



Phase 2 (site investigation) report

Corner House, Church Gate, Whaplode

Produced for Mr and Mrs Graves

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Phase 2 Site Investigation Report

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EXECUTIVE SUMMARY

<i>Proposed works</i>	New low-rise dwelling with garden areas
<i>Site history</i>	The west part of the site has been part of gardens to the Corner House. The east part has been gardens to the houses to the east of Corner House, but was adjacent to a former 20th century Piggery Historical landfill data suggests the site was within the southwest corner of a former landfill site. However, no historical map data has been found to support this suggestion
<i>Site topography</i>	The site is flat and level. Ground level about 3m or 4m above OD.
<i>Ground conditions</i>	Topsoil: - Across the site (in WS1 to WS3) [to 0.2m – 0.3m bgl] Made ground: - Mainly reworked natural soils (in WS4) [to 0.9m bgl] Tidal Flat Deposits: (in WS1 to WS4) - Brown silty SAND and sandy clayey SILT [to at least 2.0m bgl] <i>Anticipated solid geology:</i> mudstone and siltstone.
<i>Groundwater</i>	Standing groundwater was revealed in all four boreholes WS1- WS4) between 0.43m and 0.53m bgl
<i>Contamination test results</i>	Three near surface soils samples revealed: - no elevated metal or metalloid concentrations - no elevated PAH concentrations - no asbestos fibres Two samples revealed no elevated petroleum hydrocarbons. Two samples revealed TOC of between 1.4% and 2.2% PAH ratio profiling suggests detected PAH concentrations could originate from ash and clinker. There was no indication of petroleum hydrocarbons
<i>Revised risk assessment</i>	No potentially significant pollution linkages identified except: hazardous ground gases from degradable material in underlying ground
<i>Gas protection measures</i>	RB17 assessment indicates gas protection measures needed (in the absence of gas monitoring data. NHBC traffic light classification: Green BS8485:2015 (CIRIA) classification: CS2

1 Introduction

This Phase 2 site investigation has been commissioned by the client, Mr and Mrs Graves (care of Cooper Architectural Services of Whaplode) for a proposed development on land at Corner House, Church Gate, Whaplode, Lincolnshire. The land will be hereinafter referred to as *the site*.

1.1 Aims

The aim of the investigation is to assess potential land contamination using in-situ sampling and testing and previous desk study information.

1.2 Scope

The scope of the investigation includes:

- Intrusive borehole investigation works
- Geochemical laboratory testing
- A revised contamination conceptual site model and risk assessment
- Initial proposals for remediation, where required

1.3 Conditions and limitations

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

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

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

2 Review of desktop information

Several sources of desk study information were reviewed as part of this report, as shown below (in Table 1). The main source of information was the HML Phase 1 Desk Study report dated June 2019 (HML ref.: 0991/4873/P).

Table 1: Sources of site information			
Source description		Details	Date
Site specific	HML site walkover	Photos (in Appendix A) and notes	Feb 2020
	Online maps and photos	www.google.co.uk , www.openstreetmap.org , www.promap.co.uk & www.streetmap.co.uk	Feb 2020
	Phase 1 (desk study)	HML report (HML ref.: 0991/4873/P) which includes a copy of an Envirocheck report and historical maps	Jun 2019
	Site investigation report for adjoining land to north of the site	South Holland Planning Application portal (https://planning.sholland.gov.uk/) HML Phase 2 site investigation report (HML ref: 973/3041/P), planning application reference H23-0194-17	Jun 2017
	Local EPO comments	Email from planningadvice@sholland.gov.uk to D. Gedney regarding planning ref. H23-0795-19 with comments from S. Armour the SHDC Environmental Protection Officer.	11 Feb 2020
	Soil report	South Lincs Consulting Ltd Soil Report detailing the findings of a hand augered test hole and proposed raft foundation solution	30 Jan 2020
Local	Local geological map	BGS 1:50000 series, Spalding, Sheet 144	1992
	Online BGS data	www.bgs.ac.uk (map data & borehole records)	Feb 2020
	Historic aerial photos	www.britainfromabove.org.uk	Feb 2020
	Historical maps	www.oldmapsonline.org ; www.old-maps.co.uk	Feb 2020
	Historical information	www.nationalarchives.gov.uk	Feb 2020

2.1 The site

2.1.1 Location and size

The site comprises land which is currently within the curtilage of the residential property at Corner House, Church Gate, Whaplode, in the South Holland district of Lincolnshire. The site is roughly centred around grid reference 532510, 324230.

The site is roughly rectangular. It is about 30m long and about 16m wide.

2.1.2 Site features

The site is an existing rear garden area to the Corner House dwelling. It mainly comprises a lawn but there is a gravel area along the west side of the site. There is also a greenhouse in the northeast portion of the site.

No evidence of potential contamination was identified during the site works. Notably, the vegetation across the site appeared very healthy with no sign of distress.

Photographs of the site are presented in the Phase 1 report and later within this report (in Appendix A).

2.1.3 Adjacent land use

The site is surrounded by the following:

- North: a recently-built residential dwelling with gardens and domestic garage
- East: an existing residential dwelling and gardens
- South: the Corner House dwelling, outbuildings and gardens
- West: Church Gate (pavement and carriageway)

2.1.4 Site topography

The site is flat and level. The average ground level is estimated to be about 3m or 4m above Ordnance Datum (AOD).

The land adjacent to the north of the site appears to be as much as about 0.5m higher than at the site. Inspection of the boundary fence showed some retained ground adjacent to the domestic garage in the neighbouring property.

Nevertheless, the land in the area of the site and around the village of Whaplode is very flat. The village is located within the low-lying flatlands of the Lincolnshire Fens.

2.2 Proposed development

Recent development proposals included the construction of two low-rise dwellings on the site to be accessed off Church Gate. However, the current proposals are understood to comprise a single low-rise dwelling.

The proposed foundation solution is a monolithic cast in situ concrete raft design. This is based on a ground bearing pressure limited to 50kPa.

The proposed dwelling is expected to contain private gardens, mainly located in the rear (east) of the site. It is assumed the final ground levels will be similar to existing.

2.3 Site history

Inspection of historical maps suggests the site has never experienced any development and could have had little significant previous land use. The site was originally an open field with trees which were subsequently removed. The gravel area in the west part of the site is shown to become gardens to the Corner House in mapping dated 1931 and

included a small structure (possible shed). The east portion of the site appears to have been part of the gardens to the houses to the east of Corner House, although this area could have been part of or adjacent to a Piggery, which was shown in some mid-20th century maps (e.g. of 1977).

Marshy ponded land called 'The Broads' were present adjacent to the northeast of the site in early mapping (e.g. dated 1931). In later mapping (e.g. 1970), 'The Broads' were no longer shown but a drain feature about 20m northeast of the site is shown even in very recent mapping (e.g. dated 2019). It is understood that the neighbouring residential property to the north of the site was built in the last couple of years at which time – it is assumed – the previous drain immediately north of the site became culverted.

2.4 Geology

2.4.1 *Made ground*

There could be some thin made ground at the site associated with the site's history as a rear garden or the adjacent piggery

2.4.2 *Drift deposits*

British Geology Survey (BGS) online mapping indicates Tidal Flat Deposits beneath the location of the site. These tend to mainly consist of soft silts and clays with fine sands and occasional peaty layers.

Older published BGS paper maps show the local Tidal Flat Deposits are called the Terrington Beds. These comprise 'younger marine alluvium; salt marsh, tidal creek and river deposits (sandy silt, sand and clay).' The site and the village of Whaplode are just south of the location of the coastline during Saxon times.

2.4.3 *Solid geology*

The site is shown to be underlain by the West Walton Formation - Mudstone And Siltstone. This mainly consists of calcareous mudstone, silty mudstone and siltstone, with subordinate fine-grained sandstones and argillaceous limestone (cementstone) or siltstone nodules.

2.5 Hydrogeology

There are no reported groundwater abstractions near the site (within 1km) and the site is not in a source protection zone. The underlying bedrock is likely to be of very low to low permeability and is not classed as an aquifer.

The shallow Tidal Flat Deposits tend to contain significant amounts of fines (i.e. silts and clays) so should be able to attenuate pollutants. However, where coarser sands are present, the ground conditions could be more permeable.

2.6 Hydrology

According to the Envirocheck report, the nearest surface water feature is about 116m northeast of the site. This appears to be a drainage ditch to the rear of 'The Old Methodist Church.' However, historical map evidence suggests there could be a culverted drain possibly about 20m northeast of the site.

2.7 Waste

The site is within the boundary of a reported historical landfill site, which was named 'The Piggery' and encompassed a roughly rectangular area about 120m long by 70m wide. However, no evidence of any such landfill has been identified in historical maps (apart from some possible infilling of the marshy 'Broads' area) and there is no BGS or local authority landfill record within 1km of the site.

There is also a reported historical landfill site located about 132m east of the site, which was named Foundry House. This was also roughly rectangular in area but only about 75m long and 60m wide. On the other hand, as with the Piggery landfill, no evidence has been found in historical mapping of a landfill at this location and it is not mentioned in BGS or local authority records.

The explanation for the above reported historical landfills could be the infilling of the marshy ponded area known as 'The Broads' which was formerly located to the north and east of the site. However, within the HML Phase 1 Envirocheck report, the nearest *potentially infilled land (water)* was located 229m west of the site.

2.8 Radon gas

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

2.9 Industrial land use

There is a cycle store located about 48m north of the site which is an obsolete fuel filling station. The nearest active petrol station is about 211m east of the site.

3 Previous ground investigation works

No previous site investigation works are known to have taken place on the site.

3.1 Recent hand-augered borehole

A hand-augered test hole, BHA, was recently drilled by South Lincs Consulting Ltd to assess the engineering properties of the ground. The log within the soil report indicates the hole reached a depth of 2.1m bgl and was drilled near the centre of the proposed building.

The recorded ground conditions are summarised below (in Table 2). The findings suggest that the soil between 0.4m and 0.9m is a soft/firm cohesive clayey silt. However, it seems the deeper silt (to at least 2.1m bgl) is less cohesive.

Table 2: Findings of previous hand-augered borehole, BHA		
Depth (m bgl)		Stratum description
Top	Base	
0.0	0.4	Topsoil
0.4	0.9	Soft/firm brown-grey clayey silt
0.9	2.1	Grey silt

No made ground was recorded and no anthropogenic material was noted. The descriptions are consistent with natural Tidal Flat Deposits soils.

A relatively shallow groundwater level was reported of 0.9m bgl.

The soil report concluded that a raft foundation ought to be suitable. This would, ideally, be cast as one unit.

3.2 Nearby Phase 2 site investigation

Two trial pits (TP1 and TP2) were carried out in the land immediately to the north of the site in May 2017 by HML. The results were reported in an HML Phase 2 site investigation report (HML ref.: 973/3041/P), which can be viewed publicly on the South Holland planning portal.

TP1 was located about 25m northeast of the site (on the far side of the former drain). On the other hand, TP2 was located only a few metres north of the site (on the near side of the former drain).

Both trial pits (TP1 and TP2) were terminated at a depth of 1.5m bgl. The revealed ground conditions are summarised below (in Table 3).

Table 3: Findings of previous trial pits

TP1			TP2		
Depth (m bgl)		Stratum description	Depth (m bgl)		Stratum description
Top	Base		Top	Base	
0.0	0.3	Dark brown silt TOPSOIL with much roots	0.0	0.3	Dark brown silt TOPSOIL with occasional rootlets
0.3	0.9	Light brown SILT with occasional boulder to fine macadam and concrete [MADE GROUND]	0.3	0.7	Light brown SILT [MADE GROUND]
0.9	1.1	Dark brown SILT with very occasional concrete rubble [MADE GROUND]	0.7	1.3	Dark brown SILT with occasional brick and concrete rubble [MADE GROUND]
1.1	1.5	Light brown SILT	1.3	1.5	Light brown SILT

Made ground was found in both trial pits to depths ranging between 1.1m and 1.3m bgl. The made ground mostly consisted almost natural soils – mainly silt – with only occasional macadam (i.e. asphalt) and concrete recorded. The silts within the made ground could be reworked local Tidal Flat Deposits soils.

The underlying natural soils were found to be light brown silt. Such soils are typical of the anticipated Tidal Flat Deposits.

Contamination testing included analysis for suites of metals and PAHs on near surface samples from TP1 and TP2 (0.1m to 0.5m bgl) and a deeper sample from TP2 (0.8m to 1.0m bgl). No elevated levels of metals were detected based on current assessment criteria used herein (detailed later, in Section 7.1).

However, significantly elevated levels of PAHs were detected in the near surface sample from TP1. Some slightly elevated levels of PAHs were found in the deeper sample in TP2. PAH profiling indicated the source of the elevated PAH levels could be ash/clinker or coal tar.

Testing also reportedly included two tests for the presence of asbestos fibres. No fibres were detected.

The results of forensic analysis and organic matter contents tests were also reported. Evidently, the organic matter content was determined to be 2.8%, which was converted to a total organic carbon (TOC) content of 1.6%.

4 Preliminary contamination assessment

The HML Phase 1 (desk study) report for the site included the development of a conceptual site model (CSM) based on the available desk study information. Further, a preliminary contamination risk assessment was carried out to identify potentially significant contamination linkages.

A summary of the initial CSM and preliminary risk assessment is as follows.

4.1 Initial conceptual site model

The Phase 1 conceptual site model identified potential sources of contamination at the site, as shown below (in Table 4).

Table 4: Potential sources of contamination					
Location	Source	Potential contaminants			
		Metals	PAHs	Asbestos*	Ground gas*
On-site	Made ground and former land use	P	P	P	
Off-site	Gas sources (e.g. highly organic subsoils)				P
*not considered a viable source due to mitigating factors – see comments below					

The Phase 1 desk study reported that ground gas should not be an issue due to the provision of CS2 ground gas protection measures. This assumes that the sources of gas only present a low risk.

The Phase 1 report also suggested that asbestos was not considered to be a viable source as it was not found in the adjacent property. That is, asbestos was not detected in samples of made ground from TP1 and TP2, as discussed (in Section 3). However, subsequent comments from the local Environmental Protection Officer (EPO) indicate that asbestos should be considered as a source.

The EPO comments also suggest that TPH could be a potential source of contamination. Some testing was recommended.

The EPO comments also recommended Total Organic Carbon (TOC) testing. This could determine the amount of organic material in a soil to help determine the gas generating potential and the levels of hydrocarbon that could be tolerable.

The Phase 1 considered the following contamination pathways.

- Inhalation (i.e. indoor or outdoor dust or vapour)
- Ingestion (i.e. swallowing soil, dust) including soil and contamination in home grown produce

- Absorption (i.e. dermal contact with soil)
- Migration (i.e. vertical/lateral movement through soil, rock, groundwater, building materials, voids and along services, including potable water supply pipes)

Identified receptors consist of humans (e.g. future site users and ground workers), controlled waters, ecological systems, surface water, building materials and services and adjacent site users.

4.2 Preliminary risk assessment

The HML Phase 1 (desk study) report developed a preliminary risk assessment based on the source-pathway-receptor approach. A copy of the preliminary risk assessment is shown below (in Table 5).

Table 5: Preliminary risk assessment						
Potential source	Potential pathway	Potential receptor	Probability	Severity	Risk rating	Comments
General contaminants madeground - metals and PAH	inhalation, ingestion, absorption	Future occupants	Low likelihood	Medium	Medium / Low	Unproductive aquifer
	Inhalation, ingestion, absorption	Construction workers	Low likelihood	Mild	Low	
	Aggressive attack	Building materials	Low likelihood	Mild	Low	
	Migration	Bedrock aquifer	Low likelihood	Minor	Very low	
	Migration	Surface waters	Low likelihood	Mild	Low	

The above preliminary risk assessment indicates that there is a potentially significant risk associated with metals and PAH. Some lead and PAH contamination was detected in the made ground subsoils in the adjacent property. The main receptors identified to be at risk are future site occupants, with children typically being the most vulnerable.

The EPO comments suggest that asbestos and TPH contamination might also pose a potentially significant risk. Also, ground gas could potentially be an issue, especially if deep made ground is present on site.

4.3 (Phase 2) Investigation recommendations

The Phase 1 report recommended further investigation including two exploratory holes (at least 1.5m-deep) at locations in the garden areas with suitable sampling of made ground and natural soils, especially near surface soils. However, the South Holland EPO comments suggested that four exploratory holes should be carried out due to the potential variability of the ground conditions.

The Phase 1 report proposed an initial testing regime which comprised of a metals and a PAH test in both made ground and natural soils. This regime could be altered depending on the revealed ground conditions. However, comments from the South Holland EPO suggest that asbestos screening, TOC and TPH testing should also be carried out.

The Phase 1 report suggested that gas was not a viable source of contamination provided that CS2 gas protection measures were provided. However, EPO comments suggested that gas monitoring or a (CL:AIRE) Research Bulletin 17 (RB17) assessment would be desirable. Should significant made ground be found, then gas monitoring might be a definite requirement (to determine the appropriate ground gas protection measures).

5 Site Investigation Works

The procedures adopted for this site investigation are based on BS 5930 (2015) – Code of Practice for Site Investigations and BS 10175 (2011 + A2, 2017). The soils and rocks encountered have been described based on BS5930 (2015), BS EN ISO 14688-1 (2002) and BS EN ISO 14689-1 (2003).

5.1 Fieldwork

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

The positions of the exploratory holes were established relative to existing site features and using GPS locating equipment. The depths to sub-strata and groundwater were measured from ground level.

Borehole drilling and sampling took place on the 26th February 2020.

Four windowless sampler boreholes (WS1 to WS4) were drilled with a Dando Terrier rig around the site. The maximum depth of sampling was 2.0m below ground level (bgl). The rig extracted consecutive 1m-long tubes of soil material for logging and sampling. The diameter of the holes decreased from about 110mm to about 85mm, with depth. No casing was used for any of the boreholes.

Logs for the boreholes are presented later (in Appendix B).

5.2 Laboratory testing

Geochemical testing was undertaken by Chemtech Environmental Ltd, a UKAS and MCERTS accredited laboratory. The scope of geochemical testing comprised the following.

- 3 number tests for a suite of metals (and metalloids)
- 3 number tests for speciated polycyclic aromatic hydrocarbons (PAHs)
- 3 number asbestos identification tests
- 2 number organic matter content test
- 2 number total petroleum hydrocarbons (TPH) by aliphatic/aromatic fractions

A schedule of testing is shown below (in Table 6). Results for all the laboratory testing undertaken are included later in this report (in Appendix C).

Table 6: Schedule of laboratory testing

<i>Sampling holes</i>	<i>Sample Location</i>	<i>HML Sample ref.</i>	<i>Chemtech sample ref.</i>	<i>Depth (m bgl)</i>	<i>Metals</i>	<i>PAHs</i>	<i>Asbestos ID</i>	<i>Organic matter content (%)</i>
WS1	WS1-1	55453	84839-1	0.1-0.5	P	P	P	P
WS2	WS2-1	55454	84839-2	0.1-0.5	P	P	P	
WS3	WS3-2	55455	84839-3	1.1-1.25				P
WS4	WS4-1	55456	84839-4	0.1-0.5	P	P	P	
	WS4-3	55457	84839-5	1.7-1.9				

6 Ground Conditions

6.1 Sequence of sub-strata

The sub-strata as revealed during the site works are summarised below (in Table 7).

Table 7: Summary of revealed ground conditions (during site works)				
Strata	Locations revealed	Summary description	Depth to base of stratum (m bgl)	
			Min	Max
Topsoil	WS1, WS2, WS3, WS4	Dark brown clayey SILT with occasional rootlets (and occasional stone gravel) WS1 only: Rare clinker fragments	0.2	0.3
Made ground	WS4	Soft greyish brown clayey SILT. Clay pipe at 0.7m bgl (possible land drain)	0.9	
Tidal Flat Deposits	WS1, WS3,	Soft brown slightly sandy clay SILT with rare rootlets. Sand is fine	0.9	1.25
	WS2	Orangish greyish brown silty fine SAND	0.6	
	WS4	Soft slightly organic slightly sandy clayey SILT	1.9	
	WS1, WS2, WS4	Dark greyish black slightly sandy SILT.	2.0+	2.0+

Presented later are copies of the borehole logs (in Appendix B).

The revealed ground conditions were generally as anticipated. The underlying soils mainly comprised (soft) silts which are consistent with the anticipated geology (Tidal Flat Deposits).

6.2 Topsoil

The ground surface was generally underlain by a 0.2m-thick layer of topsoil. This was recorded in all four boreholes (WS1 to WS4).

6.3 Made ground

Made ground was only recorded in WS4 to a depth of 0.9m bgl. No other made ground was reported.

A piece of clay pipe (possible land drain) was reported in WS4 at a depth of 0.7m bgl along with a piece of flint gravel at 0.9m bgl. No other unusual or anthropogenic material was revealed. The logged made ground is probably associated with the backfilling of the clay pipe.

The revealed made ground in WS4 was logged as greyish brown clayey SILT. This soil is generally consistent with reworked Tidal Flat Deposits which could have been used as backfill.

6.4 Tidal Flat Deposits (TFD)

The shallow natural ground conditions around the site were found to be comprised of soils which were judged to be consistent with natural Tidal Flat Deposits (TFD). These soils were revealed in all four boreholes (WS1 to WS4) to the maximum depth of exploration (2.0m bgl).

On the other hand, historical records suggest the site and the adjacent area could be part of a historical landfill, although no map evidence has been found to support this suggestion. Nevertheless, there is a possibility of made ground at the site. Therefore, it is conceivable that some of the logged TFD could be reworked natural soils.

The TFD were logged mainly as silty soil. The soils were found to be soft (cohesive) clayey silts in many locations but were just as commonly revealed as (less cohesive) slightly sandy silts. A shallow band of very silty fine sand was also logged (to a depth of 0.6m bgl in WS2) and some slightly organic peaty silt was logged (1.7m to 1.9m bgl, in WS4). All these soils are all consistent with TFD, which was the anticipated geology.

Much of the TFD silts were found to be grey or dark grey in colour, especially at depths below the groundwater level. This is relatively typical of sands and silts which are often brown in dry conditions and grey in wet conditions. The darker grey colour is typical of slightly organic / peaty soils.

A slight organic odour was noted in some locations within the deeper silts. Such peaty odours are also normal in TFD.

Two of the samples which appeared to be the most organic (in smell and appearance) were subjected to testing for total organic carbon (TOC). The tests indicate values of between 1.4% (WS4, 1.7m to 1.9m bgl) and 2.2% (WS3, 1.1m to 1.25m bgl). These results indicate organic matter contents (OMCs) of between 2.4% and 3.8%, which is typical of slightly organic soils.

6.5 Groundwater observations

Groundwater observations were made in all four of the boreholes (WS1 to WS4). Standing groundwater levels of between 0.43m (in WS1) and 0.53m (in WS4) were recorded below ground level (bgl) after the end of drilling.

The recorded groundwater levels were generally slightly shallower (i.e. higher) than were recorded during the recent South Lincs Consulting Ltd single borehole (BHA) investigation. The water level at that time was recorded at 0.9m bgl.

It should be noted that the recent groundwater levels were recorded after unusually heavy winter rainfalls. Therefore, potentially deeper (lower) groundwater levels might occur at drier, warmer times of year. Groundwater levels can fluctuate seasonally.

6.6 Potential evidence of contamination

No clear visual or olfactory evidence of contamination was noted during the site investigation works. Nevertheless, made ground was encountered, although this was apparently only due to the presence of a clay pipe (land drain) to 0.9m bgl. No other anthropogenic material was revealed.

7 Analysis of soil contamination test data

Assessment criteria (in mg/kg) have been taken from the *generic assessment criteria* (GAC) published in the *Land Quality Management Ltd/Chartered Institute of Environmental Health suitable for use levels* (LQM/CIEH S4ULs) report (LQM/CIEH, 2015). The exception to this is the GAC for lead which is taken from the Category 4 Screening Level (C4SL) data published in a report by Defra (2014). All the GAC are based on the context of a *residential* development with the potential for consumption of home-grown produce (i.e. with plant uptake) which is more onerous than a *commercial* development, say.

7.1 Metals and metalloids

Table 8 (below) gives the GAC for metal (and metalloid) contaminants considered for the site.

Table 8: Generic assessment criteria for metals	
<i>Element</i>	<i>Residential with plant uptake* (mg/kg)</i>
Arsenic	37
Boron	290
Cadmium	11
Chromium III	910
Chromium VI	6
Copper	2400
Lead**	200
Mercury element	1.2
Mercury inorganic	40
Mercury methyl	11
Nickel	130
Selenium	250
Vanadium	410
Zinc	3700
* from LQM/CIEH (2015) except: ** from Defra (2014)	

Three samples of near surface soils were subjected to a suite of metals and metalloids tests. The samples were taken from between depths ranging from 0.1m to 0.5m bgl from WS1, WS2 and WS4. The samples from WS1 and WS2 were logged as natural soil, but the sample from WS4 was made ground.

The complete test results are presented later (in Appendix C).

The test results show that no elevated concentrations were detected of any metal or metalloid. The detected concentrations were below the relevant GAC screening values and none of the results indicate any potentially harmful levels of metals.

It is noted that the total chromium concentrations ranged between 17mg/kg and 40mg/kg. These are consistent with (or slightly lower than) the anticipated natural levels of between 40mg/kg and 60mg/kg. There is no nearby source of chromium VI which is associated with heavy industrial processes. Therefore, there is not considered to be a risk of chromium VI at the site.

7.2 Polycyclic aromatic hydrocarbons (PAHs)

Table 9 (below) gives the GAC (from LQM/CIEH, 2015) for speciated PAH contaminants. These vary with soil organic matter (SOM) content. At this stage, the most onerous SOM of 1% is assumed, which should be reasonably conservative.

Table 9: Soil GACs for PAH			
Element	Residential with plant uptake		
	SOM of 1%	SOM of 2.5%	SOM of 6%
Acenaphthene	210	510	1100
Acenaphthylene	170	420	920
Anthracene	2400	5400	11000
Benzo(a)anthracene	7.2	11	13
Benzo(a)pyrene	2.2	2.7	3
Benzo(b)fluoranthene	2.6	3.3	3.7
Benzo(k)fluoranthene	77	93	100
Benzo(ghi)perylene	320	340	350
Chrysene	15	22	27
Dibenzo(ah)anthracene	0.24	0.28	0.3
Fluoranthene	280	560	890
Fluorene	170	400	860
Indeno(123-cd) pyrene	27	36	41
Naphthalene	2.3	5.6	13
Phenanthrene	95	220	440
Pyrene	620	1200	2000
BaP as Surrogate marker	0.79	0.98	1.1

Three samples of near surface soils were subjected to a suite of PAH tests. The samples were taken from between depths ranging from 0.1m to 0.5m bgl from WS1, WS2 and WS4. The samples from WS1 and WS2 were logged as natural soil, but the sample from WS4 was made ground.

The complete test results are presented later (in Appendix C).

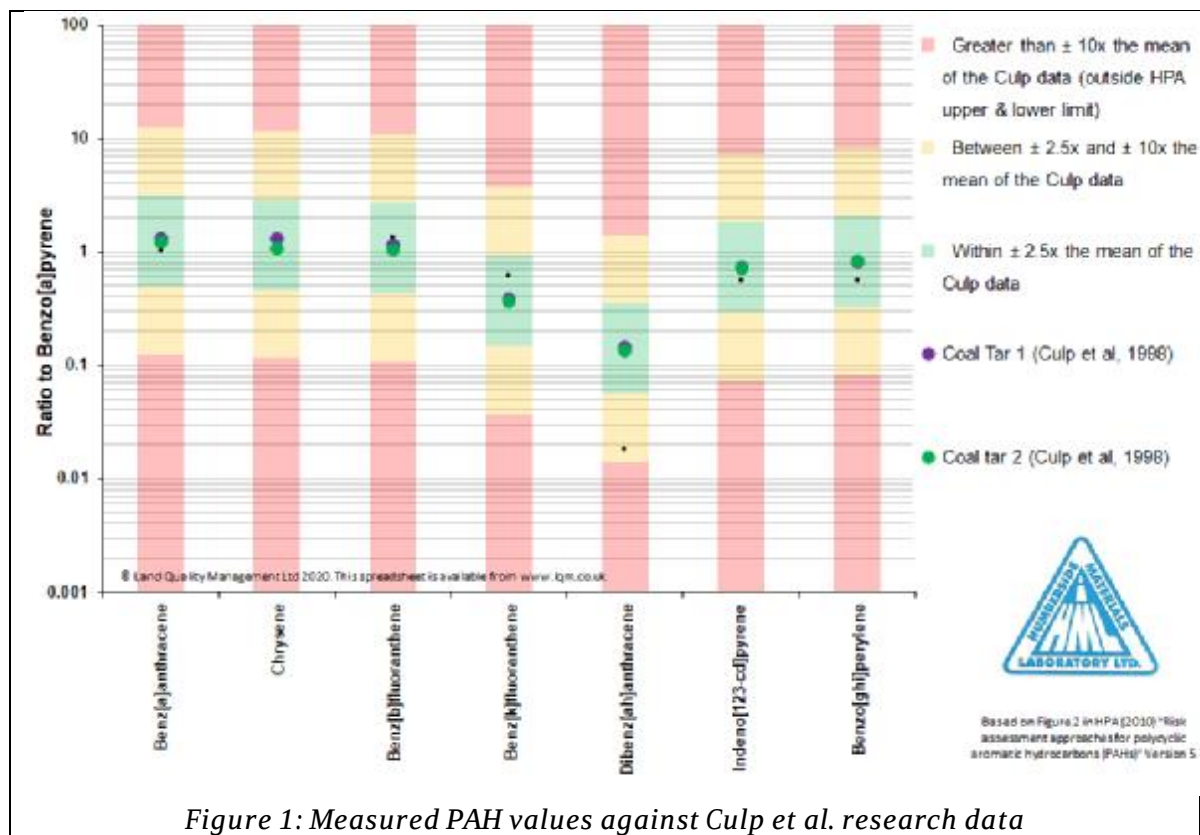
The test results show that the detected levels of PAH are all below the generic screening values. For instance, the highest measured concentration of benzo(a)pyrene was 1.1mg/kg which is below the GAC of 2.2mg/kg.

The highest measured PAH concentrations were from the near surface made ground sample from WS4. Some low concentrations were also measured in the near surface sample from WS1, which was drilled close to the site's northern boundary. Negligible concentrations were detected in the sample from WS2.

7.2.1 PAH profiling analysis

Double ratios and PAH profiling has been undertaken on the data for the sample which indicated PAHs mostly above the detection limits. This was the made ground sample from WS4 (0.1m to 0.5m bgl). The plots are shown below (in Figures 1 to 4).

Figure 1 shows the measured data generally lies reasonably close (within 2.5 times the mean) to the Culp et al. (1998) data. Only the dibenzo(a,h)anthracene is outside this factor, which is not surprising as the concentration of dibenzo(a,h)anthracene was found to be below the test detection limits. Therefore, PAH double ratio profiling should be generally applicable to the data.



The profiling plots below (Figures 2 to 4) indicate the PAH concentrations in the sample have the signature of a *carbonization or coke oven tar*. The profile clearly falls into the

category of *Grass/Wood/Coal Combustion and Coal Tar and Creosote* signatures. However, the profiles are closer to an *Urban Background* than *Creosote*.

Therefore, the source of the PAH contamination in the sample is likely to be either (A) ash or clinker from burnt wood or coal or (B) coal tar. Given the lack of asphalt in the made ground descriptions, option A (ash or clinker) seems more likely, especially when rare clinker fragments were noted in the topsoil in WS1.

It was commonplace in the 20th century to scatter ash and clinker from coal and log burning fireplaces into gardens. This acted as a fertiliser. Such domestic contamination only occasionally gives rise to levels of pollution that might pose a significant threat to human health.

It is noted that the double ratio profiles do not indicate any potential petroleum signatures.

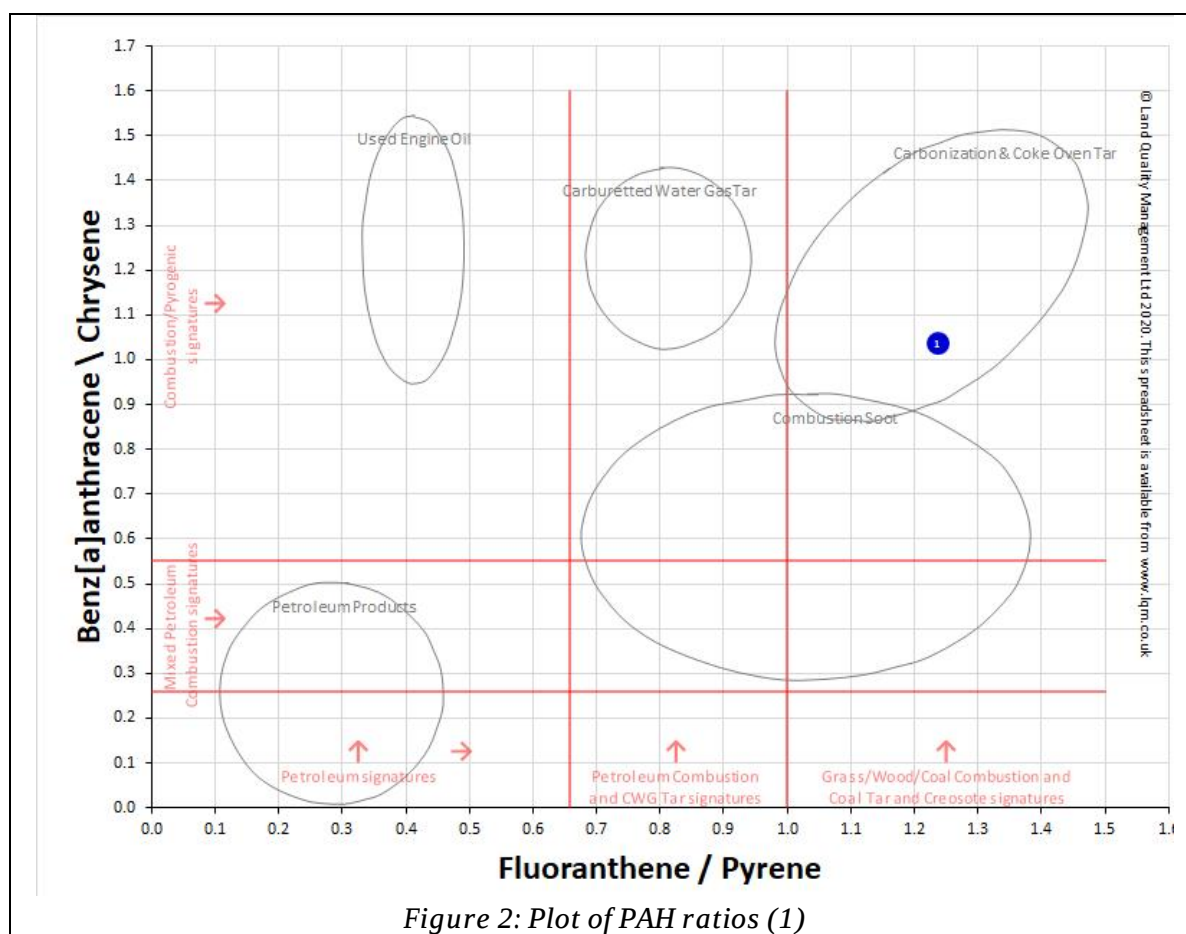
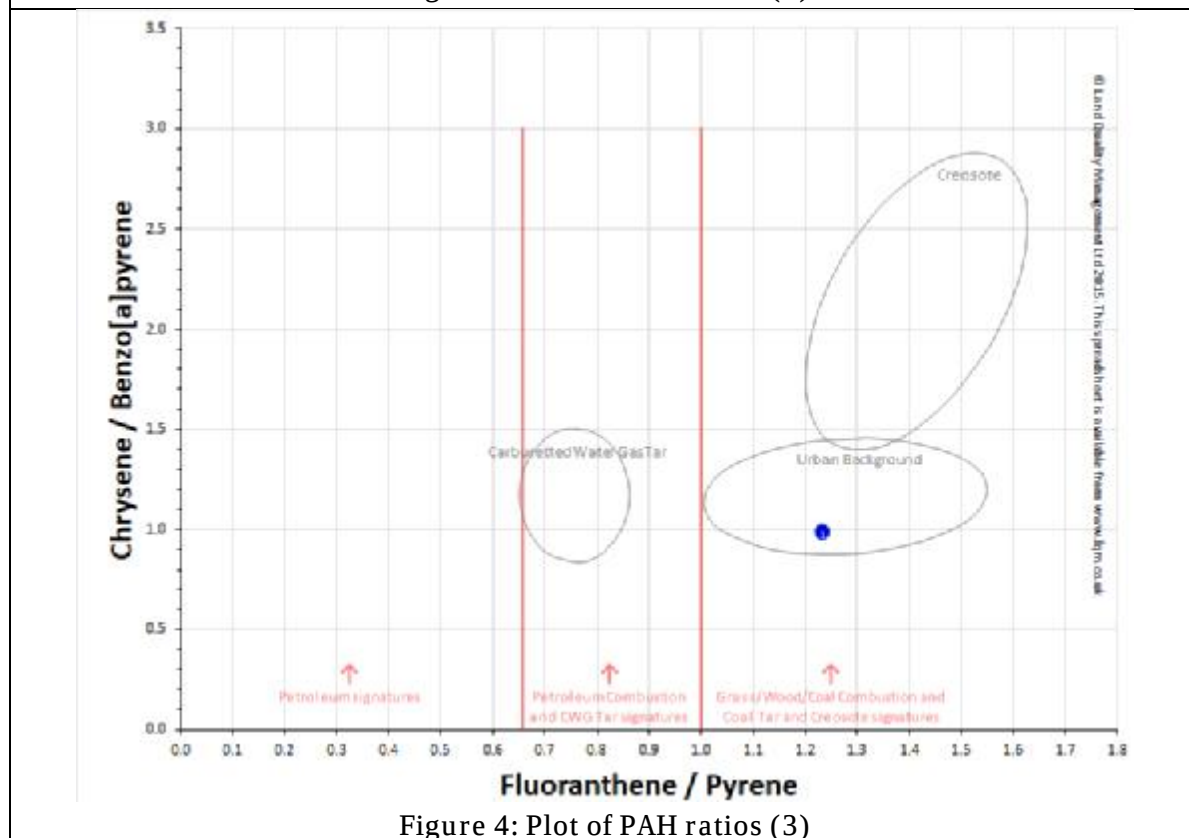
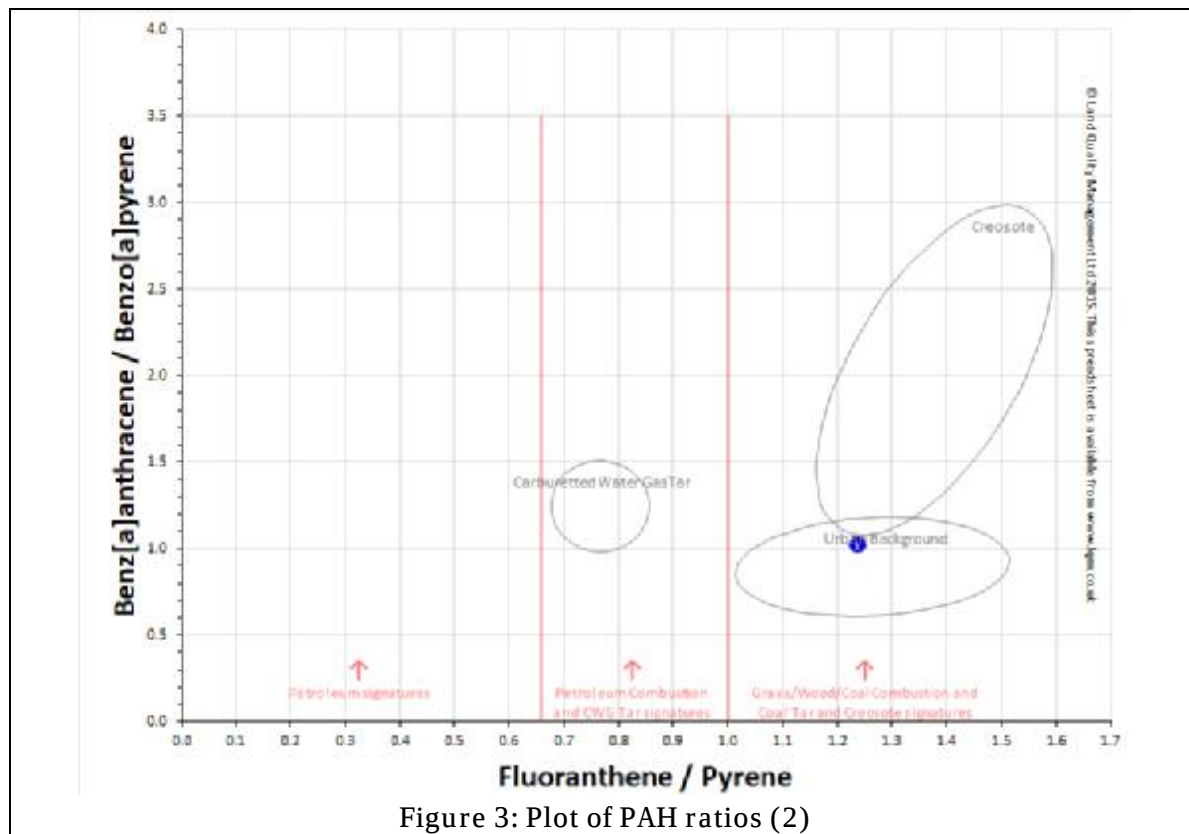


Figure 2: Plot of PAH ratios (1)



7.3 Asbestos

Three samples of near surface soils were subjected to tests for the presence of asbestos. The samples were taken from between depths of 0.1m to 0.5m bgl from boreholes WS1, WS2 and WS4. The samples from WS1 and WS2 were logged as natural soil, but the sample from WS4 was recorded as made ground.

The complete test results are presented later (in Appendix C). No asbestos fibres were detected in any of the samples.

7.4 Petroleum hydrocarbons (TPH)

Table 10 (below) gives the GAC (from LQM/CIEH, 2015) for speciated Total Petroleum Hydrocarbon (TPH) fractions in aliphatic and aromatic compounds. These vary with soil organic matter (SOM) content. At this stage, the most onerous SOM of 1% is assumed, which should be reasonably conservative.

Table 10 - Total Petroleum hydrocarbons (TPHs) generic acceptance criteria – residential with plant uptake				
Compound		1% SOM	2.5% SOM	6% SOM
TPH Aliphatic	C5-6	42	78	160
	C6-8	100	230	530
	C8-10	27	65	150
	C10-12	130 (48)	330 (118)	760 (283)
	C12-16	1100 (24)	2400 (59)	4300 (142)
	C16-35	65000 (8.5)	92000 (21)	110000
	C35-44	65000 (8.5)	92000 (21)	110000
TPH Aromatic	C5-7	70	140	300
	C7-8	130	290	660
	C8-10	34	83	190
	C10-12	74	180	380
	C12-16	140	330	660
	C16-21	260	540	930
	C21-35	1100	1500	1700
BTEX	Benzene	0.087	0.17	0.37
	Toluene	130	290	660
	Ethylbenzene	47	110	260
	O-xylene	60	140	330
	M-xylene	59	140	320
	P-xylene	56	130	310
Note: values in parentheses indicate vapour saturation limit (v) or limit of solubility (s)				

No visual or olfactory evidence was found of potential petroleum contamination during site works. Nevertheless, two samples of soils were subjected to tests for fraction of

TPHs (one sample from WS1, 0.1m to 0.5m bgl and another from WS3, 1.1m to 1.25m bgl).

The results of the TPH testing did not find any elevated levels of petroleum hydrocarbons. All measured concentrations were well below the GAC threshold values.

In fact, nearly all the fractions of TPH tested were found to be below the limit of test detection. By far the highest recorded concentrations were in the aliphatic equivalent carbon chain C16 to C35 range, where between 34mg/kg and 36mg/kg of petroleum was detected. However, such levels of contamination are considered insignificant.

8 Revised Contamination Assessment

8.1 Revised conceptual site model (CSM) and risk assessment

Based on the Phase 1 contamination assessment, findings of the site works and analysis of the contamination test data, a revised combined CSM and risk assessment has been developed, as shown below (in Table 11), based on a *source-pathway-receptor* consideration of potential pollution linkages.

Table 11: Preliminary risk assessment						
Potential source	Potential pathway	Potential receptor	Probability	Severity	Risk rating	Comments
General contaminants and made ground: metals, PAH, asbestos & TPH	Inhalation, ingestion, absorption	Future occupants	Low likelihood	Mild	Low	No elevated levels of PAH, metals or TPH detected in test samples
	Inhalation, ingestion, absorption	Construction workers	Unlikely	Mild	Very low	No asbestos fibres detected
	Aggressive attack	Building materials	Unlikely	Mild	Very low	Negligible anthropogenic material or made ground recorded. Ground material comprised almost entirely of natural soil material.
	Migration	Bedrock aquifer	Unlikely	Minor	Very low	
	Migration	Surface waters	Unlikely	Mild	Very low	
Degradable organic matter in the underlying ground: Hazardous ground gas (e.g. methane, carbon dioxide)	Migration, inhalation, explosion, combustion	Future occupants	Unlikely	Severe	Moderate / Low	Most highly organic material revealed was found to contain between 2.4% and 3.8% organic matter (1.4% to 2.2% TOC). No deep degradable made ground detected.

A risk rating of *very low* or *low* is not considered significant while a rating of *moderate* / *low* (or greater) could be potentially hazardous and the associated source-pathway-receptor is taken to be a plausible contamination linkage and in need of further consideration.

The above revised risk assessment has not identified any potentially significant pollution linkages associated with soil contamination. However, there is still the potential for ground gas generation from degradable organic matter in the underlying Tidal Flat Deposits. Therefore, at this stage, the only contamination remediation measures that should be required are gas protection measures.

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

8.2 Gas / Vapour protection measures

The only identified potentially significant source of hazardous ground gas is degradable material in the underlying ground. There are no known mine workings nearby and no radon gas protection measures are required. However, the deeper Tidal Flat Deposits drift geology beneath the site could be of significant thickness and contain much peaty or organic material even though the organic matter in the near surface soils has been tested to be no greater than 3.8% (just slightly organic).

The site is recorded to be within the southwest part of a historical landfill which was possibly associated with the former Piggery and was located adjacent to the east of the site. However, no evidence of any landfill has been found in historical mapping and there are no nearby BGS-reported landfills. Therefore, the existence of a *bona fide* landfill is in significant doubt, although it is credible that there could have been much reworked ground in the vicinity of the Piggery that gave rise to the wider area being classed as a historical landfill. Nevertheless, the alleged landfill is not considered to be a potentially significant source of hazardous ground gas; at least not compared to organic material in the underlying natural TFD soils.

A Pragmatic Approach to Ground Gas Risk Assessment, published by CL:AIRE as Research Bulletin 17 (RB17), recommends that: “Where natural sources of gas such as Alluvium, peat, etc are present provide CS2 gas protection measures” (Card *et al.*, 2012: page 4). Therefore, in the absence of gas monitoring data, CS2 classification (as per BS8485:2015+A1:2019) or Amber 1 (based on the RSK/NHBC Traffic Light system) gas protection measures should be installed.

No petroleum hydrocarbon contamination has been identified from analysis of PAH results. Also, no visual or olfactory evidence of petroleum hydrocarbons has been identified. Therefore, no hydrocarbon barrier system should be required unless unforeseen hydrocarbon contamination is encountered.

9 SUMMARY & CONCLUSIONS

9.1 Ground conditions

The findings of the investigation indicate the following general sequence of sub-strata at the site (in descending order).

- Topsoil:
 - § Across the site (in WS1 to WS3)
[to 0.2m – 0.3m bgl]
- Made ground:
 - § Mainly reworked natural soils (in WS4)
[to 0.9m bgl]
- Tidal Flat Deposits: (in WS1 to WS4)
 - § Brown silty SAND and sandy clayey SILT *[to at least 2.0m bgl]*

Standing groundwater was revealed in all four boreholes at depths ranging between 0.43m and 0.53m bgl. This is slightly shallower than in a previous investigation possibly due to heavy recent rainfalls.

9.2 Results of contamination testing

Three near surface soils samples revealed:

- no elevated metal or metalloid concentrations
- no elevated PAH concentrations
- no asbestos fibres

Two samples revealed no elevated petroleum hydrocarbons.

Two samples revealed TOC of between 1.4% and 2.2% (i.e. OMC of 2.4% to 3.8%).

PAH ratio profiling suggests that the detected PAH concentrations could originate from ash and clinker. There is no indication of petroleum hydrocarbons.

9.3 Revised contamination risk assessment

A revised risk assessment did not identify any potentially significant pollution linkages associated with soil contamination. However, there is still the potential for ground gas generation from degradable organic matter in the underlying Tidal Flat Deposits.

Nevertheless, should any unforeseen contamination encountered during the development of the site should be monitored and reported to the local authority. Work

should be halted in the area of the revealed potential contamination and the contamination investigated and assessed to the satisfaction of the local authority.

9.4 Gas / Vapour protection measures

The only identified potentially significant source of hazardous ground gas is degradable material in the deeper Tidal Flat Deposits drift geology beneath the site which could contain much peaty or organic material. This is the case even though the most organic soils in the near surface have been tested to contain no more than 3.8% organic matter.

Accordingly, in the absence of gas monitoring data, CS2 classification (as per BS8485:2015+A1:2019) or Amber 1 (based on RSK/NHBC Traffic Light system) gas protection measures should be installed. This is based on recommendations by CL:AIRE in RB17 (2012).

No hydrocarbon barrier system should be required unless unforeseen hydrocarbon contamination is encountered.

- End of Report -

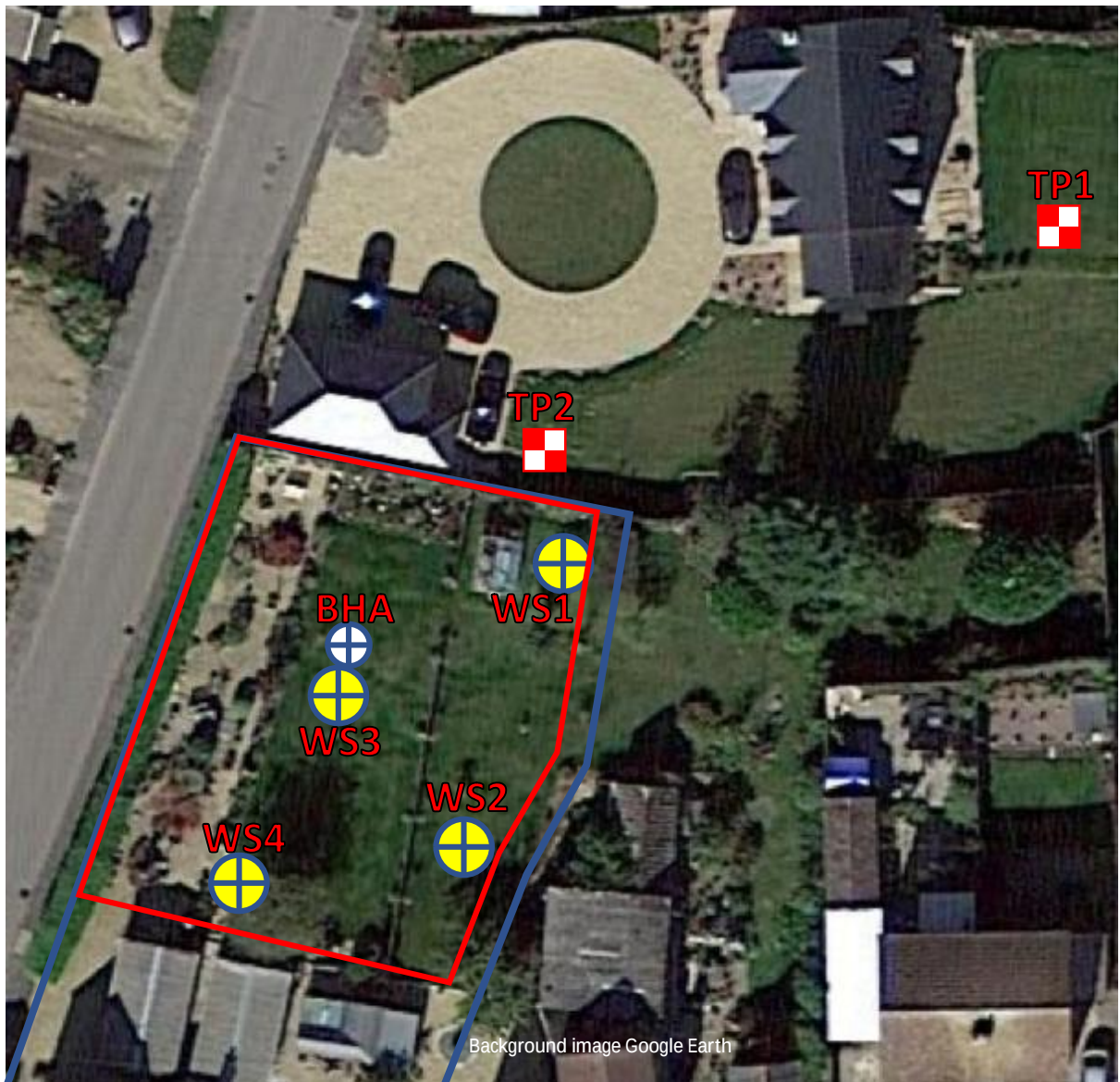
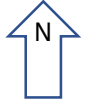
10 References

- Boyle, R. and Witherington, P. (2007) Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating 'traffic lights' Report Edition No.: 04 for National House Building Council and RSK Group PLC, March 2007.
- Bowles, J. E. (1996) Foundation Analysis and Design, 5th Edn. McGraw-Hill, New York, NY, USA.
- BRE Special Digest 1 (2005) Concrete in Aggressive Ground, British Research Establishment.
- BS 5930 (2015) Code of Practice for Site Investigations, British Standards Institute.
- BS 10175:2011 (plus A1:2013) Investigation of potentially contaminated sites – code of practice, British Standards Institute
- BS8485 (2015) Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, British Standards Institute
- Card G, Wilson S, Mortimer S. (2012) A Pragmatic Approach to Ground Gas Risk Assessment. CL:AIRE Research Bulletin RB17. CL:AIRE, London, UK.
- CLEA documents published by DEFRA and the Environment Agency.
- Culp, S.J., Gaylor, D.W., Sheldon, W.G. Goldstein, L.W., Beland, F.A. (1998) A comparison of the tumors induced by coal tar and benzo(a)pyrene in a 2-year bioassay. *Carcinogenesis*, 19, 117-124.
- EA/Defra (2004) Model Procedures for the Management of Land Contamination, Contaminated Land Report 11, Environment Agency, Department for Environment Food and Rural Affairs. Bristol: Environment Agency.
- Garvin, S. L. (2016) Soakaway Design, BRE Digest 365. British Research Establishment.
- Harris, M. R., Herbert, S. M. and Smith, M. A. (2005) Remedial treatment for contaminated land, Vols I-XII, CIRIA Special Publication 164. London: CIRIA.
- Johnson, R. (2001) BRE 414: Protective Measures for Housing on Gas Contaminated Land. British Research Establishment.
- Irvine, D. J. & Smith, R. J. (1992) CIRIA Report 97 - Trenching Practice – 2nd Edition.
- LQM/CIEH S4Uls for human health risk assessment
- Mallett, H, Cox (nee Taffel-Andureau), L, Wilson, S, Corban, M (2014) *Good practice on the testing and verification of protection systems for buildings against hazardous ground gases*, CIRIA, C735, London (ISBN: 978-0-86017-739-5). Go to: www.ciria.org
- NHBC (2018) NHBC Standards. Available online at <http://www.nhbc.co.uk/>
- Pecksen G N. (1986) Methane and the Development of Derelict Land London Environmental Supplement, Summer 1985, No.13 London Scientific Services, Land Pollution Group
- Rudland, D. J., Lancefield, R. M., Mayell, P. N. (2001) CIRIA C552 Contaminated Land Risk Assessment: A guide to good practice, London: CIRIA.
- Stroud, M. A. (1974) "The standard penetration test in insensitive clays and soft rock," Proceedings of the 1st European Symposium on Penetration Testing, Sweden: Stockholm, vol. 2(2), 367-375.
- Tomlinson, M. J. (2001) Foundation Design and Construction, 7th Edition. London: Pearson.
- Wilson, S; Oliver, S; Mallett, H; Hutchings, H; Card, G (2007) CIRIA C665: Assessing risks posed by hazardous ground gases to buildings. London: CIRIA.
- Wilson S and Card G. (1999) Reliability and risk in gas protection design. *Ground Engineering*, February 1999 pp 32 to 36 and clarification article in the News Section of *Ground Engineering*, March 1999
- YALPAG (2015) Verification Requirements for Gas Protection Systems, Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG). Available online
- YALPAG (2017) Verification Requirements for Cover Systems: Technical Guidance for Developers, Landowners and Consultants (Version 3.4, November 2017) Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG). Available online
- YALPAG (2018) Development on Land Affected by Contamination: Technical Guidance for Developers, Landowners and Consultants (Version 9.2, March 2018), Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG). Available online

Appendix A
Plans & Photographs

Notes:

1. Do not scale
2. Locations of all features are approximate only



HUMBERSIDE MATERIALS LABORATORY LIMITED

Atherton Way
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www.humbersidematerialslab.co.uk



Drawing Title: Borehole location plan

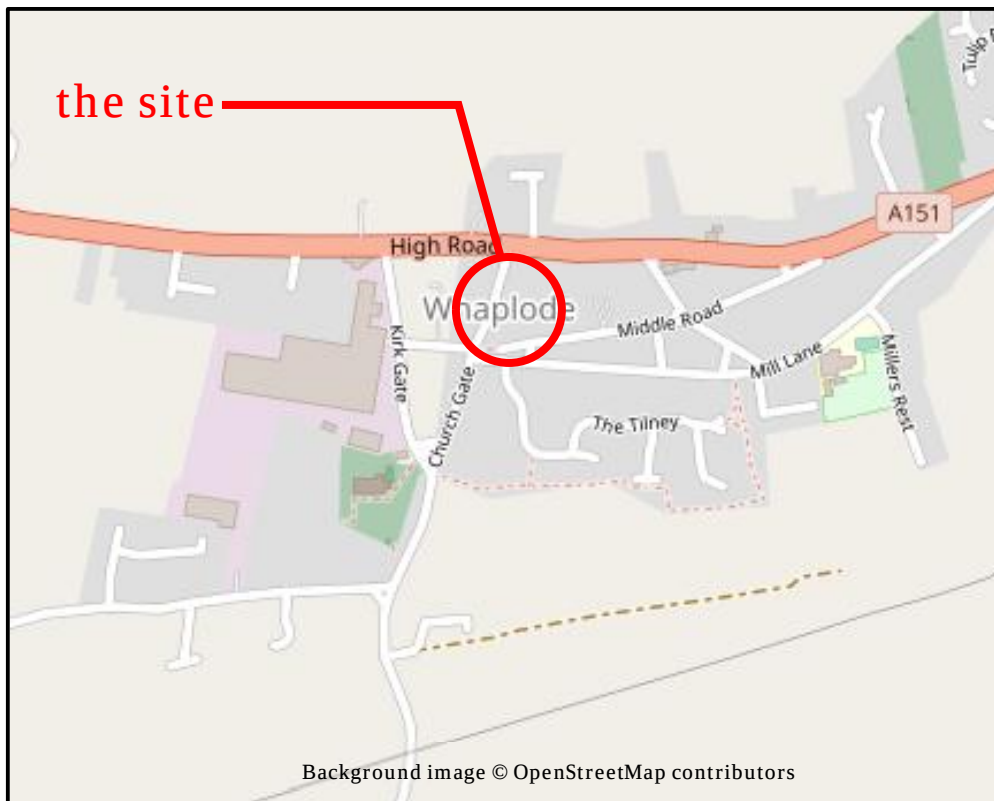
Drawing No.: 0991-4873-P2-01 *Revision:* 0

Site: Corner House, Church Gate, Whaplode

Client: Mr & Mrs Graves

Project No.: 0991/4873/P

Date: 12/03/2020



Location plan



Recent (Google Earth) aerial view of the site

Appendix B

Exploratory hole logs



HUMBERSIDE MATERIALS LABATORY Ltd.

Atherton Way, Brigg
North Lincs DN20 8AR
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BOREHOLE LOG

Borehole
No
WS1

Client :- Mr & Mrs Graves

Site :- Corner House, Whaplode

Project No :- 4873

Location :- see site plan

Date :- 26-Feb-20

Coordinates E: 532520 N: 324239

Elevation :-

Excavated by :- Dando Terrier

Drilled by :- RL & MBP

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Dark brown very silty locally clayey SILT with occasional rootlets and occasional stone gravel and rare clinker fragments. (TOPSOIL)	0	0.20	WS1-1 D				
0.2	Soft brown slightly sandy clayey SILT with occasional rootlets. Sand is fine.	0.2						
0.4		0.4						
0.6		0.6	0.70		0.53m: 20 mins after drilling			
0.8		0.8						
1	Dark greyish black slightly sandy SILT. Sand is fine. Slight organic odour.	1		WS1-2 D				
1.2		1.2						
1.4		1.4	1.10					
1.6		1.6						
1.8		1.8						
2		2						
2.2		2.2						
2.4		2.4						
2.6		2.6						
2.8		2.8						

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

Notes :-

Depth drilled :- 2
Casing depth :- 0

File Ref :- 991/ 4873
Logged by :- MBP



HUMBERSIDE MATERIALS LABATORY Ltd.

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North Lincs DN20 8AR
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BOREHOLE LOG

Borehole
No
WS1

Client :- Mr & Mrs Graves

Site :- Corner House, Whaplode

Project No :- 4873

Location :- see site plan

Date :- 26-Feb-20

Coordinates E: 532520 N: 324239

Elevation :-

Excavated by :- Dando Terrier

Drilled by :- RL & MBP

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Dark brown locally clayey SILT with occasional rootlets and occasional stone gravel and rare clinker fragments. (TOPSOIL)	0	0.20	WS1-1 D				
0.2	Soft brown slightly sandy clayey SILT with occasional rootlets. Sand is fine.	0.2	0.70		0.53m: 20 mins after drilling			
0.4		0.4						
0.6		0.6						
0.8		0.8						
0.9	Dark greyish black slightly sandy SILT. Sand is fine. Slight organic odour.	0.9	1.10	WS1-2 D				
1		1						
1.2		1.2						
1.4		1.4						
1.6		1.6						
1.8		1.8						
2		2						
2.2		2.2						
2.4		2.4						
2.6		2.6						
2.8		2.8						

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

Notes :-

Depth drilled :- 2
Casing depth :- 0

File Ref :- 991/ 4873
Logged by :- MBP



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BOREHOLE LOG

Borehole
No
WS2

Client :- Mr & Mrs Graves

Site :- Corner House, Whaplode

Project No :- 4873

Location :- see site plan

Date :- 26-Feb-20

Coordinates E: 532514 N: 324223

Elevation :-

Excavated by :- Dando Terrier

Drilled by :- RL & MBP

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Dark brown very silty locally clayey SILT with occasional rootlets and occasional stone gravel. (TOPSOIL)	0						
0.2		0.2	0.30	WS2-1 D	0.45m: 20 mins after drilling			
0.4	Orangish greyish brown very silty fine SAND.	0.4	0.30					
0.6		0.6						
0.8	Brown slightly sandy SILT. Sand is fine.	0.8						
1.0		1.0	0.80					
1.2		1.2						
1.4		1.4						
1.6	Dark greyish black slightly sandy SILT. Slight organic odour.	1.6	0.60	WS2-2 D				
1.8		1.8						
2.0		2.0						
2.2		2.2						
2.4		2.4						
2.6		2.6						
2.8		2.8						

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

Notes :-

Depth drilled :- 2
Casing depth :- 0

File Ref :- 991/ 4873
Logged by :- MBP



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BOREHOLE LOG

Borehole
No
WS3

Client :- Mr & Mrs Graves

Site :- Corner House, Whaplode

Project No :- 4873

Location :- see site plan

Date :- 26-Feb-20

Coordinates E: 532507 N: 324232

Elevation :-

Excavated by :- Dando Terrier

Drilled by :- RL & MBP

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Dark brownish grey clayey SILT with occasional rootlets. (TOPSOIL)	0	0.20					
0.2	Soft dark brownish grey slightly sandy clayey SILT with rare rootlets. Sand is fine.	0.2	0.50	WS3-1 D				
0.4		0.4						
0.6		0.6						
0.7	Soft grey mottled orangish brown clayey SILT.	0.7	0.40					
0.8		0.8						
1		1						
1.1	Soft dark blackish grey clayey SILT.	1.1	0.15	WS3-2 D				
1.2	Brown slightly grey SILT	1.25						
1.4		1.4						
1.6		1.6	0.75					
1.8		1.8						
2		2						
2.2		2.2						
2.4		2.4						
2.6		2.6						
2.8		2.8						

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

Notes :-

Depth drilled :- 2
Casing depth :- 0

File Ref :- 991/ 4873
Logged by :- MBP



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North Lincs DN20 8AR
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BOREHOLE LOG

Borehole
No
WS4

Client :- Mr & Mrs Graves

Site :- Corner House, Whaplode

Project No :- 4873

Location :- see site plan

Date :- 26-Feb-20

Coordinates E: 532502 N: 324221

Elevation :-

Excavated by :- Dando Terrier

Drilled by :- RL & MBP

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT	SH DCP	Notes
0	Dark brown clayey SILT with occasional rootlets. Piece of wood at 0.2m bgl. (TOPSOIL)	0	0.20	WS4-1 D	0.43m: 20 mins after drilling			
0.2	Soft greyish brown clayey SILT with occasional rootlets. Clay pipe at 0.7m bgl (possible land drain). Gravel-sized piece of flint at 0.9m bgl. (MADE GROUND)	0.2	0.70	WS4-2 D				
0.4		0.4						
0.6		0.6						
0.8		0.8						
0.9	Dark brownish grey SILT.	0.9	0.80	WS4-3 D				
1		1						
1.2		1.2						
1.4		1.4						
1.6		1.6						
1.7	Soft dark blackish grey slightly organic slightly sandy clayey SILT. Sand is fine. Organic matter is fibrous peat.	1.7	0.20					
1.8		1.8						
1.9	Dark brownish grey SILT.	1.9	0.10					
2		2						
2.2		2.2						
2.4		2.4						
2.6		2.6						
2.8		2.8						

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

Notes :-

Depth drilled :- 2
Casing depth :- 0

File Ref :- 991/ 4873
Logged by :- MBP

Appendix C

Test results



ANALYTICAL TEST REPORT

Contract no: 84839

Contract name: Church Gate, Whaplode

Client reference: 991/4873/P

Clients name: Humberside Materials Laboratory

Clients address: Atherton Way
Brigg
North Lincolnshire
DN20 8AR

Samples received: 02 March 2020

Analysis started: 02 March 2020

Analysis completed: 09 March 2020

Report issued: 09 March 2020

Notes: Opinions and interpretations expressed herein are outside the UKAS accreditation scope.
Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling.
All testing carried out at Unit 6 Parkhead, Stanley, DH9 7YB, except for subcontracted testing.
Methods, procedures and performance data are available on request.
Results reported herein relate only to the material supplied to the laboratory.
This report shall not be reproduced except in full, without prior written approval.
Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed.

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

Approved by:

Karan Campbell
Director

Chemtech Environmental Limited

SAMPLE INFORMATION

MCERTS (Soils):

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

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

Analytical results are inclusive of stones.

Lab ref	Sample id	Depth (m)	Sample description	Material removed	% Removed	% Moisture
84839-1	S/55453	0.10-0.50	Sandy Clay with Gravel & Roots	-	-	23.2
84839-2	S/55454	0.10-0.50	Sandy Clay with Gravel & Roots	-	-	25.8
84839-3	S/55455	1.10-1.25	Sandy Clay with Gravel	-	-	28.1
84839-4	S/55456	0.10-0.50	Sandy Clay with Gravel & Roots	-	-	25.9
84839-5	S/55457	1.70-1.90	Sandy Clay with Gravel	-	-	27.4

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SOILS

Lab number Sample id Location Depth (m) Date sampled			84839-1 S/55453 WS1-1 0.10-0.50 26/02/2020	84839-2 S/55454 WS2-1 0.10-0.50 26/02/2020	84839-3 S/55455 WS3-2 1.10-1.25 26/02/2020	84839-4 S/55456 WS4-1 0.10-0.50 26/02/2020	84839-5 S/55457 WS4-3 1.70-1.90 26/02/2020
Test	Method	Units			-		
Arsenic (total)	CE127 ^M	mg/kg As	7.5	11	-	6.9	-
Beryllium (total)	CE127 ^U	mg/kg Be	<1	<1	-	2.0	-
Boron (water soluble)	CE063 ^M	mg/kg B	0.6	1.2	-	1.7	-
Cadmium (total)	CE127 ^M	mg/kg Cd	<0.2	<0.2	-	1.6	-
Chromium (total)	CE127 ^M	mg/kg Cr	14	25	-	29	-
Copper (total)	CE127 ^M	mg/kg Cu	25	17	-	40	-
Lead (total)	CE127 ^M	mg/kg Pb	174	55	-	101	-
Mercury (total)	CE127 ^M	mg/kg Hg	<0.5	<0.5	-	0.7	-
Nickel (total)	CE127 ^M	mg/kg Ni	11	17	-	18	-
Selenium (total)	CE127 ^M	mg/kg Se	0.6	0.8	-	2.0	-
Vanadium (total)	CE127 ^M	mg/kg V	20	27	-	33	-
Total Organic Carbon (TOC)	CE072 ^M	% w/w C	-	-	2.2	-	1.4
PAH							
Naphthalene	CE087 ^M	mg/kg	<0.02	<0.02	-	<0.02	-
Acenaphthylene	CE087 ^M	mg/kg	<0.02	<0.02	-	<0.02	-
Acenaphthene	CE087 ^M	mg/kg	<0.02	<0.02	-	<0.02	-
Fluorene	CE087 ^U	mg/kg	<0.02	<0.02	-	0.04	-
Phenanthrene	CE087 ^M	mg/kg	0.20	0.18	-	0.68	-
Anthracene	CE087 ^U	mg/kg	<0.02	<0.02	-	0.17	-
Fluoranthene	CE087 ^M	mg/kg	0.56	<0.02	-	2.09	-
Pyrene	CE087 ^M	mg/kg	0.39	<0.02	-	1.69	-
Benzo(a)anthracene	CE087 ^U	mg/kg	0.33	<0.02	-	1.12	-
Chrysene	CE087 ^M	mg/kg	0.33	<0.03	-	1.08	-
Benzo(b)fluoranthene	CE087 ^M	mg/kg	0.41	<0.02	-	1.47	-
Benzo(k)fluoranthene	CE087 ^M	mg/kg	0.19	<0.03	-	0.62	-
Benzo(a)pyrene	CE087 ^U	mg/kg	0.31	<0.02	-	1.10	-
Indeno(123cd)pyrene	CE087 ^M	mg/kg	<0.02	<0.02	-	0.62	-
Dibenz(ah)anthracene	CE087 ^M	mg/kg	<0.02	<0.02	-	<0.02	-
Benzo(ghi)perylene	CE087 ^M	mg/kg	<0.02	<0.02	-	0.67	-
PAH (total of USEPA 16)	CE087	mg/kg	2.72	<0.34	-	11.3	-
TPH							
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	<0.01	-	<0.01	-	-
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	<0.01	-	<0.01	-	-
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	<0.01	-	<0.01	-	-
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	<1	-	<1	-	-
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	<1	-	<1	-	-
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	2	-	<1	-	-
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	3	-	<1	-	-
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	<1	-	<1	-	-
VPH Aliphatic (>C5-C6)	CE067	mg/kg	<0.1	-	<0.1	-	-

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SOILS

Lab number			84839-1	84839-2	84839-3	84839-4	84839-5
Sample id			S/55453	S/55454	S/55455	S/55456	S/55457
Location			WS1-1	WS2-1	WS3-2	WS4-1	WS4-3
Depth (m)			0.10-0.50	0.10-0.50	1.10-1.25	0.10-0.50	1.70-1.90
Date sampled			26/02/2020	26/02/2020	26/02/2020	26/02/2020	26/02/2020
Test	Method	Units			-		
VPH Aliphatic (>C6-C8)	CE067	mg/kg	<0.1	-	<0.1	-	-
VPH Aliphatic (>C8-C10)	CE067	mg/kg	<0.1	-	<0.1	-	-
EPH Aliphatic (>C10-C12)	CE068	mg/kg	<4	-	<4	-	-
EPH Aliphatic (>C12-C16)	CE068	mg/kg	<4	-	6	-	-
EPH Aliphatic (>C16-C35)	CE068	mg/kg	36	-	34	-	-
EPH Aliphatic (>C35-C44)	CE068	mg/kg	<10	-	<10	-	-
Subcontracted analysis							
Asbestos (qualitative)	\$	-	NAD	NAD	-	NAD	-

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METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE127	Arsenic (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg As
CE127	Beryllium (total)	Aqua regia digest, ICP-MS	Dry	U	1	mg/kg Be
CE063	Boron (water soluble)	Hot water extract, ICP-OES	Dry	M	0.5	mg/kg B
CE127	Cadmium (total)	Aqua regia digest, ICP-MS	Dry	M	0.2	mg/kg Cd
CE127	Chromium (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cr
CE127	Copper (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Cu
CE127	Lead (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Pb
CE127	Mercury (total)	Aqua regia digest, ICP-MS	Dry	M	0.5	mg/kg Hg
CE127	Nickel (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg Ni
CE127	Selenium (total)	Aqua regia digest, ICP-MS	Dry	M	0.3	mg/kg Se
CE127	Vanadium (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg V
CE072	Total Organic Carbon (TOC)	Removal of IC by acidification, Carbon Analyser	Dry	M	0.1	% w/w C
CE087	Naphthalene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Acenaphthylene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Acenaphthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Fluorene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Phenanthrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Anthracene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Fluoranthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(a)anthracene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Chrysene	Solvent extraction, GC-MS	As received	M	0.03	mg/kg
CE087	Benzo(b)fluoranthene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(k)fluoranthene	Solvent extraction, GC-MS	As received	M	0.03	mg/kg
CE087	Benzo(a)pyrene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Indeno(123cd)pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Dibenz(ah)anthracene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(ghi)perylene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	PAH (total of USEPA 16)	Solvent extraction, GC-MS	As received		0.34	mg/kg
CE067	VPH Aromatic (>EC5-EC7)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC7-EC8)	Headspace GC-FID	As received		0.01	mg/kg
CE067	VPH Aromatic (>EC8-EC10)	Headspace GC-FID	As received		0.01	mg/kg
CE068	EPH Aromatic (>EC10-EC12)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC12-EC16)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC16-EC21)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC21-EC35)	Solvent extraction, GC-FID	As received		1	mg/kg
CE068	EPH Aromatic (>EC35-EC44)	Solvent extraction, GC-FID	As received		1	mg/kg
CE067	VPH Aliphatic (>C5-C6)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C6-C8)	Headspace GC-FID	As received		0.1	mg/kg
CE067	VPH Aliphatic (>C8-C10)	Headspace GC-FID	As received		0.1	mg/kg
CE068	EPH Aliphatic (>C10-C12)	Solvent extraction, GC-FID	As received		4	mg/kg
CE068	EPH Aliphatic (>C12-C16)	Solvent extraction, GC-FID	As received		4	mg/kg
CE068	EPH Aliphatic (>C16-C35)	Solvent extraction, GC-FID	As received		4	mg/kg
CE068	EPH Aliphatic (>C35-C44)	Solvent extraction, GC-FID	As received		10	mg/kg

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METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
\$	Asbestos (qualitative)	HSG 248, Microscopy	Dry	U	-	-

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DEVIATING SAMPLE INFORMATION

Comments

Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.

For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.

Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

Key

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

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
84839-1	S/55453	0.10-0.50	N	
84839-2	S/55454	0.10-0.50	N	
84839-3	S/55455	1.10-1.25	N	
84839-4	S/55456	0.10-0.50	N	
84839-5	S/55457	1.70-1.90	N	