | % | TM4/PM8 |

***Client Name:*** Betts Geo

***Reference:*** 13SEC001

***Location:*** HOPE AND ANCHOR

***Contact:*** Beverley Bryant

***JE Job No.:*** 13/5374

**Report : Solid**

**Solids:** V=60g VOC jar, J=250g glass jar, T=plastic tub

| J E Sample No. | 21-22 | 23-24 | | | | | | | | | LOD | Units | Method No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | WS3 | WS4 | | | | | | | | | | | |
| **Depth** | 1.0 | 0.5 | | | | | | | | | | | |
| **COC No / misc** | | | | | | | | | | | | | |
| **Containers** | V J | V J | | | | | | | | | | | |
| **Sample Date** | 10/06/2013 | 10/06/2013 | | | | | | | | | | | |
| **Sample Type** | Soil | Soil | | | | | | | | | | | |
| **Batch Number** | 1 | 1 | | | | | | | | | | | |
| **Date of Receipt** | 11/06/2013 | 11/06/2013 | | | | | | | | | | | |
| **TPH CWG** | | | | | | | | | | | | | |
| **Aliphatics** | | | | | | | | | | | | | |
| >C5-C6 # | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM36/PM12 |
| >C6-C8 # | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM36/PM12 |
| >C8-C10 | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM36/PM12 |
| >C10-C12 # | <0.2 | <0.2 | | | | | | | | | <0.2 | mg/kg | TM5/PM16 |
| >C12-C16 # | <4 | <4 | | | | | | | | | <4 | mg/kg | TM5/PM16 |
| >C16-C21 # | <7 | <7 | | | | | | | | | <7 | mg/kg | TM5/PM16 |
| >C21-C35 # | <7 | 78 | | | | | | | | | <7 | mg/kg | TM5/PM16 |
| Total aliphatics C5-35 | <19 | 78 | | | | | | | | | <19 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics >C5-C10 | <0.3 | <0.3 | | | | | | | | | <0.3 | mg/kg | TM3/PM12 |
| Total aliphatics >C10-C16 # | <4.2 | <4.2 | | | | | | | | | <4.2 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics >C16-C35 # | <14 | 78 | | | | | | | | | <14 | mg/kg | TM5/TM36/PM12/PM16 |
| **Aromatics** | | | | | | | | | | | | | |
| >C5-EC7 | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM36/PM12 |
| >EC7-EC8 | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM36/PM12 |
| >EC8-EC10 # | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM36/PM12 |
| >EC10-EC12 # | <0.2 | <0.2 | | | | | | | | | <0.2 | mg/kg | TM5/PM16 |
| >EC12-EC16 # | <4 | <4 | | | | | | | | | <4 | mg/kg | TM5/PM16 |
| >EC16-EC21 # | <7 | 7 | | | | | | | | | <7 | mg/kg | TM5/PM16 |
| >EC21-EC35 # | <7 | 135 | | | | | | | | | <7 | mg/kg | TM5/PM16 |
| Total aromatics C5-35 | <19 | 142 | | | | | | | | | <19 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aromatics >C5-C10 | <0.3 | <0.3 | | | | | | | | | <0.3 | mg/kg | TM3/PM12 |
| Total aromatics >C10-C16 # | <4.2 | <4.2 | | | | | | | | | <4.2 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aromatics >C16-C35 # | <14 | 142 | | | | | | | | | <14 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics and aromatics(C5-35) | <38 | 220 | | | | | | | | | <38 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics and aromatics >C5-C10 | <0.6 | <0.6 | | | | | | | | | <0.6 | mg/kg | TM3/PM12 |
| Total aliphatics and aromatics >C10-C16 # | <8.4 | <8.4 | | | | | | | | | <8.4 | mg/kg | TM5/TM36/PM12/PM16 |
| Total aliphatics and aromatics >C16-C35 # | <28 | 220 | | | | | | | | | <28 | mg/kg | TM5/TM36/PM12/PM16 |
| | | | | | | | | | | | | | |
| GRO (>C4-C8) # | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM36/PM12 |
| GRO (>C8-C12) # | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM36/PM12 |
| GRO (>C4-C12) # | <0.1 | <0.1 | | | | | | | | | <0.1 | mg/kg | TM36/PM12 |
| MTBE # | <0.005 | <0.005 | | | | | | | | | <0.005 | mg/kg | TM31/PM12 |
| Benzene # | <0.005 | <0.005 | | | | | | | | | <0.005 | mg/kg | TM31/PM12 |
| Toluene # | <0.005 | <0.005 | | | | | | | | | <0.005 | mg/kg | TM31/PM12 |
| Ethylbenzene # | <0.005 | <0.005 | | | | | | | | | <0.005 | mg/kg | TM31/PM12 |
| m/p-Xylene # | <0.005 | <0.005 | | | | | | | | | <0.005 | mg/kg | TM31/PM12 |
| o-Xylene # | <0.005 | <0.005 | | | | | | | | | <0.005 | mg/kg | TM31/PM12 |
| | | | | | | | | | | | | | |
| Hexavalent Chromium | <0.3 | <0.3 | | | | | | | | | <0.3 | mg/kg | TM38/PM20 |
| Sulphate as SO4 (2:1 Ext) # | 0.0107 | <0.0015 | | | | | | | | | <0.0015 | g/l | TM38/PM20 |
| Sulphate as SO4 (2:1 Ext) # | - | - | | | | | | | | | <0.0015 | g/l | TM38/PM60 |

Please see attached notes for all abbreviations and acronyms

*Jones Environmental Laboratory*

***Client Name:*** Betts Geo

***Reference:*** 13SEC001

***Location:*** HOPE AND ANCHOR

***Contact:*** Beverley Bryant

***JE Job No.:*** 13/5374

**Report : Solid**

**Solids:** V=60g VOC jar, J=250g glass jar, T=plastic tub

| J E Sample No. | 21-22 | 23-24 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | WS3 | WS4 | | | | | | | | | | | |
| **Depth** | 1.0 | 0.5 | | | | | | | | | | | |
| **COC No / misc** | | | | | | | | | | | | | |
| **Containers** | V J | V J | | | | | | | | | | | |
| **Sample Date** | 10/06/2013 | 10/06/2013 | | | | | | | | | | | |
| **Sample Type** | Soil | Soil | | | | | | | | | | | |
| **Batch Number** | 1 | 1 | | | | | | | | | | | |
| **Date of Receipt** | 11/06/2013 | 11/06/2013 | | | | | | | | | | | |
| Organic Matter | <0.2 | 1.0 | | | | | | | | | | <0.2 | % |
| pH # | 8.02 | 7.61 | | | | | | | | | | <0.01 | pH units |

Please see attached notes for all abbreviations and acronyms

| LOD | Units | Method No. |
|---|---|---|
| <0.2 | % | TM21/PM24 |
| <0.01 | pH units | TM73/PM11 |

***Client Name:*** Betts Geo

***Reference:*** 13SEC001

***Location:*** HOPE AND ANCHOR

***Contact:*** Beverley Bryant

**Note:**

Analysis was carried out in accordance with our documented in-house methods PM042 and TM065 and HSG 248 by Stereo and Polarised Light Microscopy using Dispersion Staining Techniques and is covered by our UKAS accreditation. Samples are retained for not less than 6 months from the date of analysis unless specifically requested.

Opinions lie outside the scope of our UKAS accreditation.

*Where the sample is not taken by a Jones Environmental Laboratory consultant, Jones Environmental Laboratory cannot be responsible for inaccurate or unrepresentative sampling.*

*If asbestos fibres are reported at trace levels there will not be enough fibres to quantify and will be less than 0.001%.*

Signed on behalf of Jones Environmental Laboratory:

Gemma Newsome
Asbestos Team Leader

| J E Job No. | Batch | Sample ID | Depth | J E Sample No. | Date Of Analysis | Description | Asbestos Results |
|---|---|---|---|---|---|---|---|
| 13/5374 | 1 | TP1 | 0.7 | 1-2 | 14/06/2013 | Soil/Sand | NAD |
| 13/5374 | 1 | TP2 | 0.6 | 3-4 | 14/06/2013 | Soil/Sand | NAD |
| 13/5374 | 1 | TP3 | 0.4 | 5-6 | 14/06/2013 | Soil | NAD |
| 13/5374 | 1 | TP5 | 0.5 | 7-8 | 14/06/2013 | Soil/Stone/Brick-Trace | Chrysotile |
| 13/5374 | 1 | TP4 | 0.5 | 11-12 | 14/06/2013 | Soil/Clay | NAD |
| 13/5374 | 1 | WS2 | 0.5 | 17-18 | 14/06/2013 | Soil/Stone | NAD |
| 13/5374 | 1 | WS3 | 0.2 | 19-20 | 14/06/2013 | Soil/Stone | NAD |
| 13/5374 | 1 | WS4 | 0.5 | 23-24 | 14/06/2013 | Soil/Stone | NAD |

***Client Name:*** Betts Geo

***Reference:*** 13SEC001

***Location:*** HOPE AND ANCHOR

***Contact:*** Beverley Bryant

| J E Job No. | Batch | Sample ID | Depth | J E Sample No. | NDP Reason |
|---|---|---|---|---|---|
| 13/5374 | 1 | TP5 | 0.5 | 7-8 | Asbestos detected in sample |

# NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

***JE Job No.:*** 13/5374

**SOILS**

Please note we are only MCERTS accredited for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary. If we are instructed to keep samples, a storage charge of £1 (1.5 Euros) per sample per month will be applied until we are asked to dispose of them.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

**WATERS**

Please note we are not a Drinking Water Inspectorate (DWI) Approved Laboratory . It is important that detection limits are carefully considered when requesting water analysis.

UKAS accreditation applies to surface water and groundwater and one other matrix which is analysis specific, any other liquids are outside our scope of accreditation

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

**DEVIATING SAMPLES**

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

**SURROGATES**

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

**NOTE**

Data is only accredited when all the requirements of our Quality System have been met. In certain circumstances where the requirements have not been met, the laboratory may issue the data in an interim report but will remove the accreditation, in this instance results should be considered indicative only. Where possible samples will be re-extracted and a final report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

**ABBREVIATIONS and ACRONYMS USED**

| | |
|---|---|
| # | UKAS accredited. |
| B | Indicates analyte found in associated method blank. |
| DR | Dilution required. |
| M | MCERTS accredited. |
| NA | Not applicable |
| NAD | No Asbestos Detected. |
| ND | None Detected (usually refers to VOC and/SVOC TICs). |
| NDP | No Determination Possible |
| SS | Calibrated against a single substance. |
| SV | Surrogate recovery outside performance criteria. This may be due to a matrix effect. |
| W | Results expressed on as received basis. |
| + | AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page. |
| ++ | Result outside calibration range, results should be considered as indicative only and are not accredited. |
| * | Analysis subcontracted to a Jones Environmental approved laboratory. |
| CO | Suspected carry over |
| OC | Outside Calibration Range |
| NFD | No Fibres Detected |

***JE Job No*** 13/5374

| Test Method No. | Description | Prep Method No. (if appropriate) | Description | UKAS | MCERTS (soils only) | Analysis done on As Received (AR) or Air Dried (AD) | Solid Results expressed on Dry/Wet basis |
|---|---|---|---|---|---|---|---|
| TM3 | GRO (C4-8,8-12) by GC-MS, modified USEPA 8015 | PM12 | GRO GC-FID | | | AR | DRY |
| TM4 | 16 PAH by GC-MS, modified USEPA 8270 | PM8 | End Over End extraction | | | AR | DRY |
| TM4 | 16 PAH by GC-MS, modified USEPA 8270 | PM8 | End Over End extraction | Yes | | AR | DRY |
| TM4 | 16 PAH by GC-MS, modified USEPA 8270 | PM8 | End Over End extraction | | | AR | |
| TM5 | EPH by GC-FID, modified USEPA 8015 | PM16 | Aliphatic/Aromatic fractionation | Yes | | AR | DRY |
| TM5/TM36 | TPH CWG by GC-FID | PM12/PM16 | CWG GC-FID | | | AR | DRY |
| TM5/TM36 | TPH CWG by GC-FID | PM12/PM16 | CWG GC-FID | Yes | | AR | DRY |
| TM21 | TOC and TC by Combustion | PM24 | Eltra preparation | | | AD | DRY |
| TM30 | Metals by ICP-OES | PM15 | Aqua Regia extraction (Soils) | Yes | | AD | DRY |
| TM30 | Metals by ICP-OES | PM62 | Aqua Regia extraction (Soils) (as received sample) | | | AR | DRY |
| TM31 | BTEX/MTBE by GC-FID, modified USEPA 8015 | PM12 | GRO GC-FID | | | AR | DRY |
| TM31 | BTEX/MTBE by GC-FID, modified USEPA 8015 | PM12 | GRO GC-FID | Yes | | AR | DRY |
| TM36 | GRO by Headspace GC-FID | PM12 | GRO GC-FID | | | AR | DRY |
| TM36 | GRO by Headspace GC-FID | PM12 | GRO GC-FID | Yes | | AR | DRY |
| TM38 | SO4,Cl,NO3,NO2,F,PO4, Amm N2,ThioCN, Hex Cr by Aquakem | PM20 | 1:2 soil to water extraction | Yes | | AD | DRY |
| TM38 | SO4,Cl,NO3,NO2,F,PO4, Amm N2,ThioCN, Hex Cr by Aquakem | PM20 | 1:2 soil to water extraction | | | AR | DRY |
| TM38 | SO4,Cl,NO3,NO2,F,PO4, Amm N2,ThioCN, Hex Cr by Aquakem | PM60 | 1:2 soil to water extraction (as received sample) | Yes | | AR | DRY |
| TM65 | Asbestos Bulk Identification | PM42 | Screening of soils for fibres | | | AR | |
| TM65 | Asbestos Bulk Identification | PM42 | Screening of soils for fibres | Yes | | AR | |
| TM73 | pH in by Metrohm | PM11 | 1:2.5 soil/water extraction | Yes | | AR | WET |

BETTS ASSOCIATES
GEO ENVIRONMENTAL

# SUMMARY OF CONTAMINATION ANALYSIS: METALS

**Project Name** HOPE AND ANCHOR
**Project No** 13SEC001
**Date** 10/06/13

| SOIL TYPE | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE LOCATION | TP1 | TP2 | TP3 | TP3 | TP4 | TP4 | TP5 | WS1 | WS2 | WS3 | WS3 | WS4 |
| DEPTH (m) | 0.7 | 0.6 | 0.4 | 1.0 | 0.5 | 3.0 | 0.5 | 0.3 | 0.5 | 0.2 | 1.0 | 0.5 |
| pH | 8.77 | 8.53 | 7.55 | 6.01 | 7.52 | 7.86 | 7.99 | 5.41 | 7.34 | 8.42 | 8.02 | 7.61 |
| Sulphate (water sol 2:1) | 0.0065 | 0.0057 | 0.0163 | 0.0091 | 0.0188 | 0.0114 | <0.0015 | <0.0015 | 0.0349 | 0.1583 | 0.0107 | <0.0015 |
| Organic matter | <0.2 | <0.2 | 3.4 | <0.2 | 1.4 | 1.2 | NDP | 5 | 2.4 | 1.9 | <0.2 | 1 |
| Arsenic | 2.5 | 3.8 | 6.7 | 7.7 | 10.5 | 11.5 | 9.3 | 8.1 | 7.9 | 18.5 | 1.8 | 2.7 |
| Cadmium | 0.5 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 | 0.3 | 0.5 | 0.2 | 0.3 | <0.1 | <0.1 |
| Copper | 8 | 12 | 15 | 12 | 7 | 17 | 20 | 16 | 14 | 25 | 9 | 7 |
| Chromium (hexavalent) | <0.3 | <0.3 | <0.3 | 0.3 | <0.3 | <0.3 | <0.3 | <0.3 | 1.7 | <0.3 | <0.3 | <0.3 |
| Lead | 8 | <5 | 82 | <5 | 28 | 15 | 97 | 73 | 46 | 44 | <5 | 24 |
| Mercury | 0.1 | <0.1 | 0.5 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Nickel | 4.8 | 6.7 | 7.9 | 11.2 | 24 | 11.1 | 11.4 | 9.1 | 16.6 | 22.6 | 4.8 | 3.5 |
| Selenium | <1 | <1 | <1 | <1 | <1 | 1 | <1 | 1 | <1 | 2 | <1 | <1 |
| Zinc | 33 | 10 | 24 | 16 | 61 | 38 | 105 | 70 | 66 | 78 | 6 | 17 |
| Asbestos | NAD | NAD | NAD | NA | NAD | NA | Chrysotile | NA | NAD | NAD | NA | NAD |

| Metals | Mean Value Test * | Range | | Residential Use with Homegrown ATRisk. (mg/kg) | Residential Use with Homegrown ATRisk. (mg/kg) |
|---|---|---|---|---|---|
| | $US_{95}$ | Largest Value (mg/kg) | Smallest Value (mg/kg) | With Homegrown Produce (1% SOM) | With Homegrown Produce (6% SOM) |
| **pH** | 7.88 | 8.77 | 5.41 | | |
| **Sulphate (water sol 2:1)** | 0.05 | 0.158 | <0.0015 | | |
| **Organic matter** | 2.36 | 5.00 | <0.2 | | |
| **Arsenic** | 10 | 18.50 | 1.80 | 32 | 32 |
| **Cadmium** | 0.29 | 0.50 | <0.1 | 10 | 10 |
| **Copper** | 16 | 25.00 | 7.00 | 3970 | 4020 |
| **Chromium (hexavalent)** | 0.63 | 1.70 | <0.3 | 14.2 | 14.2 |
| **Lead** | 53 | 97.00 | <5 | 276 | 342 |
| **Mercury**** | 0.19 | 0.50 | <0.1 | 6.28 | 11 |
| **Nickel** | 15 | 24.00 | 3.50 | 130 | 130 |
| **Selenium** | 1 | 2.00 | <1 | 350 | 350 |
| **Zinc** | 60 | 105.00 | 6.00 | 16900 | 17200 |

NOTE:
Any individual results and mean value tests above SGVs are shown RED highlighted.
Any outlier values which exceed relevant SGVs are shown in red

* - The calculations for the mean value test include outliers

BETTS ASSOCIATES
GEO ENVIRONMENTAL

## SUMMARY OF CONTAMINATION ANALYSIS: PAH

**Project Name** HOPE AND ANCHOR
**Project No** 13SEC001
**Date** 10/06/13

| SOIL TYPE | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE LOCATION | TP1 | TP2 | TP3 | TP3 | TP4 | TP4 | TP5 | WS1 | WS2 | WS3 | WS3 | WS4 |
| DEPTH (m) | 0.7 | 0.6 | 0.4 | 1.0 | 0.5 | 3.0 | 0.5 | 0.3 | 0.5 | 0.2 | 1.0 | 0.5 |
| Acenaphthene | <0.05 | <0.05 | <0.05 | <0.05 | 0.07 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Acenaphthylene | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Anthracene | <0.04 | <0.04 | <0.04 | <0.04 | 0.71 | <0.04 | 0.11 | <0.04 | <0.04 | <0.04 | <0.04 | 0.07 |
| Benzo(a)anthracene | <0.06 | <0.06 | <0.06 | <0.06 | 3.11 | <0.06 | 0.56 | <0.06 | 0.16 | <0.06 | <0.06 | 0.13 |
| Benzo(a)pyrene | <0.04 | <0.04 | <0.04 | <0.04 | 3.19 | <0.04 | 0.38 | <0.04 | 0.08 | <0.04 | <0.04 | 0.09 |
| Benzo(b)fluoranthene | <0.05 | <0.05 | <0.05 | <0.05 | 3.41 | <0.05 | 0.41 | <0.05 | 0.12 | <0.05 | <0.05 | 0.13 |
| Benzo(ghi)perylene | <0.04 | <0.04 | <0.04 | <0.04 | 1.67 | <0.04 | 0.18 | <0.04 | 0.06 | <0.04 | <0.04 | 0.05 |
| Benzo(k)fluoranthene | <0.02 | <0.02 | <0.02 | <0.02 | 1.32 | <0.02 | 0.16 | <0.02 | 0.04 | <0.02 | <0.02 | 0.05 |
| Chrysene | <0.02 | <0.02 | <0.02 | <0.02 | 3.24 | <0.02 | 0.45 | 0.06 | 0.16 | 0.03 | <0.02 | 0.17 |
| Dibenzo(ah)anthracene | <0.04 | <0.04 | <0.04 | <0.04 | 0.47 | <0.04 | 0.06 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Fluoranthene | <0.03 | <0.03 | <0.03 | <0.03 | 6.75 | 0.03 | 0.99 | 0.06 | 0.23 | 0.03 | <0.03 | 0.23 |
| Fluorene | <0.04 | <0.04 | <0.04 | <0.04 | 0.07 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Indeno(123-cd)pyrene | <0.04 | <0.04 | <0.04 | <0.04 | 1.95 | <0.04 | 0.18 | <0.04 | 0.07 | <0.04 | <0.04 | 0.04 |
| Naphthalene | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | 0.09 | <0.04 | 0.07 |
| Phenanthrene | <0.03 | <0.03 | <0.03 | <0.03 | 1.83 | <0.03 | 0.46 | <0.03 | 0.14 | 0.36 | <0.03 | 0.13 |
| Pyrene | <0.03 | <0.03 | <0.03 | <0.03 | 5.58 | 0.03 | 0.79 | 0.06 | 0.21 | <0.03 | <0.03 | 0.21 |
| Organic Matter | <0.2 | <0.2 | 3.4 | <0.2 | 1.4 | 1.2 | NDP | 5 | 2.4 | 1.9 | <0.2 | 1 |

| PAH | Mean Value Test * | Range | | LQM / CIEH 2009 Guidelines For Residential use- WITH Homegrown Produce | LQM / CIEH 2009 Guidelines For Residential use- WITH Homegrown Produce | LQM / CIEH 2009 Guidelines For Residential use- WITH Homegrown |
|---|---|---|---|---|---|---|
| | $US_{95}$ | Largest Value (mg/kg) | Smallest Value (mg/kg) | 1% SOM WITHOUT Free Product*** | 2.5% SOM WITHOUT Free Product*** | 6% SOM WITHOUT Free Product*** |
| Acenaphthene | 0.05 | 0.07 | <0.05 | **210** | **480** | **1000** |
| Acenaphthylene | 0.03 | <0.03 | <0.03 | **170** | **400** | **850** |
| Anthracene | 0.20 | 0.71 | <0.04 | **2300** | **4900** | **9200** |
| Benzo(a)anthracene | 0.82 | 3.11 | <0.06 | **3.1** | **4.7** | **5.9** |
| Benzo(a)pyrene | 0.81 | 3.19 | <0.04 | **0.83** | **0.94** | **1** |
| Benzo(b)fluoranthene | 0.87 | 3.41 | <0.05 | **5.6** | **6.5** | **7** |
| Benzo(ghi)perylene | 0.43 | 1.67 | <0.04 | **44** | **46** | **47** |
| Benzo(k)fluoranthene | 0.34 | 1.32 | <0.02 | **8.5** | **9.6** | **10** |
| Chrysene | 0.83 | 3.24 | <0.02 | **6** | **8** | **9.3** |
| Dibenzo(ah)anthracene | 0.14 | 0.47 | <0.04 | **0.76** | **0.86** | **0.9** |
| Fluoranthene | 1.70 | 6.75 | <0.03 | **260** | **460** | **670** |
| Fluorene | 0.05 | 0.07 | <0.04 | **160** | **380** | **780** |
| Indeno(123-cd)pyrene | 0.50 | 1.95 | <0.04 | **3.2** | **3.9** | **4.2** |
| Naphthalene | 0.06 | 0.09 | <0.04 | **1.5** | **3.7** | **8.7** |
| Phenanthrene | 0.53 | 1.83 | <0.03 | **92** | **200** | **380** |
| Pyrene | 1.41 | 5.58 | <0.03 | **560** | **1000** | **1600** |

Results expressed as mg/kg air dried unless otherwise stated.

* - The calculations for the mean value test include outliers

*** THESE RESULTS PRESENTED ARE ASSESSED UNDER THE COMBINED CLEA ASSESSMENT CRITERION AS OUTLINED WITHIN SR4 ASSUMING **NO** FREE PRODUCT WAS OBSERVED DURING FIELDWORK- SEE 'GUIDANCE NOTES ON CONTAMINATION'.

**NOTES:**

For the Purpose of this investigation- results will be assessed agains **RESIDENTIAL GUIDELINES WITH HOMEGROWN PRODUCE WITH NO FREE PRODUCT.**

BETTS ASSOCIATES
GEO ENVIRONMENTAL

# SUMMARY OF CONTAMINATION ANALYSIS: TPH

**Project Name** HOPE AND ANCHOR
**Project No** 13SEC001
**Date** 10/06/13

| SOIL TYPE | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE LOCATION | TP1 | TP2 | TP3 | TP3 | TP4 | TP4 | TP5 | WS1 | WS2 | WS3 | WS3 | WS4 |
| DEPTH (m) | 0.7 | 0.6 | 0.4 | 1.0 | 0.5 | 3.0 | 0.5 | 0.3 | 0.5 | 0.2 | 1.0 | 0.5 |
| Ali >C5-C6 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Ali >C6-C8 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Ali >C8-C10 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Ali >C10-C12 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Ali >C12-C16 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 |
| Ali >C16-C21 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 |
| Ali >C21-C35 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | <7 | 78 |
| Total Aliphatics | <19 | <19 | <19 | <19 | <19 | <19 | <19 | <19 | <19 | <19 | <19 | 78 |
| Aro >C5-C7 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Aro >C7-C8 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Aro >C8-C10 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Aro >C10-C12 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| Aro >C12-C16 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 |
| Aro >C16-C21 | <7 | <7 | <7 | <7 | 17 | <7 | <7 | <7 | <7 | <7 | <7 | 7 |
| Aro >C21-C35 | <7 | <7 | <7 | <7 | 22 | <7 | <7 | <7 | 25 | <7 | <7 | 135 |
| Total Aromatics | <19 | <19 | <19 | <19 | 39 | <19 | <19 | <19 | 25 | <19 | <19 | 142 |
| TPH (Ali & Aro) | <38 | <38 | <38 | <38 | 39 | <38 | <38 | <38 | <38 | <38 | <38 | 220 |
| BTEX - Benzene | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| BTEX - Toluene | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| BTEX - Ethyl Benzene | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| BTEX - m & p Xylene | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| BTEX - o Xylene | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| MTBE | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Organic Matter | <0.2 | <0.2 | 3.4 | <0.2 | 1.4 | 1.2 | NDP | 5 | 2.4 | 1.9 | <0.2 | 1 |

| TPH | Mean Value Test * | Range | | LQM / CIEH 2009 Guidelines For Residential use- WITH Homegrown Produce | LQM / CIEH 2009 Guidelines For Residential use- WITH Homegrown | LQM / CIEH 2009 Guidelines For Residential use- WITH Homegrown |
|---|---|---|---|---|---|---|
| | $US_{95}$ | Largest Value (mg/kg) | Smallest Value (mg/kg) | 1% SOM WITHOUT Free Product*** | 2.5% SOM WITHOUT Free Product*** | 6% SOM WITHOUT Free Product*** |
| Ali >C5-C6 | 0.10 | <0.1 | <0.1 | 30 | 55 | 110 |
| Ali >C6-C8 | 0.10 | <0.1 | <0.1 | 73 | 160 | 370 |
| Ali >C8-C10 | 0.10 | <0.1 | <0.1 | 19 | 46 | 110 |
| Ali >C10-C12 | 0.20 | <0.2 | <0.2 | 48 | 118 | 283 |
| Ali >C12-C16 | 4.00 | <4 | <4 | 24 | 59 | 142 |
| Ali >C16-C21 | 7.00 | <7 | <7 | 45000 | 64000 | 76000 |
| Ali >C21-C35 | 23.54 | 78.00 | <7 | | | |
| Total Aliphatics | 32.75 | 78.00 | <19 | | | |
| Aro >C5-C7 | 0.10 | <0.1 | <0.1 | 65 | 130 | 280 |
| Aro >C7-C8 | 0.10 | <0.1 | <0.1 | 120 | 270 | 611 |
| Aro >C8-C10 | 0.10 | <0.1 | <0.1 | 27 | 65 | 151 |
| Aro >C10-C12 | 0.20 | <0.2 | <0.2 | 69 | 160 | 346 |
| Aro >C12-C16 | 4.00 | <4 | <4 | 140 | 310 | 593 |
| Aro >C16-C21 | 9.33 | 17.00 | <7 | 250 | 480 | 770 |
| Aro >C21-C35 | 39.42 | 135.00 | <7 | 890 | 1100 | 1230 |
| Total Aromatics | 49.72 | 142.00 | <19 | | | |
| TPH (Ali & Aro) | 80.47 | 220.00 | <38 | | | |
| BTEX - Benzene | 0.01 | <0.005 | <0.005 | 0.08 | 0.18 | 0.33 |
| BTEX - Toluene | 0.01 | <0.005 | <0.005 | 120 | 320 | 610 |
| BTEX - Ethyl Benzene | 0.01 | <0.005 | <0.005 | 65 | 180 | 350 |
| BTEX - m & p Xylene | 0.01 | <0.005 | <0.005 | 42 | 120 | 230 |
| BTEX - o Xylene | 0.01 | <0.005 | <0.005 | 42 | 120 | 250 |
| MTBE | 0.01 | <0.005 | <0.005 | | | |

| | UU Drinking Water Guidelines |
|---|---|
| | PE Threshold |
| Total BTEX &MTBE | 0.1 |
| EC5-EC10 Ali-Aro | 2 |
| EC10-EC16 Ali-Aro | 10 |
| EC16-EC40 Ali-Aro | 500 |

Results expressed as mg/kg air dried unless otherwise stated.

* - The calculations for the mean value test include outliers

*** THESE RESULTS PRESENTED ARE ASSESSED UNDER THE COMBINED CLEA ASSESSMENT CRITERION AS OUTLINED WITHIN SR4 ASSUMING NO FREE PRODUCT WAS OBSERVED DURING FIELDWORK- SEE 'GUIDANCE NOTES ON CONTAMINATION'.

NOTES:

For the Purpose of this investigation- results will be assessed agains RESIDENTIAL GUIDELINES WITH HOMEGROWN PRODUCE WITH NO FREE PRODUCT.

# APPENDIX E

(i) Gas Monitoring Data

## APPENDIX F

### (i) Conceptual Model

The report aims to identify land which could potentially be affected by contamination, such that it could affect the value or re-use of the land, or such that mitigation would be required for certain proposed end uses of the land.

The assessment also aims to identify land which would be regarded as 'contaminated land' under the terms of the Environmental Protection Act 1990, Part IIa. This act includes a stricter test for contaminated land than that outlined above. Land is considered to be contaminated if either:

- the land is causing significant harm to people, ecosystems or infrastructure; or
- there is a significant possibility that such harm could be caused; or
- Pollution of controlled waters is being, or is likely to be, caused.

The following situations are defined as being where harm is to be regarded as significant:

- chronic or quite toxic effect, serious injury or death to humans;
- irreversible or other adverse harm to the ecological system;
- substantial damage to or failure of buildings;
- death of, or disease or other physical damage affecting, livestock or crops;
- Pollution of controlled waters.

The risk assessment uses a 'Source-Pathway-Receptor' methodology for assessing whether a source of contamination could potentially lead to harmful consequences. This means that there needs to be a pollutant linkage from source to receptor for harm to be caused, this linkage consisting of:

- a source of pollution;
- a pathway for the pollutant to move along;
- A receptor that is affected by the pollutant.

As an example, the pollutant source could be an identified leak of oil or an area of dumped waste.

The pathways could include transport of the contaminant by groundwater, surface water, windblown dust, or vapours, and for human receptors will include the means, by which contaminants enter the body, for example skin contact, ingestion and inhalation.

Receptors include people, other living organisms, the built environment and groundwater and surface waters (these latter two also being contaminant pathways).

The source-pathway-receptor methodology relationship allows an assessment of the environmental risk to be determined, based on the nature of the source, the degree of exposure of the receptor to the source and the sensitivity of the receptor.

This section of the report is based on the information set out in the previous sections of the report and should not be read independently of such sections.

**Initial Conceptual Model**

From the available information the preliminary conceptual model is visualised as follows:

| **Target (Receptor)** | **POTENTIAL SOURCE-PATHWAY LINKAGE** |
|---|---|
| **Site users / residents** | Inhalation of soil gas, odours or dust. |
| | Ingestion of, and skin contact with, contaminated soil. |
| | Ingestion of contaminants in vegetables etc. or in soils adhering to vegetables, etc. |
| **Construction/ maintenance workers.** | Inhalation of soil gas, odours or dust |
| | Ingestion of, and skin contact with, contaminated soil |
| **Plants** | Adverse effects on growth caused by presence of contaminants in soil |
| **Buildings and Structures** | Flow of ground gas into buildings. Asphyxiation, toxicity, explosion and fire hazards |
| | Sulphate attack of foundations |
| | Hydrocarbons penetrating plastic water supply pipes |
| **Groundwater** | Migration of soluble contaminants into groundwater on or off site. Migration of oils into groundwater on or off site. |
| **Surface water** | Migration of soluble contaminants and/or direct run-off of contaminants. Migration of oils into groundwater on or off site. |

## Initial Environmental Risk Assessment

### General

It is accepted that an environmental risk assessment can be based on a source-pathway-target model. An examination is carried out as to whether a target will be at risk from a contamination source, that a source exists, and whether there are any pathways (routes of exposure) which might actually link the source to the target.

Environmental risk assessments rely heavily on numerical trigger concentrations or guidelines because exposure of targets to contamination is difficult to quantify directly. Quantification of risk is therefore mainly undertaken for general scenarios in order to derive trigger levels. These are derived for various contaminants for particular targets and routes of exposure. An example of a sensitive target would be users of a domestic back garden, where routes of exposure might be skin contact, dust inhalation, direct ingestion and indirect ingestion via cultivation and consumption of fruit and vegetables.

In March 2002, the first parts of the new CLEA risk assessment guidance were released by DEFRA/Environment Agency.

The risk assessment approach is an extension of the 'fit for use' concept whereby land is cleaned up to a standard fit for the proposed use, that is, so all remaining risks are acceptable. However, as well as being 'fit for use', the environmental risk assessment approach also addresses the soil and water environment so that these are also safeguarded where necessary. For example if a site was contaminated with heavy metals and the development comprised the proposed construction of hard standings and buildings only, the fit-for-use approach might require no remediation for the site. However, consideration of the wider environment needs to address whether groundwater is being contaminated, and if so whether remediation is required for this reason.

The following classification presented by CIRIA has been used in the assessment of risk:

| Estimation of risk from consideration of magnitude, consequences and probabilities | | | | |
|---|---|---|---|---|
| **Probability** | **Consequences** | | | |
| | **Severe** | **Moderate** | **Mild** | **Minor** |
| **High** | Very high | High | Moderate | Moderate / Low |
| **Medium** | High | Moderate | Moderate / Low | Low |
| **Low** | Moderate | Moderate / Low | Low | Very Low |
| **Unlikely** | Moderate / Low | Low | Very Low | Very Low |

Reference: Contaminated Land Risk Management; A Guide to Good Practice, CIRIA C552:2001

### CIRIA C665 Situation A Ground Gas Conceptual Model

The risk table contained in C665 is basically a modified risk assessment from CIRIA 152 1995, by which a conceptual model and semi-quantitative risk assessment can be made.

## APPENDIX G

(iii) Notes on Ground Gas

### Ground Gas

The Building Regulations and BRE Report 212 state that precautions are not mandatory against carbon dioxide unless 5.0% volume is exceeded. These documents do not give a threshold level for methane, but Baker suggests that this level is 0.1% volume. For methane up to 1.0% volume, and carbon dioxide above 5.0% volume, the Building Regulations and BRE Report state that passive measures may be adopted. Above 1.0% methane further specific guidance must be sought.

CIRIA Report 149 gives further guidance on the appropriate precautions for various gas regimes, called characteristic situations in this report. In the DETR Guide for Design by Ove Arup, various types of passive measures are assessed for performance with different gas regimes. The assessments used computational fluid dynamic (CFD) modelling.

A gas regime is essentially defined by two parameters:

i) The concentration of the gas (e.g. % methane)

ii) The emission rate of the gas from the ground.

The fact that two parameters are used is problematic if the site is to be classified on the basis of Table 28 in CIRIA Report 149. This is because high gas concentrations are often encountered which fall into an onerous gas regime; whereas the low flow rates which are also frequently encountered fall into less onerous gas regimes.

In order to use the Guide for Design to decide if passive measures are suitable, it is necessary to combine the gas concentration and the emission rate.

Three recent publications are used for ground gas risk assessment:

- CIRIA C665 for high rise residential / flats
- 'Guidance on Evaluation of Development Proposals on Sites Where Methane and Carbon Dioxide are Present' Report Edition No.04 March 2007 NHBC – designed for use with low rise residential properties
- BS8485:2007 'Code of practice for the characterization and remediation from ground gas in affected developments'

These documents improve upon the approach used in previous CIRIA and Wilson /Card Papers, by placing emphasis on gas flow rates, but still retain some reliance on the gas concentrations themselves.

## CIRIA C665 Situation A Ground Gas Conceptual Model

The risk table contained in C665 is basically a modified risk assessment from CIRIA 152 1995, by which a conceptual model and semi-quantitative risk assessment can be made.

### High Rise / Flats (CIRIA 665 Table 8.5)

| Characteristic Situation (CIRIA Report 149) | Risk Classification | Gas Screening Value (CH4 or CO2) (l/hr) [1] | Additional factors | Typical source of generation |
|---|---|---|---|---|
| **1** | Very low risk | **<0.07** | Typically methane ≤1%v/v and/or carbon dioxide ≤5%v/v. Otherwise consider increase to Situation 2 | Natural soils with low Organic content. "Typical" Made Ground |
| **2** | Low risk | **<0.7** | Borehole flow rate not to exceed 70l/hr. Otherwise consider increase to Situation 3 | Natural soil, high peat/organic content. "Typical" Made Ground |
| **3** | Moderate risk | **<3.5** | | Old landfill, inert waste, mineworking flooded |
| **4** | Moderate to high risk | **<15** | Quantitative risk assessment required to evaluate scope of protective measures | Mineworking susceptible to flooding, completed landfill (WMP 26B criteria) |
| **5** | High risk | **<70** | | Mineworking unflooded inactive with shallow workings near surface |
| **6** | Very high risk | **>70** | | Recent landfill site |

**Notes:**

1. Gas screening value: litres of gas/hour is calculated by multiplying the gas concentration (%) by the measured borehole flow rate (l/hr);
2. Site characterisation should be based on gas monitoring of concentrations and borehole flow rates for the minimum periods as defined within within CIRIA Report 665;
3. Source of gas and generation potential/performance must be identified;
4. Soil gas investigation to be in accordance with guidance contained within CIRIA Report 665;
5. If there is no detectable flow, use the limit of detection of the instrument;
6. The boundaries between the Partners in Technology classifications do not fit exactly with the boundaries for the above classification.

**Typical scope of protective measures (extract from CIRIA Report 665 Table 8.6)**

| Characteristic Situation (from Table 8.5) | Number of levels of protection | Typical scope of protective measures for residential building (not low-rise traditional housing)[1] |
|---|---|---|
| **1** | None | No special precautions |
| **2** | 2 | a) Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200g DPM and under-floor venting<br>b) Beam and block or pre-cast concrete and 2000 g DPM/reinforced gas membrane and under-floor venting. All joints and penetrations sealed. |
| **3** | 2 | All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated or positively pressurised under-floor sub-space. |
| **4** | 3 | All types of floor slab as above. All joints and penetrations sealed. Proprietary gas resistant membrane and passively ventilated under-floor subspace or positively pressurised under-floor sub-space, over-site capping or blinding and in ground venting layer |
| **5** | 4 | Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft). All joints and penetrations sealed. Proprietary gas resistant membrane and ventilated or positively pressurised under-floor sub-space, over-site capping and in ground venting layer and in ground venting wells or barriers. |
| **6** | 5 | Not suitable unless gas regime is reduced first and quantitative risk assessment carried out to assess design of protection measures in conjunction with foundation design. |

**Notes:**

1. Not suitable for use with low rise traditional housing. (Use the NHBC document instead);
2. Typical scope of protective measures may be rationalised for specific developments on the basis of quantitative risk assessments;
3. Note the type of protection is given for illustration purposes only. Information on the detailing and construction of passive protection measures is given in BR414 (Johnson, 2001). Individual site specific designs should provide the same number of separate protective methods for any given characteristic situation. See CIRIA Report 49;
4. In all cases there should be minimum penetration of ground slabs by services and minimum number of confined spaces such as cupboards above the ground slab. Any confined spaces should be ventilated;
5. Foundation design must minimise differential settlement particularly between structural elements and ground-bearing slabs;
6. Commercial buildings with basement car parks, provided with ventilation in accordance with the Building Regulations, may not require gas protection for Characteristic Situations 3 and 4;
7. Floor slabs should provide an acceptable formation on which to lay the gas membrane. If a block beam floor is used it should be well detailed so it has no voids in it that membranes have to span, and all holes for service penetrations should be filled. The minimum density of the blocks should be 600kg/m3 and the top surface should have a 4:1 ratio sand to cement grout brushed into all joints before placing any membrane (this is also good practice to stabilise the floor and should be carried out regardless of the need for ground gas membranes);
8. The ground gas-resistant membrane can also act as the damp-proof membrane;
9. Based on Building Regulations Approved Document C (Office of the Deputy Prime Minister, 2004a),which states that "a membrane below the concrete could be formed with a sheet of polyethylene, which should be at least 300mu thick (1200 gauge)". Please note the alteration from 300mm (as stated in the Approved Document C) to 300mu, as 300mm is a typographical error that has been recognised and corrected for within this report and CIRIA Report 665.

## Low Rise Residential (NHBC)

**Table 14.1: Gas Risk Assessment - Traffic Lights with Typical Maximum Concentrations and Gas Screening Values**

| | Methane [1] | | Carbon Dioxide [1] | |
|---|---|---|---|---|
| **Classification** | **Typical Maximum Concentration** [3] (%v/v) | **Gas Screening Value** [2,4] (l/hr) | **Typical Maximum Concentration** [3] (%v/v) | **Gas Screening Value** [2,4] (l/hr) |
| Green | | | | |
| Amber 1 | 1 | **0.13** | 5 | **0.78** |
| Amber 2 | 5 | **0.63** | 10 | **1.60** |
| Red | 20 | **1.60** | 30 | **3.10** |
| | | | | |

**Notes:**

1. The worst-case ground gas regime identified on the site, either methane or carbon dioxide, at the worst case temporal conditions that the site may be expected to encounter will be the decider as to what Traffic Light is allocated;
2. Borehole Gas Volume Flow Rate, in litres per hour as defined in Wilson and Card (1999), is the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered;
3. The Typical Maximum Concentrations can be exceeded in certain circumstances should the Conceptual Site Model indicate it is safe to do so;
4. The Gas Screening Value thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.

**Table 14.2: Ground Gas Protection Measures Required for the Traffic Lights**

| Traffic Light | Ground Gas Protection Measures Required |
|---|---|
| **Green** | Ground gas protection measures are not required. (note based on standard NHBC house detail with 150mm void space under suspended floor) |
| **Amber 1** | Low-level ground gas protection measures are required, using a membrane and ventilated sub-floor void that creates a permeability contrast to limit the ingress of gas into buildings. Gas protection measures are to be installed as prescribed in BRE 414. Ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours. |
| **Amber 2** | High-level ground gas protection measures are required, creating a permeability contrast to prevent ingress of gas into buildings. Gas protection measures are to be installed as prescribed in BRE 414. **Membranes used should always be fitted by a specialist contractor and should be fully certified (see Appendix G).** As with Amber 1, ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours. |
| **Red** | Standard residential housing is not normally acceptable without further Ground Gas Risk Assessment and/or possible remedial mitigation measures to reduce/remove the source of the ground gases. In certain circumstances, active protection methods could be applied, but only when there is a legal agreement assuring the management and maintenance of the system for the life of the property. |

## BS8485: 2007

**Table 2: Required Gas Protection By Characteristic Gas Situation & Type Of Building**

| Characteristic gas situation, CS | NHBC traffic light | Required gas protection | | | |
|---|---|---|---|---|---|
| | | Non-managed property, e.g. private housing | Public building [A] | Commercial buildings | Industrial buildings [B] |
| 1 | Green | 0 | 0 | 0 | 0 |
| 2 | Amber 1 | 3 | 3 | 2 | 1 [C] |
| 3 | Amber 2 | 4 | 3 | 2 | 2 |
| 4 | Red | 6 [D] | 5 [D] | 4 | 3 |
| 5 | | | 6 [E] | 5 | 4 |
| 6 | | | | 7 | 6 |

*NOTE Traffic light indications are taken from NHBC Report no.: 10627-R01 (04) [3] and are mainly applicable to low-rise residential housing. These are for comparative purposes but the boundaries between the traffic light indications and CS values do not coincide.*

A) Public buildings include, for example, managed apartments, schools and hospitals.
B) Industrial buildings are generally open and well ventilated. However, areas such as office pods might require a separate assessment and may be classified as commercial buildings and require a different scope of gas protection to the main building.
C) Maximum methane concentration 20% otherwise consider an increase to CS3.
D) Residential building on higher traffic light/CS sites is not recommended unless the type of construction or site circumstances allow additional levels of protection to be incorporated, e.g. high-performance ventilation or pathway intervention measures, and an associated sustainable system of management of maintenance of the gas control system, e.g. in institutional and/or fully serviced contractual situations.
E) Consideration of issues such as ease of evacuation and how false alarms will be handled are needed when completing the design specification of any protection scheme.

## Table 3: Solutions Scores

| PROTECTION ELEMENT/SYSTEM | | SCORE | COMMENTS |
|---|---|---|---|
| **a) Venting/dilution (See Annex A)** | | | |
| Passive sub floor ventilation (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) A) | Very good performance | 2.5 | Ventilation performance in accordance with Annex A.<br><br>If passive ventilation is poor this is generally unacceptable and some form of active system will be required. |
| | Good performance | 1 | |
| Subfloor ventilation with active abstraction/pressurization (venting layer can be a clear void or formed using gravel, geocomposites, polystyrene void formers, etc.) A) | | 2.5 | There have to be robust management systems in place to ensure the continued maintenance of any ventilation system.<br><br>Active ventilation can always be designed to meet good performance.<br><br>Mechanically assisted systems come in two main forms: extraction and positive pressurization. |
| Ventilated car park (basement or undercroft) | | 4 | Assumes car park is vented to deal with car exhaust fumes, designed to Building Regulations Document F [5] and IStructE guidance [6]. |
| **b) Barriers** | | | |
| **Floor slabs** | | | It is good practice to install ventilation in all foundation systems to effect pressure relief as a minimum.<br><br>Breaches in floor slabs such as joints have to be effectively sealed against gas ingress in order to maintain these performances. |
| Block and beam floor slab | | 0 | |
| Reinforced concrete ground bearing floor slab | | 0.5 | |
| Reinforced concrete ground bearing foundation raft with limited service penetrations that are cast into slab | | 1.5 | |
| Reinforced concrete cast in situ suspended slab with minimal service penetrations and water bars around all slab penetrations and at joints | | 1.5 | |
| Fully tanked basement | | 2 | |
| **c) Membranes** | | | |
| Taped and sealed membrane to reasonable levels of workmanship/in line with current good practice with validation B), C) | | 0.5 | The performance of membranes is heavily dependent on the quality and design of the installation, resistance to damage after installation, and the integrity of joints |
| Proprietary gas resistant membrane to reasonable levels of workmanship/in line with current good practice under independent inspection (CQA) B), C) | | 1 | |
| Proprietary gas resistant membrane installed to reasonable levels of workmanship/in line with current good practice under CQA with integrity testing and independent validation | | 2 | |
| **d) Monitoring and detection (not applicable to non-managed property, or in isolation)** | | | |
| Intermittent monitoring using hand held equipment | | 0.5 | |
| Permanent monitoring and alarm system A) | Installed in the underfloor venting/ dilution system | 2 | Where fitted, permanent monitoring systems ought to be installed in the underfloor venting/dilution system in the first instance but can also be provided within the occupied space as a fail safe |
| | Installed in the building | 1 | |
| **e) Pathway Intervention** | | | |
| Pathway intervention | | - | This can consist of site protection measures for off-site or on-site sources (see Annex A). |

*NOTE In practice the choice of materials might well rely on factors such as construction method and the risk of damage after installation. It is important to ensure that the chosen combination gives an appropriate level of protection*

A) It is possible to test ventilation systems by installing monitoring probes for post installation validation.

B) If a 1 200 g DPM material is to function as a gas barrier it should be installed according to BRE 212 [8]/BRE 414 [9], being taped and sealed to all penetrations.

C) Polymeric Materials >1 200 g can be used to improve confidence in the barrier. Remember that their gas resistance is robust and resistant to site damage.

# APPENDIX H

## (i) Off-site Disposal of Surplus Soil Guidance Notes

The disposal of waste (including surplus soils and contaminated soils) to landfill sites is governed by the *Landfill (England & Wales) Regulations 2002*, the *Hazardous Waste Technical Guidance document WM2 (2003)* and associated legislation.

One of the aims of the above legislation is to encourage waste producers (including developers disposing of surplus soils etc) to reduce their waste (and not just discard and disown it). This can be achieved by recycling or reusing the waste. In the case of contaminated sites where leaving contaminated material in-situ poses a risk to a potential receptor such as groundwater resources, further testing and assessment for such risk could reduce the quantities requiring disposal. If there is still unacceptable risk from contaminated soil being left in place, then it may be possible to reduce the risk to an acceptable level (such that the material can be left in place) by in-situ or ex-situ clean up of the soils.

Before waste can be disposed of, the producer of the waste must undertake a number of steps. '*Initial Waste Testing and Characterisation'* is firstly undertaken to determine whether the waste is non-hazardous or hazardous. The exceptions are that some wastes such as coal tars, 'tank bottom sludge's', etc are immediately classed as hazardous, regardless of any testing or threshold concentrations.

Any inert or hazardous waste destined for landfill must undergo '*Compliance Testing'* using the Waste Acceptance Criteria (WAC). There are different inert and hazardous WAC limits relating to landfill sites that are correspondingly licensed to accept inert or hazardous waste.

If the '*Initial Waste Testing and Characterisation'* shows a waste to be hazardous, then it is a requirement that the material be tested against the WAC-hazardous suite of tests. If it *passes* the WAC-hazardous testing, then it can be taken to a hazardous waste landfill site. If the material *fails* the WAC-hazardous testing, then the material must be treated before undergoing re-characterisation, further WAC-hazardous testing and then potential disposal at a hazardous waste disposal site.

If the '*Initial Waste Testing and Characterisation'* shows a waste to be non-hazardous, then it can be taken to a non hazardous waste landfill site, without further testing. The producer may however decide to undertake WAC-inert testing, in an attempt to reclassify the waste as inert, in which case the waste could then go to an inert landfill site.

The volumes of soils associated with potential hotspots on a site (be they hazardous or non hazardous) which might require off-site disposal, could potentially be reduced by further on-site sampling and subsequent testing.

With regard to the *Compliance Testing*, it should be noted that some landfill sites are permitted to increase the standard WAC-hazardous/inert limit concentrations, such that they might accept waste that would normally fail such limits.

We would recommend that the contamination testing results (including the history of the site) be presented to the proposed landfills, to determine if they will accept waste generated at the site and what classification they would impose.

## APPENDIX I

(i) Validation Report Guidance Notes

### Unforeseen Hotspots of Contamination

Given the existence of made ground on the site it would be prudent to maintain vigilance during site clearance and construction, in case any further areas of suspected contamination are encountered.

If areas are found then a suitably qualified person should undertake appropriate sampling, testing and further risk assessment.

Any hotspots encountered during site clearance, not previously encountered in the ground investigation, are to be removed to a suitably licensed landfill site.

A validation report (see below) will be produced on completion of these works. This report will serve to confirm that the works were undertaken in accordance with the relevant legislation, the method statement, specification and planning conditions.

### Validation Report Recommendations

It is suggested that the following records will be kept on site to provide a basis for the validation report:

- Daily record sheets of the remediation works to include a summary of the day's activities
- Weather conditions
- Plant, personnel and visitors to the remediation site
- Aspects relating to Health & Safety, environmental control or non-compliance with the specification or the Method Statements.
- All in situ and laboratory testing results.

All requirements of the remediation specification should be complied with; on completion of the remediation a validation report should be provided. This report will comprise the relevant site records and act as certification that the remedial and ground preparation works have been carried out in accordance with the specification.

The validation report will include the following:

- A description of the works undertaken.
- Records of any remediation works, including daily diary sheets.
- Progress photographs.
- Any chemical and geotechnical validation test results.
- As built surveys, including base excavations and top and bottom of capping layer.
- A statement that the works have been undertaken in accordance with the agreed specification

# APPENDIX J

## (i) Notes on Limitations

This report does not consider ecological impacts (e.g. bats) or botanical risks (e.g. Japanese knotweed). It is recommended that these are considered as part of the assessment of development constraints for the site.

The assessment and judgements given in this report are directed by both the finite data on which they are based and the proposed works to which they are addressed. The data essentially comprised a study of available documented information from various sources (including Client Furnished reports) together with discussions with relevant authorities and other interested parties. There may also be circumstances at the site that are not documented. The information reviewed is not exhaustive and has been accepted in good faith as providing representative and true data pertaining to site conditions. If additional information becomes available which might impact our environmental conclusions, we request the opportunity to review the information, reassess the potential concerns and modify our opinion if warranted.

It should be noted that any risks identified in this report are perceived risks based on the available information. Actual risks can only be assessed following a physical investigation of the site.

The site investigation has been carried out to provide information concerning the type and degree of contamination, and ground and groundwater conditions to allow a reasonable risk assessment to be made. Betts Geo Environmental Ltd undertake to exercise all reasonable skill, care and due diligence in the exercise of the investigation with respect to sampling techniques, sample storage and report interpretation.

The assessments and judgement given in this report are directed by both the finite data on which they are based and the proposed works to which they are addressed. Data acquisition is subject to the limitations of the methods of investigation used. Exploratory holes undertaken during fieldwork investigate small a small volume of ground in relation to the size of the site and as such can only provide an indication of site conditions. There may be conditions pertaining to the site and the proposed development i.e. localised “hotspots” of contamination, which have not been disclosed by the investigations.

The findings and opinions are relevant to the dates of our site works and should not be relied upon to represent conditions at substantially later dates. Conditions at the site will change over time due to natural variations and anthropogenic activities. Groundwater, surface water and soil gas conditions should be anticipated to change with diurnal, seasonal and meteorological variations.

The opinions expressed in this report regarding any contamination are based on simple statistical analysis and comparison with available guidance values. No liability can be accepted for the retrospective effects of any changes or amendments to these values.

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