



Phase 2 (site investigation) report

9a Darwin Street, Kirton in Lindsey

Produced for C & K Builders

July 2019

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Phase 2 (site investigation) report

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EXECUTIVE SUMMARY

<i>Proposed works</i>	Redevelopment of previous commercial site into two semi-detached dwellings with front and rear gardens.
<i>Site history</i>	19 th century: domestic building in southwest corner and water well. Recent decades: workshop, offices and storage for construction company
<i>Site topography</i>	Flat and level ground about 30m above Ordnance Datum (AOD). Site is on a hillside location, with ground levels rising to the east.
<i>Hydrology</i>	The nearest identified surface water feature is located about 253m south of the site The site is in a Flood Zone 1 – low risk of flooding
<i>Ground conditions</i>	Topsoil – only revealed in BH1 – to max. depth of 0.1m below ground level (bgl) Hardstanding of gravel or concrete – in BH3 & BH4 – to max. depth of 0.1m bgl Made ground – silts, clays and gravels including stone, brick, concrete, blastfurnace slag– to max. depth of 1.1m bgl Charmouth Mudstone Formation (CMF) – soft (sandy) silts and clays with bands of sands and gravels – proven to at least 2.5m bgl
<i>Groundwater</i>	Standing groundwater was observed in BH1 and BH3 at depths of 1.4m and 2.0m bgl. None was observed in BH2 and BH4.
<i>Contamination test results</i>	Slightly elevated PAHs in BH2. Potentially elevated in mound. Detected PAHs could be of ash and clinker or coal tar origin. Asbestos (chrysotile, loose) found in BH2 Slightly elevated lead in shallow natural soil in BH4 No elevated TPH contamination measured. However, some suspected traces of red diesel were detected.
<i>Revised conceptual site model and risk assessment</i>	Potentially significant risks to human health due to contamination in near surface soils. Exposure pathway is in or via garden areas.
<i>Remediation strategy</i>	Remove made ground from garden areas. Replace with proven clean inert soil. Install barrier system.
<i>Gas protection measures</i>	No radon protection needed. No gas source identified. CIRIA classification: CS1. NHBC traffic light classification: Green

1 Introduction

The client, C & K Builders, has engaged Humberside Materials Laboratory Limited (HML) to undertake a Phase 2 site investigation for a proposed development on land at 9a Darwin Street, Kirton in Lindsey, North 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.

1.2 Scope

The scope of the investigation includes:

- Intrusive borehole investigation works
- Geochemical laboratory testing
- 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.

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

The main source of desk study information to complete this report is an HML Phase 1 Desk Study report dated January 2019 (HML ref.: 1166/4758/P1/P, Revision A). The Phase 1 report contains a Landmark Envirocheck Report with historical maps dated 15th January 2010 (Landmark ref.: 191150112_1_1).

Additional reviewed desk study information includes the site examination (including notes and photographs) during the recent site works (22nd May 2019).

2.1 The site

2.1.1 Location and size

The site is the plot of land at 9a Darwin Street, which is located on the north side of Darwin Street, Kirton in Lindsey, North Lincolnshire, DN21 4BZ. The site is centred around national grid reference (NGR) 493287, 398801.

The site is roughly rectangular. It is about 35m long and about 15m wide.

A site location plan is included in Appendix A.

2.1.2 Site features

The site was found to be similar to the description and photos found in the Phase 1 desk study report.

There are no significant above-ground features on the site, apart from a site stockpile / mound of topsoil in the northeast corner of the site and a raised bed of soil in the extreme east of the site.

The ground surface includes some concrete flooring in the southwest part of the site, some gravel hardstanding in the east part of the site and some grassy bare earth to the rear of the site and in other places.

The site's entrance is marked a swinging metal barrier. The west, north and east boundaries are defined by a combination of brick and masonry walls, tree and shrub vegetation, timber fencing and existing brick buildings.

There is a row of leylandii inside the rear boundary of the site, which are within a 1m-high raised bed. There is also a tall tree (of unknown type) close to the east boundary in the north of the site.

The front (south) of the site adjoins Darwin Street pavement and carriageway. There is a drop kerb permitting vehicle access.

No visual or olfactory evidence of potential contamination was noted during the site works. No surface staining was noticed or evidence of vegetative distress. No tanks or containers for liquid storage were found. No unusual odour was detected.

Photographs of the site are presented in the Phase 1 report.

2.1.3 Adjacent land use

North: Residential low rise housing

East: Residential low rise housing

South: Darwin Street, beyond which is more housing and domestic garages

West: Residential low rise housing

2.1.4 Site topography

The site is relatively flat and level and the average ground level is estimated to be about 30m above Ordnance Datum. However, there is a slight change of ground levels such that the east boundary of the site is raised about 0.5m to 1.0m higher than the west side.

Beyond the site's boundaries, the land is sloped slightly as the site is partway up the west side of a hill. The hillside location means ground levels near the site fall towards the west (and rise towards the east) and they do so at an average gradient of about 1 in 15.

2.2 Proposed development

Proposals are to construct a pair of low-rise semi-detached houses on the site. These would include front and rear gardens with off-road parking to the front.

It is unders

2.3 Site history

Early maps (e.g. from 1906) show there was (part of) a previous building in the far southwest corner of the site. There was also a pump or well in the south of the site. It is possible the site was part of a domestic property.

Some more recent mapping (e.g. from 1972 to 1987) show a very small structural extension to the rear and side of the existing building (in the front left corner of the site). However, this feature has gone from later maps (e.g. 1994).

Mapping dated 1995 shows the previous main building on site in the rear and right side of the site. This is presumably the larger commercial building shown in Google Streetview dated April 2009. The main building was evidently a portal frame structure with metal cladding. This was probably a workshop, office and storage building.

The 2009 Google Streetview shows the older building in the front left corner of the site has likely been largely demolished and rebuilt during its long history. The walls were mainly of modern masonry and the roofing was a combination of cement and steel corrugated sheets (possibly asbestos-containing).

The 2009 Google Streetview also appears to show a steel bowser or tank to the rear of the older building. This could have been used to store and transport water or some other fluid, possibly fuel.

The 2009 Google Streetview shows the front right side (i.e. southeast part) of the site was used for vehicle access and parking. Other parts of the site could have been used for the storage of construction materials.

2.4 Geology

2.4.1 *Made ground*

Some limited made ground at the site is possible. This could include construction waste associated with the redevelopment of the older former site building as well as waste from the land use and the recent demolition.

The depth of made ground is unknown. Nevertheless, no previous pits, underground workings or excavations have been identified within the site. Therefore, the anticipated depth of made ground is less than 1m, although this is subject to confirmation by site works.

2.4.2 *Drift deposits*

BGS mapping does not indicate any superficial drift deposits (i.e. soils transported by water, ice or wind) at the site. Therefore, the shallow natural soils are expected to be residual soils (i.e. weathered down in-situ bedrock).

2.4.3 *Solid geology*

BGS mapping indicates the site is underlain by the uppermost parts of the Charmouth Mudstone Formation. Therefore, this formation is likely to be present beneath the site to significant depth.

The BGS website describes the Charmouth Mudstone Formation as follows.

Dark grey laminated shales, and dark, pale and bluish grey mudstones; locally concretionary and tabular limestone beds; abundant argillaceous limestone, phosphatic or ironstone (sideritic mudstone) nodules in some areas; organic-rich paper shales at some levels; finely sandy beds in lower part in some areas.

2.5 Hydrogeology

The depth to groundwater is not known. However, it is unlikely to be shallow given the hillside location of the site.

The underlying mudstone is likely to be of very low to low permeability. It is not a significant aquifer. Nevertheless, the site is reportedly within a source protection zone (Zone II and Zone III).

The nearest reported (not revoked) water abstraction lies over 1.2km southeast of the site.

2.6 Hydrology

The nearest identified surface water feature is located about 253m south of the site. This appears to be a (possibly spring-fed) small brook or beck which runs past the local sewage works.

The site is in a Flood Zone 1 according to the Environment Agency's Flood Map for Planning (Rivers and Sea). Land and property in Flood Zone 1 have a low risk of flooding.

2.7 Waste

The nearest historical landfill site is reported to be 869m east of the site. There are no BGS-recorded, local authority-recorded or registered landfill sites within 1km of the site.

2.8 Radon gas

The site is not in an area that is affected by radon. There is **no requirement** from Building Regulations to install radon protection measures in new buildings and extensions at the site.

2.9 Mining

No significant risk has been found of coal mining or other mining in the area.

2.10 Industrial land use

Little evidence of industrial activity has been found in the area of the site. The site is located in a rural residential village location. There are no nearby petrol stations within 500m of the site.

2.11 Anticipated ground conditions

Based on the above information, the anticipated ground conditions are as shown below (in Table 1).

Table 1: Anticipated geology (subject to confirmation with site works)		
<i>Strata</i>	<i>Description</i>	<i>Anticipated depth to base of stratum (m bgl)</i>
MADE GROUND	Possible construction waste	<1
CHARMOUTH MUDSTONE FORMATION	Silts/clays (possibly with bands of weathered limestone/ironstone) grading into firmer less weathered mudstone.	20
Groundwater table: not shallow		

3 Preliminary contamination assessment

The HML Phase 1 (desk study) report 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.

3.1 Initial conceptual site model

The Phase 1 conceptual site model identified potential sources of contamination at the site, as shown below (in Table 2).

<i>Location</i>	<i>Source</i>	<i>Potential contaminants</i>			
		<i>Metals</i>	<i>PAHs</i>	<i>TPH/ BTEX</i>	<i>asbestos</i>
On-site	Made ground	P	P		P
	Former land use. Storage from bowser / tank			P	
	Stockpile	P	P	P	P
Off-site	None identified				

Contamination pathways for consideration included ingestion (via plant uptake), absorption (via dermal contact), inhalation and migration.

Identified receptors consisted of humans (e.g. future site users and ground workers), groundwater, wildlife, surface water, adjacent property and building materials.

3.2 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 3).

Table 3: Conceptual site model and Preliminary risk assessment

<i>Potential source</i>	<i>Potential pathway</i>	<i>Potential receptor</i>	<i>Probability</i>	<i>Severity</i>	<i>Risk rating</i>	<i>Comments</i>
Metals and PAH – general contamination	Inhalation, ingestion, absorption	Future occupants	Low likelihood	Mild	Low	Unknown above ground tank.
	Inhalation, ingestion, absorption	Construction workers	Unlikely	Minor	Very low	Hardstanding will afford some protection
	Aggressive attack	Building materials	Unlikely	Minor	Very low	
	Migration	Bedrock aquifer	Unlikely	Minor	Very low	
	Migration	Surface waters	Unlikely	Minor	Very low	
Asbestos from the previous building	Inhalation	Future occupants and construction workers	Likely	Medium	Medium	
TPH	Inhalation, ingestion, absorption	Future occupants	Low likelihood	Mild	Low	Area of spills and leakage from plant. Unknown above ground tank – minimal usage plus minimal due to hardstanding
	Inhalation, ingestion, absorption	Construction workers	Unlikely	Minor	Very low	
	Aggressive attack	Building materials	Likely	Mild	Medium / low	
	Migration	Bedrock aquifer	Unlikely	Minor	Very low	
	Migration	Surface waters	Unlikely	Minor	Very low	

Several plausible contamination risks (i.e. risks of *moderate/low* risk or greater) were identified associated with asbestos and TPH contamination. Receptors of plausible contamination linkages include: future occupants, construction workers and building materials.

3.3 (Phase 2) Investigation recommendations

The Phase 1 proposed the following scope of initial (Phase 2) site investigation works.

- Soil sampling from four locations targeted at sensitive areas (e.g. near surface soils in gardens) and high potential source locations (e.g. based on available evidence)
- Sampling of existing stockpile
- Chemical testing of samples for metals, PAH, TPH and asbestos

4 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).

4.1 Fieldwork

Approximate locations of all site works are shown in the exploratory hole location plan along with photographs taken during site works (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 22nd May 2019.

Four number windowless sampler boreholes (BH1 – BH4) were drilled with a Dando Terrier rig around the site. The maximum depth of sampling was between 2.0m and 2.5m 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 80mm, with depth. No casing was used for any of the boreholes.

A representative sample of the stockpile material was also collected.

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

4.2 Laboratory testing

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

- 5 number tests for a suite of metals (and metalloids)
- 5 number tests for speciated polycyclic aromatic hydrocarbons (PAHs)
- 5 number tests for fractions of total petroleum hydrocarbons (TPHs)
- 1 number asbestos identification test

A schedule of testing is shown below (in Table 4). Results for all the laboratory testing undertaken are included later in this report (in Appendix C).

Table 4: Schedule of laboratory testing

<i>Sampling holes</i>	<i>Sample Location</i>	<i>HML Sample ref. (S/_)</i>	<i>Chemtech sample ref.</i>	<i>Depth (m bgl)</i>	<i>Metals</i>	<i>Speciated PAHs</i>	<i>TPHs</i>	<i>Asbestos</i>
BH1	BH1-1	52825	78947-1	0.1-0.5	P	P	P	
BH2	BH2-1	52826	78947-2	0.1-0.5	P	P	P	P
BH3	BH3-1	52827	78947-3	0.1-0.5	P	P	P	
BH4	BH4-2	52828	78947-4	0.2-0.35	P	P	P	
stockpile	Soil mound	52829	78947-5	-	P	P	P	

5 Ground Conditions

5.1 Sequence of sub-strata

The sub-strata as revealed during the site works are summarised below (in Table 5).

Table 5: Summary of revealed ground conditions (during site works)				
<i>Strata</i>	<i>Locations revealed</i>	<i>Summary description</i>	<i>Depth to base of stratum (m bgl)</i>	
			<i>Min</i>	<i>Max</i>
Topsoil	BH1	Fine sand with occasional brick fragments and rootlets	0.1	
Hardstanding	BH3	Blast furnace slag	0.05	
	BH4	Concrete	0.1	
Made ground	BH1, BH2, BH4	Silts, clays and gravel. Includes limestone, very weak aerated concrete or stone, concrete and brick	0.2	1.1
(Possible) Charmouth Mudstone Formation	BH1 – BH4	Soft sandy silts and clays with bands of (limestone) sands and gravels	+2.0	+2.5

Presented later are copies of the borehole logs (in Appendix B) and a cross-section of the sub-strata (in Appendix A).

The revealed ground conditions were generally as anticipated. Some limited thickness of made ground was recorded as expected. The underlying natural soils were mainly silts and clays but some bands of sands and gravels were also revealed all of which are consistent with possible weathered Charmouth Mudstone Formation (CMF).

The revealed ground conditions varied slightly around the site. The possible Charmouth Mudstone Formation (CMF) was logged as the exclusive natural geology. However, the made ground was found to be thicker in the north part of the site (in BH1 and BH2). Also some variation was noted in the possible CMF.

5.2 Topsoil

Some thin topsoil material was recorded in BH1 in the rear left (northwest) part of the site. This was only 0.1m thick and included some brick fragments.

5.3 Hardstanding and Made ground

Made ground (or hardstanding) was revealed across the site. It was recorded in all four boreholes to depths ranging from 0.2m to 1.1m bgl.

The made ground (and hardstanding) was thicker in the rear (north) part of the site. The BH1 and BH2 logs show it reached a depth of 1.0m to 1.1m bgl in the north part of the site. In contrast, in BH3 and BH4 (in the south half of the site), respective maximum depths of only 0.05m and 0.2m bgl were recorded.

No clear visual or olfactory evidence of contamination was reported within the made ground. No hydrocarbon odour was noted. No unusual staining or oily sheen was noted.

5.4 Charmouth Mudstone Formation

The natural ground conditions around the site (i.e. beneath the made ground) was logged exclusively as (possible) Charmouth Mudstone Formation.

There was some variation between the CMF logged at the south and the north ends of the site. Shallow bands of sands and limestone gravel were revealed in BH3 and BH4 (in the north half of the site) but not in the south.

However, the predominating natural soil material was (sandy) silts and clays with occasional gravels. This could be highly weathered mudstone of the Charmouth Mudstone Formation (CMF).

The consistency of the silts and clays was found to range between very soft and firm. Overall, it was probably soft.

Some deeper limestone gravel was revealed in the south part of the site. This was at 2.4m to 2.5m bgl in BH1.

5.5 Groundwater observations

Some groundwater was observed during site works. The 1.05m to 1.4m-deep band of sand in BH3 was noted to be damp. Standing water levels of 1.4m and 2.0m bgl were recorded at the end of drilling in BH3 and BH1, respectively.

No groundwater observations were recorded in BH2 and BH4.

5.6 Potential evidence of contamination

No clear visual or olfactory evidence of contamination was noted during the site investigation works. No unusual odours (e.g. of petroleum hydrocarbons) were noticed. No unusual staining or potential asbestos-containing materials were recorded. No evidence of potential liquid storage was noted. Nevertheless, made ground was encountered, which contained anthropogenic material (e.g. brick and concrete) and could contain elevated levels of contamination (e.g. metals, PAHs and asbestos).

6 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 for a *commercial* development.

6.1 Metals and metalloids

Table 6 (below) gives the GAC for metal (and metalloid) contaminants considered for the site.

Table 6: 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)	

Four samples of near surface soils (from 0.1m to 0.4m bgl) were subjected to a suite of metals and metalloids tests. Two samples were of made ground (from BH1 and BH2) while the other two samples were of near surface natural sandy silts and clays (from BH3 and BH4).

In addition, a sample of the stockpile (or mound) was also subjected to a suite of metals and metalloids tests.

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

The test results show that only the near surface soil sample from BH4 was found to contain potentially elevated concentrations of any metal or metalloid. Lead was found to be present at a concentration of 236mg/kg, slightly higher than the GAC threshold value of 200mg/kg, as shown below (in Table 7).

Table 7: Potential metal exceedances						
<i>Location:</i>		BH1-1	BH2-1	BH3-1	BH4-2	Soil mound
<i>Depth (m bgl):</i>		0.1 - 0.5	0.1 - 0.5	0.1 - 0.5	0.2 - 0.35	-
<i>Soil type:</i>		Made ground	Made ground	Sandy clay	Sandy silt	-
<i>HML sample ref (S/_):</i>		52825	52826	52827	52828	52829
<i>Subcontractor ref.:</i>		78947-1	78947-1	78947-3	78947-4	78947-5
<i>Element</i>	<i>GAC* (mg/kg)</i>	<i>Concentration detected (mg/kg)</i>				
<i>Lead</i>	<i>200</i>	27	31	32	236	48

* based on residential with plant uptake. Note: GAC exceedances shown in (red) bold.

The maximum measured concentration of *total* chromium of 68mg/kg exceeded the GAC for chromium VI (of 6mg/kg). However, chromium VI is typically only present in soils in the vicinity of heavy metal industrial processes and waste deposition. That is not the case here, and there is no plausible significant risk of chromium VI contamination at the site.

6.2 Polycyclic aromatic hydrocarbons (PAHs)

Table 8 (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 8: 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

Four samples of near surface soils (from 0.1m to 0.4m bgl) were subjected to a suite of speciated PAH tests. Two samples were of made ground (from BH1 and BH2) while the other two samples were of near surface natural sandy silts and clays (from BH3 and BH4).

In addition, a sample of the stockpile (or mound) was also subjected to a suite of speciated PAH tests.

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

The results of PAH testing show that two samples were found to contain exceedances of PAH threshold values. The made ground sample from the soil mound was found to contain a potential (minor) exceedance of one species of PAH. BH2 showed the greatest exceedances with elevated levels of three species of PAHs, as shown below (in Table 9).

Table 9: Potential PAH exceedances

Table 9: Potential PAH exceedances								
<i>Location:</i>		BH1-1	BH2-1	BH3-1	BH4-2	Soil mound		
<i>Depth (m bgl):</i>		0.1 – 0.5	0.1 – 0.5	0.1 – 0.5	0.2 – 0.35	-		
<i>Soil type:</i>		Made ground	Made ground	Sandy clay	Sandy silt	-		
<i>HML sample ref (S/_):</i>		52825	52826	52827	52828	52829		
<i>Subcontractor ref.:</i>		78947-1	78947-1	78947-3	78947-4	78947-5		
<i>Element</i>	<i>GAC* (mg/kg)</i>			<i>Concentration detected (mg/kg)</i>				
	<i>SOM of 1%</i>	<i>SOM of 2.5%</i>	<i>SOM of 6%</i>					
<i>Benzo(b)fluoranthene</i>	2.6	3.3	3.7	<0.02	6.47	<0.02	0.20	2.45
<i>Benzo(a)pyrene</i>	2.2	2.7	3	<0.02	4.74	<0.02	0.13	1.80
<i>Dibenzo(ah)anthracene</i>	0.24	0.28	0.3	<0.02	0.90	<0.02	<0.02	0.29

* based on residential with plant uptake. Note: GAC exceedances shown in (red) bold.

The three PAHs that were found to be elevated are benzo(b)fluoranthene, benzo(a)pyrene and dibenzo(ah)anthracene. The only clear exceedances are in the made ground sample from BH2.

The exceedance of dibenzo(ah)anthracene in the on-site soil mound / stockpile is potentially acceptable. The concentration of 0.29mg/kg narrowly exceeds the 2.5% soil organic matter (SOM) threshold value of 0.28mg/kg.

No PAHs were detected in the samples from BH1 and BH3 in the west half of the site.

6.3 PAH profiling analysis

To try and identify the source of the PAH contamination detected in the near surface samples from BH2 and BH4 and the mound sample, double ratios and PAH profiling has been undertaken on the test data. The ratio plots are shown below (in Figures 1 to 4).

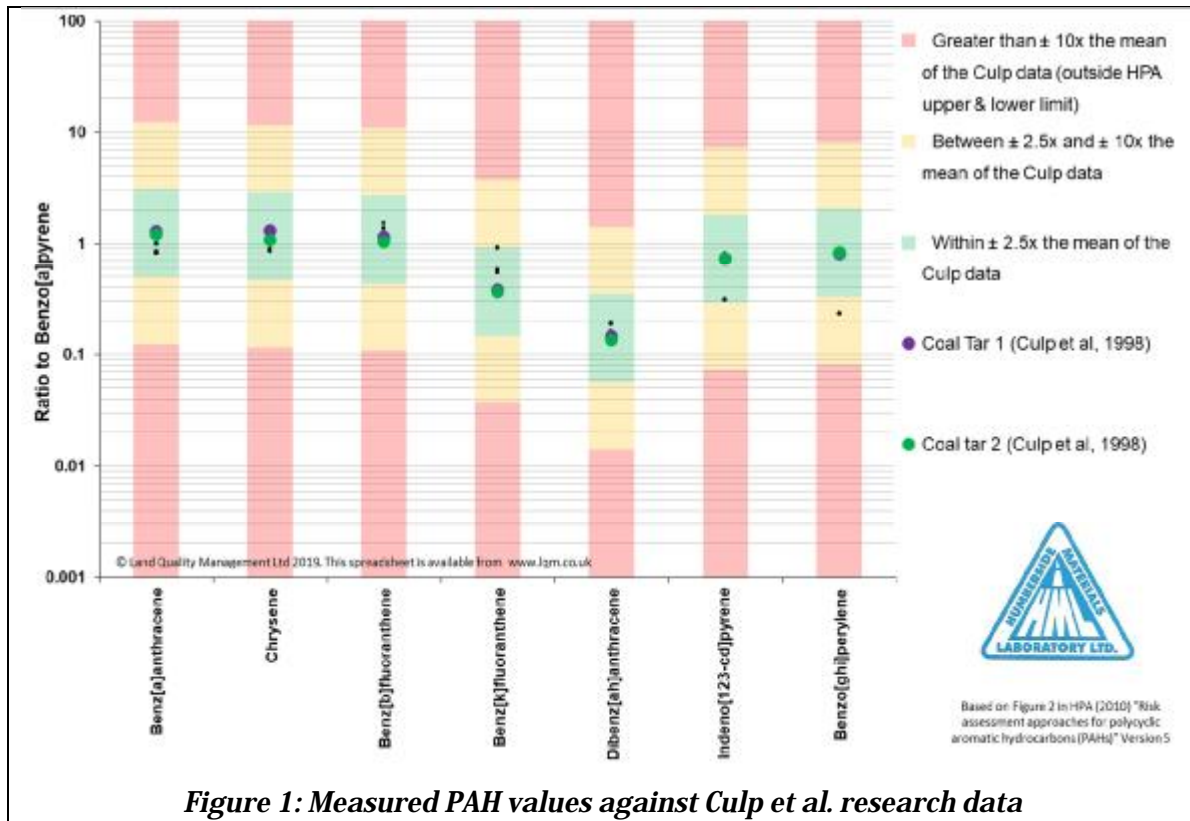


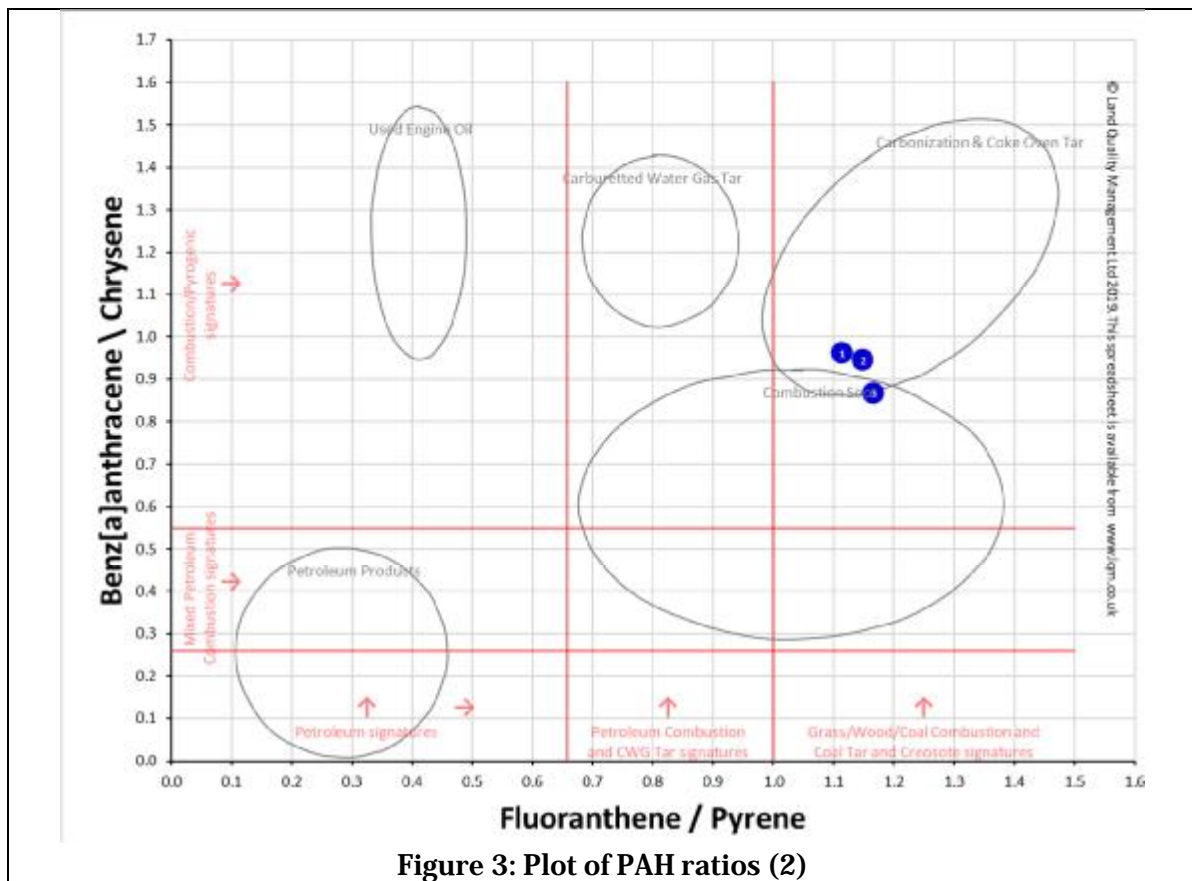
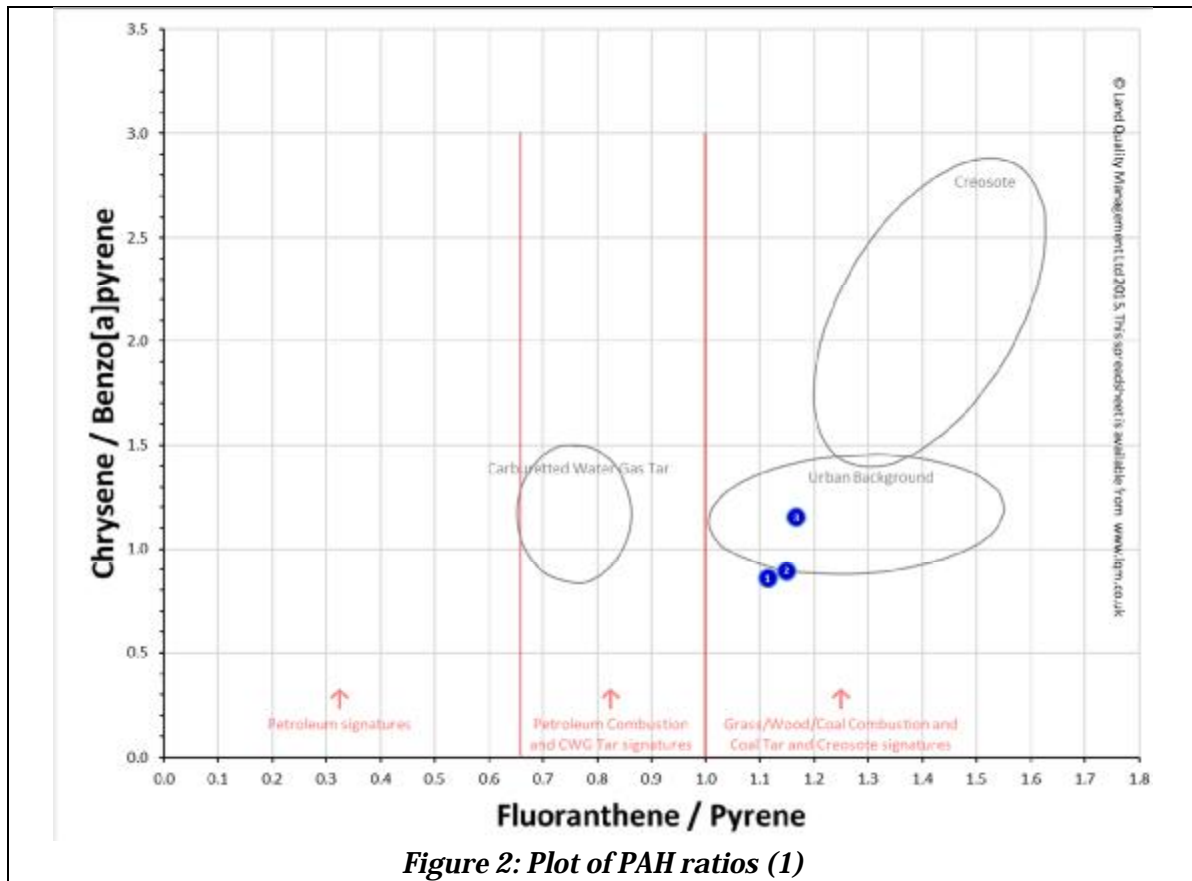
Figure 1: Measured PAH values against Culp et al. research data

Figure 1 shows the measured PAH data for all three samples lies reasonably close (within 2.5 times the mean) to the Culp et al. (1998) data. The only slight outliers are from the BH4 sample data some values of which were substituted with the limit of detection. Overall, PAH double ratio profiling should be applicable to the data.

The profiling plots below (Figures 2 to 4) indicate the samples both have the signature of a **carbonization or coke oven tar** from an **urban background**. The profile clearly falls into the category of **Grass/Wood/Coal Combustion and Coal Tar and Creosote** signatures, although the source is of an urban background rather than creosote.

Therefore, the source of the PAH contamination in the made ground could be either (A) ash or clinker from burnt wood or coal or (B) coal tar. Given the site history, either source is feasible.

It is noted that the detected PAHs are not of a petroleum signature. Therefore, the results are not a potential indicator of petroleum hydrocarbon contamination.



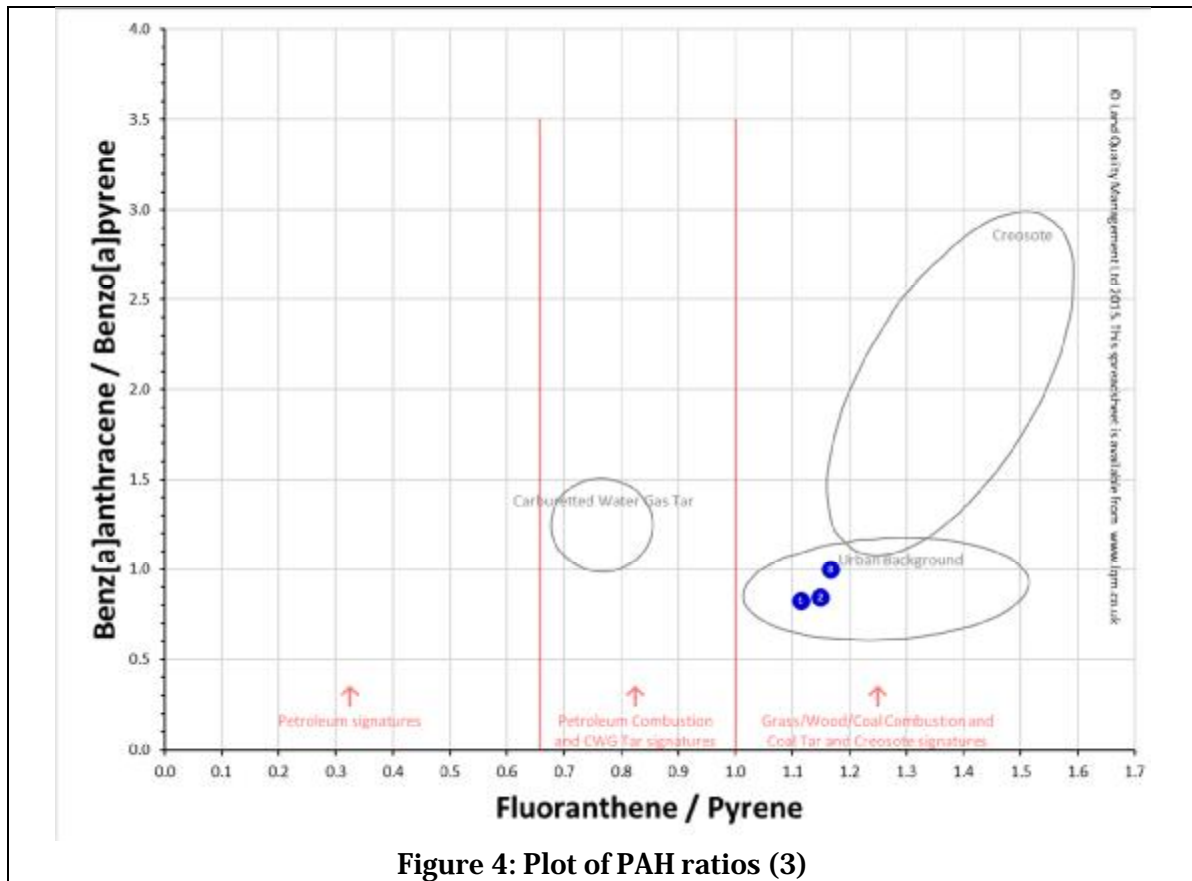


Figure 4: Plot of PAH ratios (3)

6.4 Petroleum hydrocarbons (TPH & BTEX)

Table 10 (below) gives the GAC (from LQM/CIEH, 2015) for speciated TPH fractions. 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				
<i>Compound</i>		<i>1% SOM</i>	<i>2.5% SOM</i>	<i>6% SOM</i>
TPH Aliphatic	C5-6	3200 (304)	5900 (558)	12000 (1150)
	C6-8	7800 (144)	17000 (322)	40000 (736)
	C8-10	2000 (78)	4800 (190)	11000 (451)
	C10-12	9700 (48)	23000 (118)	47000 (283)
	C12-16	59000 (24)	82000 (59)	90000 (142)
	C16-35	1600000	1700000	1800000
	C35-44	1600000	1700000	1800000
TPH Aromatic	C5-7	26000 (1220)	46000 (2260)	86000 (4710)
	C7-8	56000 (869)	110000 (1920)	180000 (4360)
	C8-10	3500 (613)	8100 (1500)	17000 (3580)
	C10-12	16000 (364)	28000 (899)	34000 (2150)
	C12-16	36000 (169)	37000	38000
	C16-21	28000	28000	28000
	C21-35	28000	28000	28000
BTEX	Benzene	27	47	90
	Toluene	56000 (869)	110000 (1920)	180000 (4360)
	Ethylbenzene	5700 (518)	13000 (1220)	27000 (2840)
	O-xylene	6600 (478)	15000 (1120)	33000 (2620)
	M-xylene	6200 (625)	14000 (1470)	31000 (3460)
	P-xylene	5900 (576)	14000 (1350)	30000 (3170)

Note: values in parentheses indicate vapour saturation limit (v) or limit of solubility (s)

No potential petroleum hydrocarbon contamination was identified during the site works. No potential visual or olfactory evidence was reported.

Nevertheless, four samples of near surface soils (from 0.1m to 0.4m bgl) were subjected to tests for fraction of TPHs. Two samples were of made ground (from BH1 and BH2) while the other two samples were of near surface natural sandy silts and clays (from BH3 and BH4).

In addition, a sample of the stockpile (or mound) was also subjected to tests for fractions of TPHs.

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, most TPH fractions were below the testing limits of detection.

Only at the heavier end of the aliphatic range were any petroleum hydrocarbons detected, notably in the BH2 sample and the soil mound sample. For example, 924mg/kg of C16-C35 aliphatic TPH were detected in the BH2 near surface sample. Trace amounts of C16-C35 aliphatic fraction were found in BH1 and BH4 near surface samples.

The presence of small amounts of C16-C35 TPH fractions could indicate small leaks or spills of gas oil (or red diesel) – a common fuel used in the construction and agricultural sectors.

6.5 Asbestos

One sample of near surface made ground from BH2 (from 0.1m to 0.5m bgl) was subjected to a test for the presence of asbestos.

Asbestos was detected in the made ground sample from BH2. A trace of loose chrysotile fibres was detected.

7 Revised Contamination Assessment

7.1 Revised conceptual site model (CSM)

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: Revised conceptual site model and risk assessment						
Potential source	Potential pathway	Potential receptor	Probability	Severity	Risk rating	Comments
Metals and PAH (General possible contamination)	Inhalation, ingestion, absorption	Future occupants	Low likelihood	Medium	Low / moderate	Some slight GAC exceedances of PAHs in BH2 near surface and mound samples. Slight lead exceedance in BH4 sample.
	Inhalation, ingestion, absorption	Construction workers	Low likelihood	Mild	Low	
	Aggressive attack	Building materials	Low likelihood	Mild	Low	
	Migration	Bedrock aquifer	Unlikely	Minor	Very low	Ground conditions are low permeability mudstone. Low groundwater table expected.
	Migration	Surface waters	Unlikely	Minor	Very low	Nearest identified surface water feature is 250m south of the site.
Asbestos (e.g. from the previous building)	Inhalation	Future occupants and construction workers	likely	medium	Moderate	Some trace of loose chrysotile fibres detected in BH2 near surface sample
TPH (Possible spills and leakage from plant. Unknown former above ground bowser / tank.)	Inhalation, ingestion, absorption	Future occupants	Low likelihood	Mild	Low	No GAC exceedances of TPH fractions, although some gas oil fraction detected well below GAC. PAH profiling does not indicate possible petroleum. No olfactory / visual evidence of potential contamination.
	Inhalation, ingestion, absorption	Construction workers	Low likelihood	Mild	Low	
	Aggressive attack	Building materials	Low likelihood	Mild	Low	
	Migration	Bedrock aquifer	Low likelihood	Mild	Low	
	Migration	Surface waters	Low likelihood	Mild	Low	

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 risk assessment indicates that there is potential for contamination linkages associated with contamination found in the made ground. Elevated PAH contaminants and lead have been detected as well as some chrysotile asbestos.

Other identified potential contamination, such as petroleum hydrocarbons has not been found to pose a significant risk to possible receptors. This is based on results of contamination testing and detailed assessment of the site and the revealed ground conditions.

The only identified receptors of plausible pollution linkages are future site users. Risks to site workers should be mitigated by safe working practices. However, the assessed *moderate/low* risk to future site occupants merits further consideration.

Contamination linkages are generally broken by either (a) removing the source or (b) severing the pathway, or a combination of the two. At the site, the pathway to identified plausible contamination linkages will be severed in areas of hardstanding and beneath building footprints. Therefore, the area of potential exposure is in gardens.

7.2 Possible remediation options

At this stage, a sensible remediation strategy could be to remove near surface soils in garden areas. The removed soils should be replaced with proven inert clean soil.

It is expected that a below-ground barrier system will also be required (unless it is demonstrated that the deeper remaining soil is not contaminated). Typically, the barrier is inserted at a depth of about 0.6m bgl in rear gardens (or 0.45m bgl in front gardens) and comprises a geotextile overlain with a layer of gravel. Details are freely available online within the YALPAG document: *Verification Requirements for Cover Systems: Technical Guidance for Developers, Landowners and Consultants* (YALPAG, 2017).

Unless further testing can prove otherwise, the mound material is not suitable for re-use in garden areas. The soil mound has been found to contain potentially elevated levels of dibenzo(ah)anthracene PAH. Further PAH and SOM testing (as a minimum) with favourable results would be needed before the mound material could be considered safe for re-use.

Any unforeseen contamination (for example, hydrocarbon odours or staining) encountered during the development of the site should be monitored and reported to the local authority. Work should be halted in any area of the revealed potential contamination and the contamination investigated and assessed to the satisfaction of the local authority.

7.3 Method statement and verification

Prior to any remediation or site development works, a (Phase 3) **remediation strategy** (i.e. remediation method statement) may need to be submitted to the local authority for approval. The detailed remediation strategy should comprise an options appraisal, remediation objectives, details of the proposed remediation and verification works, mitigation measures, licences/consents and contingency measures, as explained in the Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG) document, **Guidance - Development on Land Affected by Contamination** (YALPAG, 2017).

Remediation works will require some form of verification. The verification procedure could include documentary evidence (e.g. consignment notes and site photographs) to demonstrate the removal of the contaminated soils as well as suitability testing of imported soils and inspection of the installed materials.

It is expected that a (Phase 4) **verification report** will need to be submitted to the Local Planning Authority on completion of the remediation works. This will detail the remediation and verification carried out as agreed with the Local Planning Authority, including evidence that demonstrates whether agreed remediation objectives have been achieved.

7.4 Gas / Vapour protection measures

No plausible source of hazardous ground gas has been identified. There are no mineworkings, nearby landfills or significant deposits of organic soil or made ground present or nearby.

The ground conditions around the site are dominated by low permeability Charmouth Mudstone Formation residual soils which act to inhibit the migration of ground gas. Therefore, the risk of migration of unidentified sources of gas is further reduced.

Accordingly, an NHBC traffic light classification of Green (or CIRIA CS1 classification) should be appropriate for the site. This means that only minimum gas protection measures should be required for new dwellings.

Some slightly elevated levels of PAH contamination have been detected during this investigation within near surface soils and the site stockpile. This contamination has been found to probably result from ash and clinker or coal tar rather than petroleum hydrocarbons and no elevated TPH contamination has been detected. Therefore, at this stage, no significant risk has been identified from hydrocarbon vapours and no hydrocarbon barrier system should be required.

8 SUMMARY & CONCLUSIONS

8.1 Ground conditions

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

- **Topsoil:** *(revealed in BH1)*
 - § Fine sand with rootlets and brick fragments *[to 0.1m bgl]*
- **Hardstanding:** *(revealed in BH3 and BH4)*
 - § Blastfurnace slag gravel (in BH3) *[to 0.05m bgl]*
 - § Concrete (in BH3) *[to 0.1m bgl]*
- **Made ground:** *(revealed in BH1, BH2 and BH4)*
 - § Silts, clays and gravels. Includes stone, (weak) concrete and brick. *[to 0.2m – 1.1m bgl]*
- **(Possible) Charmouth Mudstone Formation:** *(revealed in BH1 – BH4)*
 - § Soft locally sandy silts and clays with bands of sands and gravels. *[proven to at least 2.0m bgl; anticipated to c.20m bgl]*

Some standing groundwater was observed in BH1 and BH3 between depths of 1.4m and 2.0m bgl. None was observed in BH2 and BH4.

8.2 Results of contamination testing

Slightly elevated levels of lead (236mg/kg) were detected in the near surface made ground in BH4. No elevated metals were found in samples from BH1, BH2 & BH3 or the mound.

Elevated concentrations of some PAH species were detected in the near surface sample from BH2. No elevated PAHs were found in samples from BH1, BH3 & BH4.

A potentially elevated level of dibenzo(ah) anthracene PAH contamination (0.29mg/kg) was detected in the site soil mound / stockpile.

The profiles of the detected PAH concentrations in BH2, BH4 and the soil mound were consistent with ash and clinker or coal tar pollutants.

No elevated fractions of aliphatic or aromatic TPH were detected in near surface samples from BH1 – BH4 or the mound. Some concentrations were detected of fractions consistent with gas oil (i.e. red diesel, commonly used in the construction industry).

Trace fibres of loose chrysotile asbestos were detected in the one near surface sample tested from BH2.

8.3 Revised contamination risk assessment

The revised risk assessment indicates that there is potential for contamination linkages associated with PAH, asbestos and lead contamination found in near surface soil samples. The receptors of the plausible pollution linkages are future site users.

The pathways for the identified contamination sources will be through exposure (direct or indirect) to bare earth in garden areas. The pollution linkage will be broken by hardstanding and buildings.

8.4 Possible remediation options

A sensible remediation strategy could be to remove contaminated made ground from garden areas. This should be replaced with clean inert soil. A barrier system is also likely to be required, typically installed about 0.6m bgl in rear gardens.

The health risk to construction workers should be mitigated by suitable safe working practices. This includes the provision of personal protective equipment and hygiene facilities.

Any unforeseen contamination (e.g. petroleum hydrocarbons odour or staining) encountered during the development of the site should be monitored and reported to the local authority. Work should be halted in any area of the revealed potential contamination and the contamination investigated and assessed to the satisfaction of the local authority.

8.5 Method statement and verification

Prior to any remediation or site development works, a (Phase 3) **remediation strategy** (i.e. remediation method statement) may need to be submitted to the local authority for approval.

It is expected that a (Phase 4) **verification report** will need to be submitted to the Local Planning Authority on completion of the remediation works. This will detail the remediation and verification carried out as agreed with the Local Planning Authority.

Guidance for the remediation procedure is available from YALPAG guidance (freely available online).

8.6 Gas / Vapour protection measures

A ground gas risk assessment has determined that a CIRIA C665 classification (by Card et al., 2007) of **CS-1** or an NHBC traffic light classification (by Boyle and Witherington, 2007) of **Green** should be appropriate for the site development. Therefore, subject to

approval, minimal protection measures for hazardous ground gases are required at the site.

No petroleum hydrocarbon contamination has been identified from analysis of PAH results or TPH testing. Also, no visual or olfactory evidence of petroleum hydrocarbons has been identified. Elevated levels of PAH contamination are limited to slight exceedances of only a few PAH species. Therefore, no hydrocarbon barrier system should be required.

- End of Report -

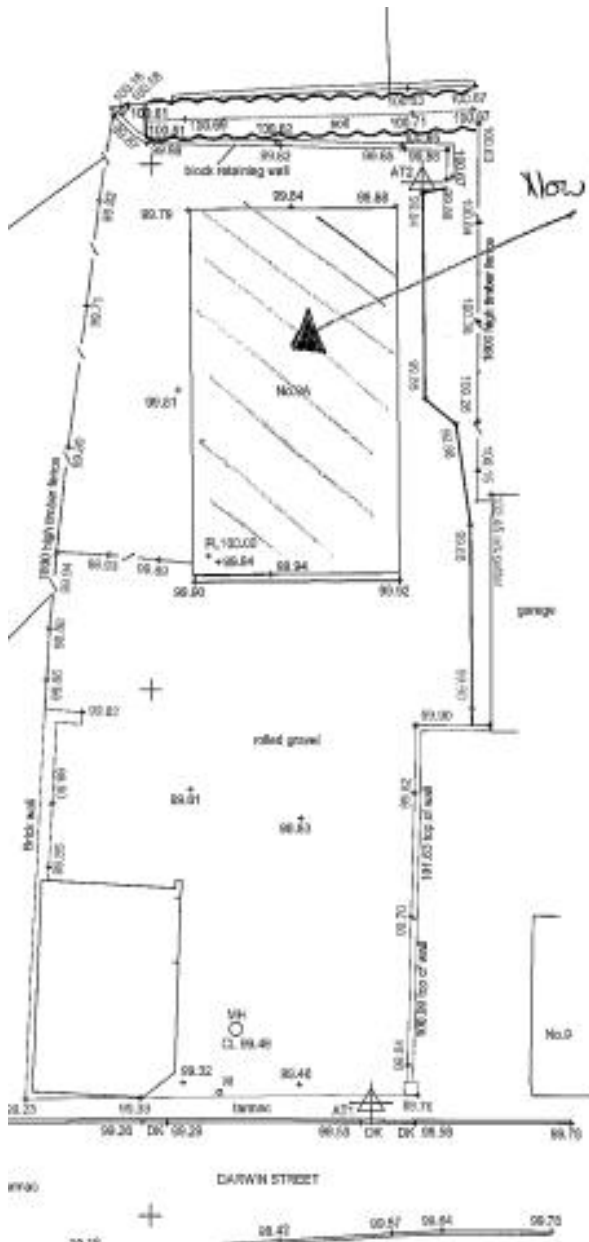
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Appendix A
Plans & Photographs

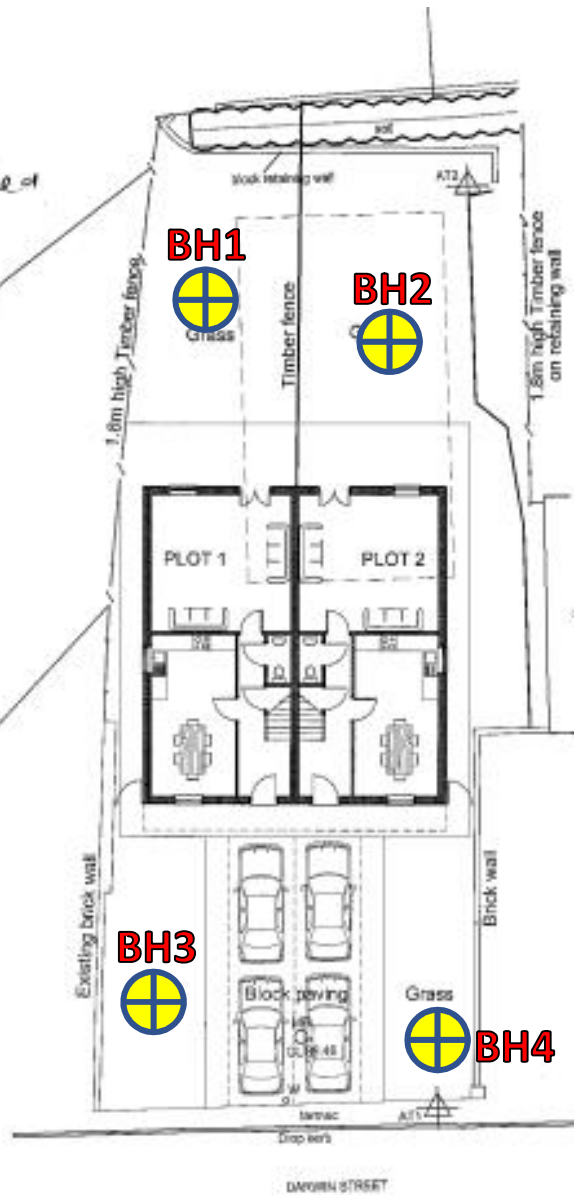
Notes:

1. Do not scale
2. Locations of all features are approximate only
3. Background image from client's drawing



Previous

Now Demolished



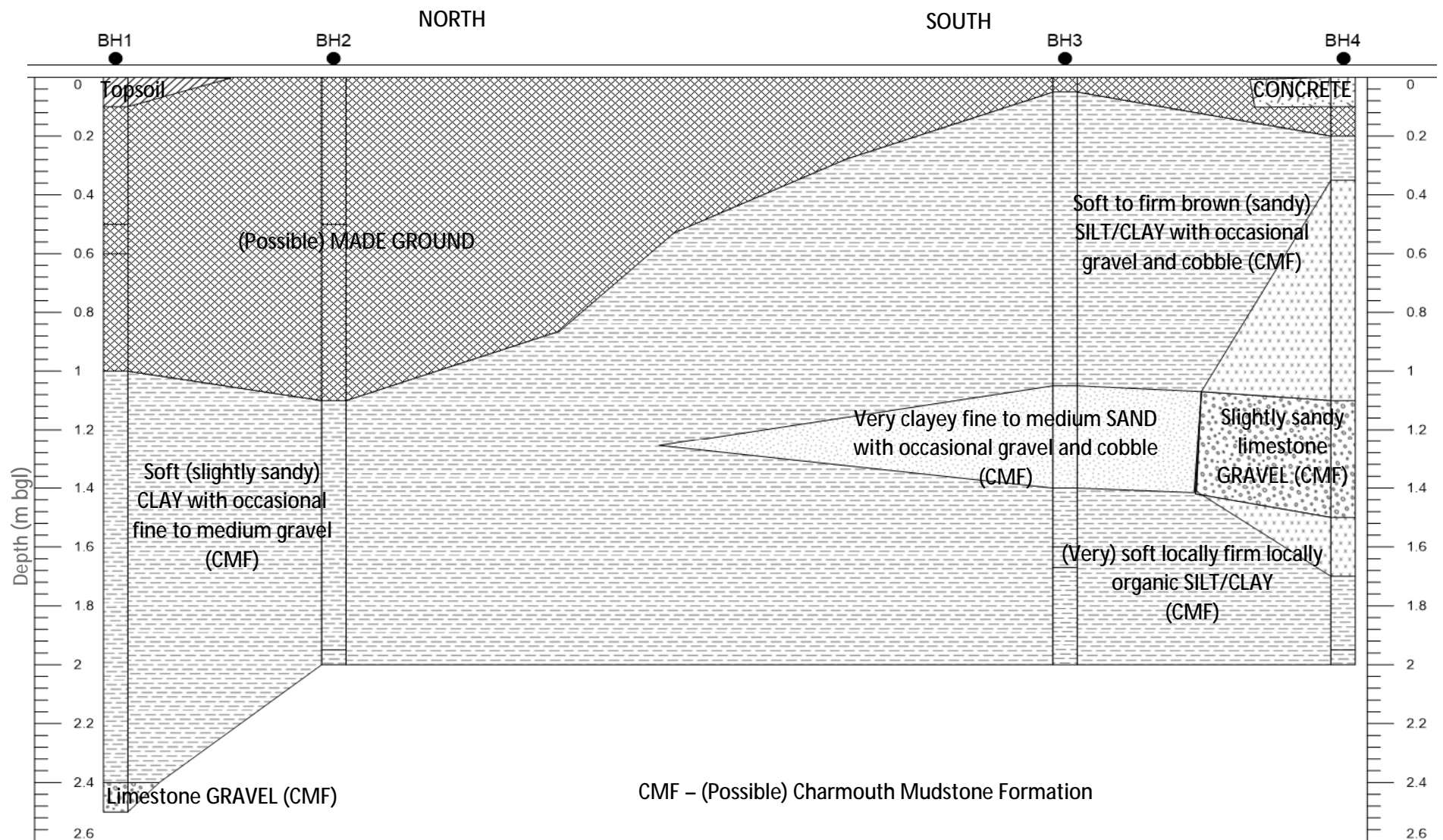
Proposed

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Drawing Title: Borehole location plan
 Drawing No.: 1166-4758-SI-01 Revision: 0
 Site: 9a Darwin St, Kirton in Lindsey
 Client: C & K Builders
 Project No.: 1166/4758/P
 Date: 03/07/2019



Notes:

1. Do not scale
2. Strata boundaries and locations are inferred and approximate only
3. Strata descriptions are generic and unlikely to represent whole strata

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Drawing Title: Cross-section of sub-strata

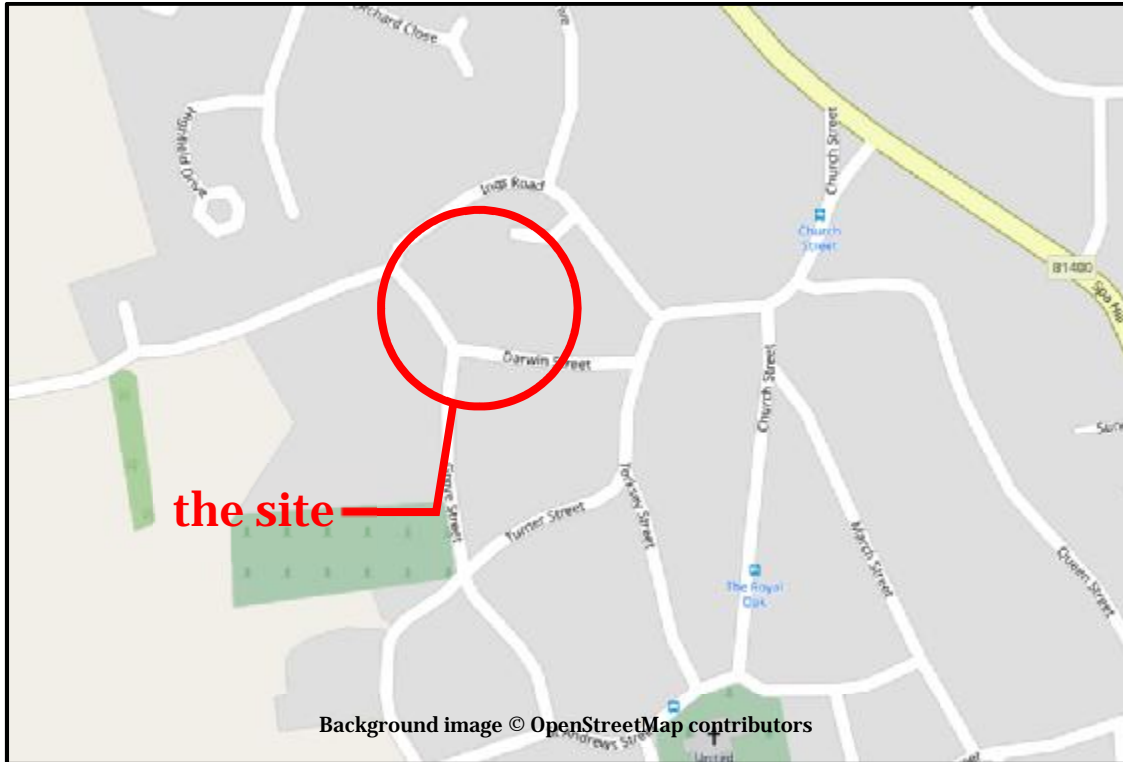
Drawing No.: 1166-4758-P-SI-02 *Revision:* 0

Site: 9a Darwin Street, Kirton in Lindsey

Client: C & K Builders Ltd

Project No.: 1166/4758/P

Date: 04/07/2019



Location plan



Aerial view of the site (north is up page)



Southwest site corner and possible former bowser / tank storage area (view to west)



Centre of the site (view to north)



Northeast corner of site and stockpile (view to northeast)



Historical Google Streetview of the site from Apr 2009 (view to northwest)

Appendix B
Exploratory hole logs



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BOREHOLE LOG

**Borehole
No
BH1**

Client :- McCabe

Site :- Darwin St, Kirton-in-Lindsey

Project No :- 4758

Location :- see site plan

Date :- 22-May-19

Coordinates E: 493285 N: 398812

Elevation :-

Excavated by :- Dando Terrier

Drilled by :- DD

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT		SH DCP		Notes	
						0	20	40	60		80
0	Brown fine to medium SAND with occasional brick fragments and occasional rootlets. (TOPSOIL)	0	0.1	1 D							
0.4	Firm brown sandy SILT/CLAY with occasional fine to coarse limestone gravel with occasional limestone cobble. Sand is fine. (Possible made ground)	0.4	0.5								
0.6	Light grey mottled orangish brown sandy SILT. (Possible made ground)	0.6									
0.8	Grey slightly silty slightly sandy fine to coarse GRAVEL of very weak aerated stone/concrete. (possible made ground)	0.8	1	2 D							
1.2	Soft brown mottled orangish brown and grey CLAY with very occasional fine to medium gravels. (Possible Charmouth Mudstone Formation)	1.2		3 D							SPT 1m: 1,1,1,2,1,1
1.6		1.6		4 D							
2.0		2.0									
2.4	Grey weak subangular to subrounded limestone GRAVEL. (Possible Charmouth Mudstone Formation)	2.4	2.4								
2.5		2.5									
2.8		2.8									
3.2		3.2									
3.6		3.6									
4.0		4.0									
4.4		4.4									
4.8		4.8									
5.2		5.2									
5.6		5.6									

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

Notes :-

Depth drilled :-2.5

Casing depth :-

File Ref :- 1166/ 4758
Logged by :- D Driver



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BOREHOLE LOG

**Borehole
No
BH2**

Client :- McCabe

Site :- Darwin St, Kirton-in-Lindsey

Project No :- 4758

Location :- see site plan

Date :- 22-May-19

Coordinates E: 493291 N: 398809

Elevation :-

Excavated by :- Dando Terrier

Drilled by :- DD

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT		SH DCP		Notes	
						0	20	40	60		80
0	Grey slightly silty slightly sandy fine to coarse limestone GRAVEL with occasional limestone cobble. (Possible made ground) Grey slightly silty slightly sandy fine to coarse GRAVEL of aerated very weak concrete/stone. (possible made ground) Soft orangish brown mottled grey sandy CLAY with occasional fine to medium weak limestone and chalk gravel. (Possible Charmouth Mudstone Formation) Soft grey slightly sandy silty CLAY. (Possible Charmouth Mudstone Formation)	0									
0.4		0.5	1	D							
0.8			1.1	2	D						
1.2			1.6	3	D						SPT 1m: 1,1,2,1,1,2.
1.6		1.95									
2		2	4	D						SPT 2m: 2,1,1,2,2,2.	
2.4											
2.8											
3.2											
3.6											
4											
4.4											
4.8											
5.2											
5.6											

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

Notes :-

Depth drilled :-2

Casing depth :-

File Ref :- 1166/ 4758
Logged by :- D Driver



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BOREHOLE LOG

**Borehole
No
BH3**

Client :- McCabe

Site :- Darwin St, Kirton-in-Lindsey

Project No :- 4758

Location :- see site plan

Date :- 22-May-19

Coordinates E: 493279 N: 398790

Elevation :-

Excavated by :- Dando Terrier

Drilled by :- DD

Depth (m)	Lithology / Description / Depth (m)	Elevation	Thickness (m)	Samples	Water level & well	SPT		SH DCP		Notes	
						0	20	40	60		80
0	Grey fine blastfurnace slag GRAVEL. (MADE GROUND)	0.05									
0.4	Soft to firm locally very soft to soft brown slightly sandy CLAY with very occasional fine to coarse limestone and chalk gravel with occasional limestone and chalk cobble. (Possible Charmouth Mudstone Formation)			1 D							
1.2	Brown very clayey fine to medium SAND. Damp. (Possible Charmouth Mudstone Formation)	1.05		2 D							SPT 1m: 0,0,0,0,0,0.
1.6	Very soft orangish brown mottled grey slightly sandy SILT/CLAY. (Possible Charmouth Mudstone Formation)	1.4		3 D							
1.67	Soft slightly organic dark greyish black SILT/CLAY. (Possible Charmouth Mudstone Formation)	1.6		4 D							
2	Soft to firm greyish brown sandy SILT/CLAY. (Possible Charmouth Mudstone Formation)	1.67									SPT 2m: 1,1,0,0,0,1.
2.4		2									
2.8											
3.2											
3.6											
4											
4.4											
4.8											
5.2											
5.6											

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

Notes :-

Depth drilled :-2

Casing depth :-

File Ref :- 1166/ 4758
Logged by :- D Driver



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BOREHOLE LOG

**Borehole
No
BH4**

Client :- McCabe

Site :- Darwin St, Kirton-in-Lindsey

Project No :- 4758

Location :- see site plan

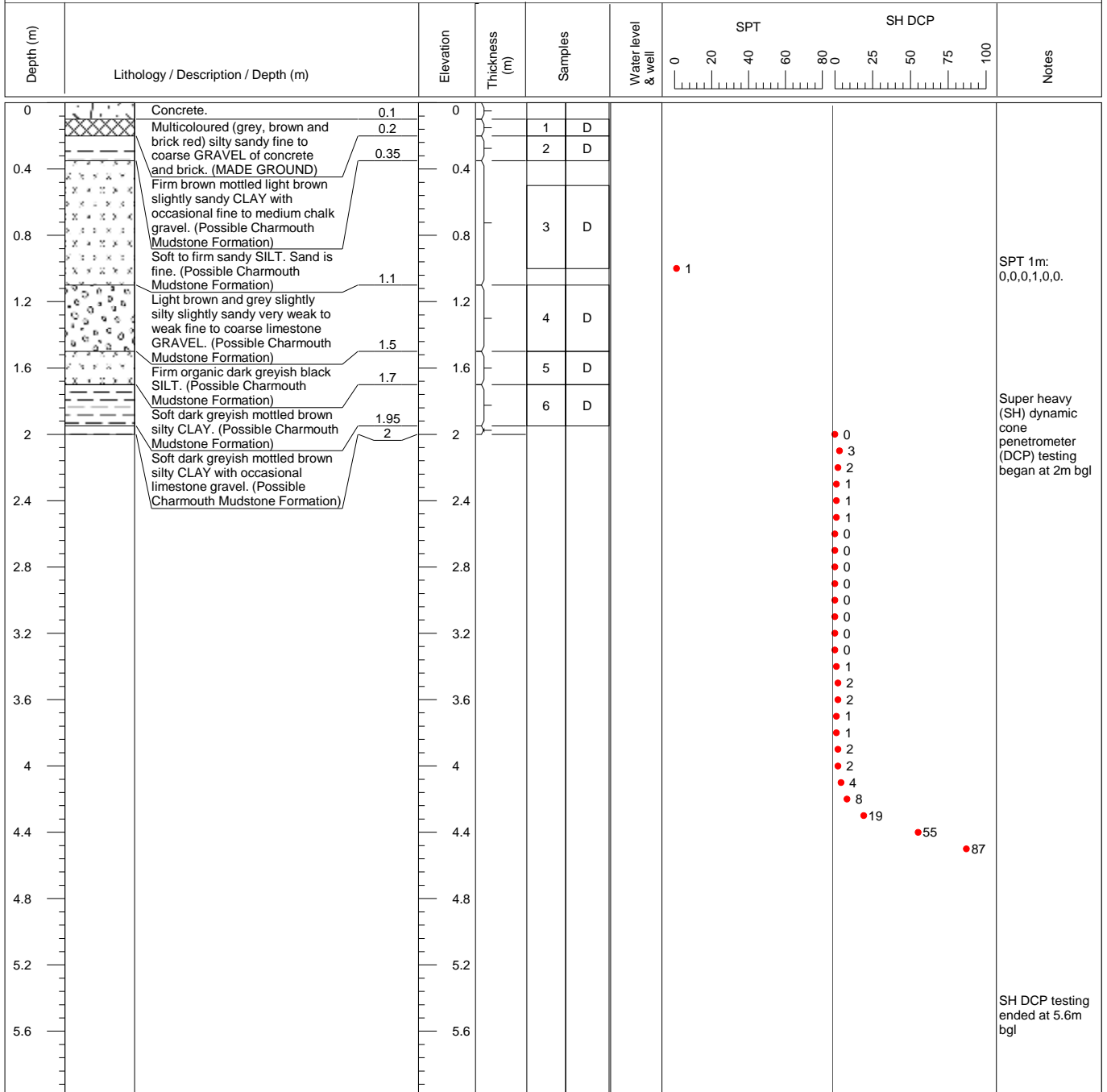
Date :- 22-May-19

Coordinates E: 493287 N: 398787

Elevation :-

Excavated by :- Dando Terrier

Drilled by :- DD



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

Notes :-
Depth drilled :-2
Casing depth :-

File Ref :- 1166/ 4758
Logged by :- D Driver

Appendix C
Test results



ANALYTICAL TEST REPORT

Contract no: 78947
Contract name: 9a Darwin St, Kirton Lindsey
Client reference: 1166/4758
Clients name: Humberside Materials Laboratory
Clients address: Atherton Way
Brigg
North Lincolnshire
DN20 8AR
Samples received: 24 May 2019
Analysis started: 24 May 2019
Analysis completed: 30 May 2019
Report issued: 30 May 2019

Notes: Opinions and interpretations expressed herein are outside the UKAS accreditation scope. Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling. 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

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
78947-1	S/52825	0.10-0.50	Sandy Clay with Gravel	-	-	20.2
78947-2	S/52826	0.10-0.50	Sand with Gravel & Roots	-	-	4.2
78947-3	S/52827	0.10-0.50	Sandy Clay with Gravel	-	-	19.3
78947-4	S/52828	0.20-0.35	Sandy Clay with Gravel	-	-	15.1
78947-5	S/52829	-	Clayey Sand with Gravel & Roots	-	-	9.6

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SOILS

Lab number			78947-1	78947-2	78947-3	78947-4	78947-5
Sample id			S/52825	S/52826	S/52827	S/52828	S/52829
Depth (m)			BH1-1	BH2-1	BH3-1	BH4-2	Soil mound
Date sampled			0.10-0.50	0.10-0.50	0.10-0.50	0.20-0.35	-
Date sampled			22/05/2019	22/05/2019	22/05/2019	22/05/2019	22/05/2019
Test	Method	Units					
Arsenic (total)	CE127 ^M	mg/kg As	12	7.2	14	16	11
Cadmium (total)	CE127 ^M	mg/kg Cd	<0.2	0.3	<0.2	0.2	0.3
Chromium (total)	CE127 ^M	mg/kg Cr	28	68	28	32	48
Copper (total)	CE127 ^M	mg/kg Cu	15	21	17	20	40
Lead (total)	CE127 ^M	mg/kg Pb	27	31	32	236	48
Mercury (total)	CE127 ^M	mg/kg Hg	0.6	<0.5	<0.5	<0.5	<0.5
Nickel (total)	CE127 ^M	mg/kg Ni	12	36	12	14	14
Selenium (total)	CE127 ^M	mg/kg Se	0.5	1.7	0.5	0.7	1.3
Vanadium (total)	CE127 ^M	mg/kg V	31	52	30	44	47
Zinc (total)	CE127 ^M	mg/kg Zn	77	192	68	432	118
PAH							
Naphthalene	CE087 ^M	mg/kg	<0.02	0.06	<0.02	<0.02	0.18
Acenaphthylene	CE087 ^M	mg/kg	<0.02	0.07	<0.02	<0.02	0.05
Acenaphthene	CE087 ^M	mg/kg	<0.02	0.14	<0.02	<0.02	0.08
Fluorene	CE087 ^U	mg/kg	<0.02	0.11	<0.02	<0.02	0.04
Phenanthrene	CE087 ^M	mg/kg	<0.02	2.48	<0.02	0.07	1.10
Anthracene	CE087 ^U	mg/kg	<0.02	0.52	<0.02	<0.02	0.29
Fluoranthene	CE087 ^M	mg/kg	<0.02	7.42	<0.02	0.35	3.17
Pyrene	CE087 ^M	mg/kg	<0.02	6.66	<0.02	0.30	2.76
Benzo(a)anthracene	CE087 ^U	mg/kg	<0.02	3.91	<0.02	0.13	1.52
Chrysene	CE087 ^M	mg/kg	<0.03	4.07	<0.03	0.15	1.61
Benzo(b)fluoranthene	CE087 ^M	mg/kg	<0.02	6.47	<0.02	0.20	2.45
Benzo(k)fluoranthene	CE087 ^M	mg/kg	<0.03	2.57	<0.03	0.12	1.04
Benzo(a)pyrene	CE087 ^U	mg/kg	<0.02	4.74	<0.02	0.13	1.80
Indeno(123cd)pyrene	CE087 ^M	mg/kg	<0.02	3.84	<0.02	0.04	1.35
Dibenz(ah)anthracene	CE087 ^M	mg/kg	<0.02	0.90	<0.02	<0.02	0.29
Benzo(ghi)perylene	CE087 ^M	mg/kg	<0.02	3.65	<0.02	0.03	1.32
PAH (total of USEPA 16)	CE087	mg/kg	<0.34	47.6	<0.34	1.52	19.1
TPH							
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	<1	<1	<1	<1	<1
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	<1	<1	<1	<1	<1
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	<1	17	<1	<1	7
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	<1	26	<1	<1	10
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	<1	4	<1	<1	<1
VPH Aliphatic (>C5-C6)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
VPH Aliphatic (>C6-C8)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
VPH Aliphatic (>C8-C10)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

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SOILS

Lab number			78947-1	78947-2	78947-3	78947-4	78947-5
Sample id			S/52825	S/52826	S/52827	S/52828	S/52829
Depth (m)			BH1-1	BH2-1	BH3-1	BH4-2	Soil mound
Date sampled			0.10-0.50	0.10-0.50	0.10-0.50	0.20-0.35	-
			22/05/2019	22/05/2019	22/05/2019	22/05/2019	22/05/2019
Test	Method	Units					
EPH Aliphatic (>C10-C12)	CE068	mg/kg	<4	<4	<4	<4	<4
EPH Aliphatic (>C12-C16)	CE068	mg/kg	<4	<4	<4	<4	<4
EPH Aliphatic (>C16-C35)	CE068	mg/kg	10	924	<4	14	255
EPH Aliphatic (>C35-C44)	CE068	mg/kg	<10	781	<10	<10	202
Subcontracted analysis							
Asbestos (qualitative)	\$	-	-	Chrysotile	-	-	-
Form of Asbestos	\$	-	-	Loose, trace	-	-	-

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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	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	Zinc (total)	Aqua regia digest, ICP-MS	Dry	M	5	mg/kg Zn
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
\$	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)
78947-1	S/52825	0.10-0.50	N	
78947-2	S/52826	0.10-0.50	N	
78947-3	S/52827	0.10-0.50	N	
78947-4	S/52828	0.20-0.35	N	
78947-5	S/52829	-	N	