



Soil Contamination Investigation Report

LOCATION	Groundsource Heating Installation, Hough End Leisure Centre, 480 Princess Road, Manchester, M20 1HD
ISSUE DATE	18 th February 2022
FOR	Ameresco
CLIENT REF.	PO 4001038-1
OUR REF.	G22017

Prepared by



Jack Harper BSc(Hons) MSc CSci MEnvSc
Contaminated Land Division Manager

Checked by



Stuart Howe BSc(Hons) FGS
Senior Geo-environmental Engineer

Table of Contents

1. Introduction	3
2. Scope of Investigation	4
2.1 Scope of Works.....	4
2.2 Sampling Rationale.....	4
3. Investigation Findings.....	5
3.1 Encountered Ground Conditions	5
4. Contamination Testing	5
5. Risk Assessment	6
5.1 Method.....	6
5.2 Contamination Risk to Identified Receptors	7
5.2.1 Contamination Risk to Human Health	7
5.2.2 Contamination Risk to Controlled Waters	9
5.3 Review of Results	11
5.3.1 CGHM	13
6. Conclusions	14
6.1 Contamination.....	14



Units 3a and 4 Terry Dicken Industrial Estate
Ellerbeck Way
Stokesley
North Yorkshire
TS9 7AE
Tel. 01642 713779
Fax 01642713923
Email enquiries@geoinvestigate.co.uk

1. Introduction

In accordance with your instruction Geoinvestigate Ltd. has carried out an additional soil contamination investigation at Hough End Leisure Centre where ground source heat (GSH) borehole are being installed.

It is understood that the Environment Agency have requested a contamination risk assessment of near-surface materials, primarily to determine whether the installation of the 150m deep boreholes might create any risk to groundwater. It is understood that the local planning authority (LPA) also require a soil contamination risk assessment with respect to human health for the proposed development.

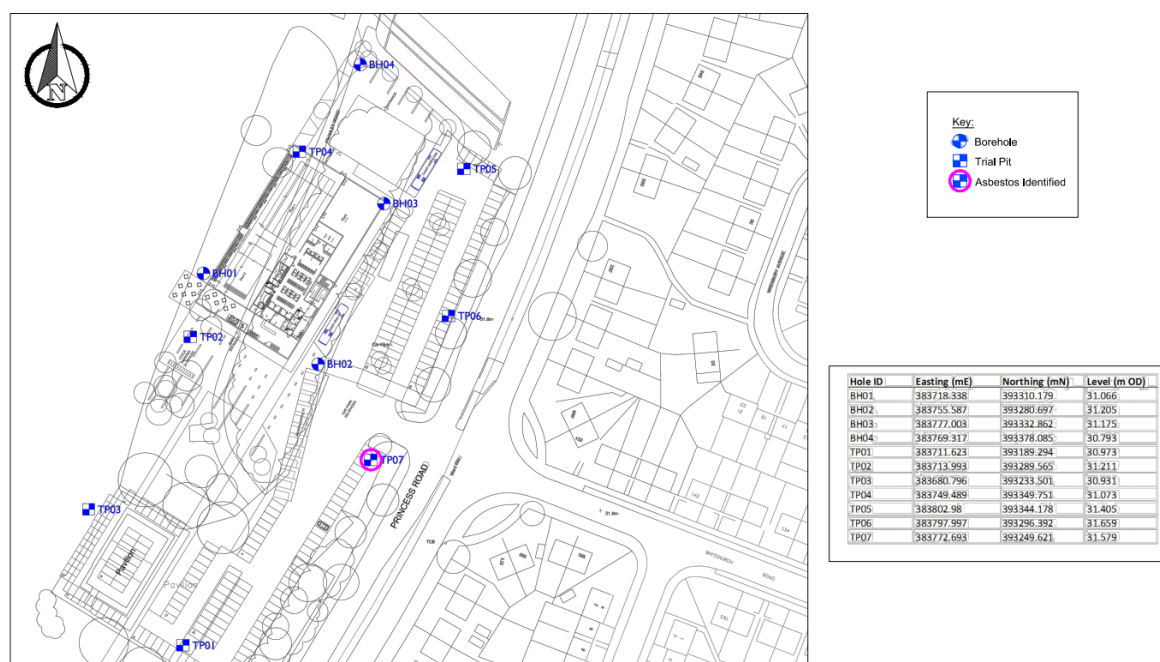
This follows on from Geoinvestigate's Phase 1 Desk Study Report (ref. G21424, issued October 2021) which found some potential for contamination to have occurred at the site in the past, and recommended a phase 2 investigation accordingly.

Additionally, Geoinvestigate was provided a copy of a 2013-2014 Site Investigation report and Remediation proposal for the site produced as part of the development of the existing leisure centre. Those reports found that:

- Made ground was encountered in some locations to depths of up to 1.00m. This mostly comprised ash gravel, sometimes underlain by clay fill containing mixed gravel including clinker.
- Asbestos containing soils were discovered in one location (trial pit ref. TP7). This was a sample of the ash gravel from a depth of 0.30m, which was underlain by the clay fill.
- A 600mm uncontaminated capping layer should be installed in that area over the implicated soils.
- Further sampling and analysis should be undertaken to assist in the remedial works, primarily to delineate the affected area.

It is not known whether these remedial works were completed or validated, but TP7 of that investigation is not within the current study area and so this may not affect the current works. The current study area comprises areas adjacent to the northeast and northwest of the leisure centre building. The excavation locations of the earlier investigation including the location of TP7 are shown below:

Figure 1: 2014 Site Investigation Plan



2. Scope of Investigation

2.1 Scope of Works

Given the above, and based on the findings of the phase 1 desk study report, the following investigation was carried out to assess the potential risks at the site:

- The investigation of near-surface soils via the sinking of five (5) windowless sampling boreholes (ref. BH1-BH5) to a depth of 1.00m or 2.00m using a Dando Terrier mini drilling rig with logging, sampling and supervision of the works by a qualified and experienced geo-environmental engineer. This was supplemented by the hand excavation of a single trial pit at a sixth location (ref. TPA) where access was not possible with the drilling rig and buried services were more likely to be encountered.
- Contamination analyses of eight (8) samples of topsoil, made ground and natural subsoil recovered at depths of between 0.20m and 1.50m. Analysis was variably undertaken for a general suite of potential metal/metalloid contaminants, PAHs (polycyclic aromatic hydrocarbons), petroleum hydrocarbons (including BTEX*), and asbestos in soil and/or leachate. Chemical analyses based on the attending engineer's assessment of soils and the requirements of the investigation works outlined in Section 1 of this report.

*Benzene, toluene, ethyl benzene and xylenes

- Provision of a factual and interpretative report including site plan, borehole and trial pit logs, and contamination analysis results, together with a quantitative risk assessment, advice on the contamination situation at the site, and advice regarding any remediation and validation works that may be necessary.

The borehole and trial pit positions are shown on the plan provided in Appendix 1. The excavations were sampled and logged at site by a geo-environmental engineer and the ground conditions encountered are described on the boreholes logs also provided in Appendix 1.

The results of the contamination testing are presented in Chemtech Environmental Report ref. 105207(1) which is included in Appendix 2.

2.2 Sampling Rationale

The borehole positions were chosen to cover the whole study area (where the GSH boreholes are being drilled) and provide information about the ground conditions throughout the study area. The drilling of the GSH boreholes was already underway at the time of the investigation works on 25th January 2022.

Boreholes (or trial pits) were sunk within the car park area, the grass verge adjacent to the car park area, and the grassed area to the rear/northwest of the leisure centre building.

3. Investigation Findings

3.1 Encountered Ground Conditions

Boreholes BH1 to BH3 found comparable materials. The asphalt surface was underlain by dolostone gravel fill which was in turn underlain by dark silty and/or sandy gravel fill at BH1 and BH2, and a grey-brown clayey and/or sandy gravel fill appearing at BH2 and BH3. These contained gravel constituents of sandstone, concrete, brick, ash and coal. Plastic and bone were also recorded in the dark fill at BH1 and limestone in the grey-brown fill at BH3. BH1 and BH2 encountered what was inferred to be a weak old asphalt layer at the base of the fill.

Natural soils comprised loose sand to the full 1.00m depth of BH1 and BH2, and to 1.60m below ground level (BGL) at BH3 where firm sandy gravelly clay was encountered to termination at BH2.

BH4 and BH5 encountered turf and topsoil to 0.20m BGL followed by natural clayey sand or sandy clay to refusal at 0.50m in BH5 and to 0.80m in BH4. BH4 then encountered sand to termination at 1.00m BGL.

TPA found 150mm of topsoil underlain by dolostone gravel to 0.40m BGL. Dark fill akin to that found at BH1-BH3 was then encountered to termination at 0.75m BGL. Some slag was also noted in this fill and it was noted to possibly mostly comprise road planings. A slight ashy odour was noticeable in this material, which could also be noticed in the fill at BH1.

4. Contamination Testing

The findings of the excavations could roughly be categorised into six different types of material. Representative samples of all of these materials were included in the analyses for varying different potential contaminants:

1. The dolomitic limestone fill encountered at BH1-BH3 and TPA. A sample of this material from 0.30m at BH3 was tested.
2. The dark fill encountered at BH1, BH2 and TPA. Samples of this material from 0.30m at BH1 and 0.50m at TPA were tested.
3. The grey-brown fill encountered at BH2 and BH3. A sample of this material from 0.80m at BH3 was tested.
4. The assumed old asphalt layer found at the base of the fill at BH1 and BH2. Samples of this material from 0.50m at BH1 and 0.60m at BH2 were tested for hydrocarbon contaminants only (including PAHs), in soil and/or leachate.
5. The topsoil encountered at BH4 and BH5. A sample of this material from 0.20m at BH5 was tested.
6. The natural subsoils encountered in all locations but TPA. A sample of the natural sand from 1.50m at BH5 was tested.

Asbestos inspection was undertaken on samples of fill or topsoil from BH1 (0.30m, dark fill), BH3 (0.80m, grey-brown fill), and BH5 (0.20m, topsoil).

The results of the contamination testing are included in Appendix 2 of this report (Chemtech Environmental Ltd. report 105207(1)) and have been used in the following contamination risk assessment.

5. Risk Assessment

5.1 Method

Geoinvestigate Ltd. uses a combination of assessment criterion provided by the DEFRA, the Environment Agency and by the Chartered Institute of Environmental Health in order to assess the presence of potentially harmful chemicals within soils and water. These include DEFRA category 4 screening levels (C4SLs), Environment Agency Environmental Quality Standards (EQSs), Site Specific Assessment Criteria (SSAC) generated using CLEA software version 1.06 site specific risk assessment modelling, and Land Quality Management / Chartered Institute of Environmental Health (LQM/CIEH) Safe for Use Limits (S4ULs).

The site is not currently being redeveloped with any change of use; the current works are limited to the installation of GSH boreholes in the north of the site. Being a leisure centre, the majority of the study area is considered to fall into the commercial end-use category (car park and surrounding verges), and this was the approach adopted in the 2013 site investigation and risk assessment. However, the area to the northwest of the building comprises grassed open space for public use, and it is therefore considered prudent to define the land use of that area as “public open space – parkland” (POS 2) to ensure a conservative approach to risk is adopted. No allowance for the cultivation of vegetables/fruit for consumption is considered necessary anywhere at the site.

No site-specific assessment criteria (SSAC) have been created for the site as no unusual circumstances (i.e. occupation periods/frequencies etc.) are considered to be present/likely at the site that would render the generic commercial and POS 2 assessment criteria unsuitable.

The results of the contamination testing that has been carried out have been compared to the target soil quality values from the above sources. Where they fall below these target values, they have been deemed safe for a residential end use. Where results have been found to be above the target values, an assessment of the available pathways and receptors has been carried out to determine whether further investigation or remediation might be necessary.

The more pragmatic C4SL values are used in preference where they exist, with S4ULs used in support where necessary. This is particularly pertinent for PAHs because Benzo(a)pyrene (B(a)P) is the only PAH species to have a corresponding C4SL. As such, B(a)P will be considered in isolation and used as a surrogate marker to draw conclusions about the overall PAH risk associated with the soils at the site (see later).

PAHs were expected to be particularly relevant to this exercise given the old asphalt material found in some of the boreholes, together with occasional ash and ashy odours noted in the made ground.

5.2 Contamination Risk to Identified Receptors

5.2.1 Contamination Risk to Human Health

Made ground was present to depths of up to with a maximum recorded depth of 1.00m (BH3) in the car park to the northeast of the building (and to at least 0.75m at TPA), with no made ground present in the grassed area to the northwest side of the building.

The made ground generally comprised dark or grey-brown sandy gravel with some possible old asphalt horizons noted at BH1 and BH2. No significant potentially contaminative materials were noted in any of the soils save for an occasional ash or slag content in places. No potential asbestos containing materials were observed.

No *significant* visual or olfactory evidence of potential contamination such as hydrocarbon odours/staining/residues was observed, though a slight ashy odour was noted in some strata at BH1 and TPA, which might sometimes be indicative of potential PAH contamination. Testing for PAHs and petroleum hydrocarbons (including BTEX) was specifically undertaken in these samples, including PAH in leachate from relevant samples.

As discussed earlier in the report, levels of determinands have been compared to the soil assessment criteria for both commercial and “public open space – parkland” end-use (depending on location) as published by DEFRA and LQM/CIEH.

The results of the analyses of eight (8) samples of made ground recovered from the site from depths of between 0.20m and 1.50m are summarised on Table 1 on the following page together with the adopted assessment criteria.

The LQM/CIEH GAC for PAHs were chosen using the Soil Organic Matter (SOM) option of 2.5%. The mean total organic carbon (TOC) content of the samples was 2.0% (or 1.72% if the slightly more organic topsoil is disregarded), and the mean SOM was 3.46% (or 3.0% if the topsoil is disregarded). Therefore, 2.5% comprises a conservative choice.

Table 1: Chemical Determinands in Soils

	Range of Returned concentrations (mgkg ⁻¹)	Public Open Space - Parkland		Commercial	
		S4UL (LQM/CIEH)* (mgkg ⁻¹)	C4SL (DEFRA)* (mgkg ⁻¹)	S4UL (LQM/CIEH)* (mgkg ⁻¹)	C4SL (DEFRA)* (mgkg ⁻¹)
Asbestos	None detected (all 3)	Any presence unacceptable			
Arsenic	1.4-11	170	168	640	640
Boron	<0.5 (all 6)	46,000		240,000	
Cadmium	<0.2-1.1	532	880	190	410
Chromium VI	<1 (all 6)	220	250	33	49
Chromium III	15-162	33,000		8,600	
Copper	3.8-32	44,000		68,000	
Lead	5.5-65		1,300		2,330
Mercury (elemental)	<0.5 (all 6)	30 (25.8*)		58 (25.88)	
Nickel	4.2-36	3,400		980	
Selenium	<0.3-0.9	1,800		12,000	
Zinc	11-72	170,000		730,000	
pH	8.2-9.0				
Phenol	<0.5 (all 6)	1,500 (9,700*)		3,200 (37,000*)	
Total PAH	0.75-3,852.26				
PAH Naphthalene	<0.02-1.45	1,200 (76.4*)		460 (183*)	
PAH Acenaphthylene	<0.02-3.16	29,000		97,000 (212*)	
PAH Acenaphthene	<0.02-55.69	29,000		97,000 (141*)	
PAH Fluorene	<0.02-73.49	20,000		68,000	
PAH Phenanthrene	0.11-598.62	6,200		22,000	
PAH Anthracene	<0.02-205.12	150,000		540,000	
PAH Fluoranthene	0.12-740.27	6,300		23,000	
PAH Pyrene	0.11-598.62	15,000		54,000	
PAH Benzo[a]anthracene	0.07- 296.07	49		170	
PAH Chrysene	<0.03- 272.18	93.0		350	
PAH Benzo(b)fluoranthene	0.09- 252.72	13		44	
PAH Benzo(k)fluoranthene	0.04-108.12	370		1,200	
PAH Benzo(a)pyrene	0.08- 246.62	11	21	35	76
PAH Dibenzo(a,h)anthracene	<0.02- 28.91	1.1		3.6	
PAH Indeno(123-cd)pyrene	0.06- 180.09	150		510	
PAH Benzo(ghi)perylene	0.05-160.32	1,400		4,000	
Benzene	<0.01 (all 4)	100	230	47	98
Toluene	<0.01 (all 4)	95,000 (1,920*)		110,000 (1,920*)	
Ethylbenzene	<0.01 (all 4)	22,000 (1,220*)		13,000 (1,220*)	
m- & p-Xylene	<0.02 (all 4)	m- 24,000 (1,470*) p- 23,000 (1,350*)		1,400 (1,470*) 1,400 (1,350*)	
o-Xylene	<0.01 (all 4)	24,000 (1,120*)		1,500 (1,120*)	
TPH Aromatic C5-C7	<0.01 (all 4)	84,000 (2,260*)		860,000 (4,710*)	
TPH Aromatic C7-C8	<0.01 (all 4)	95,000 (1,920*)		180,000 (4,360*)	
TPH Aromatic C8-C10	<0.01 (all 4)	8,500 (1,500*)		17,000 (3,580*)	
TPH Aromatic C10-C12	<1-2	9,700 (899*)		34,000 (2,150*)	
TPH Aromatic C12-C16	4-60	10,000		38,000	
TPH Aromatic C16-C21	160-2,248	7,700		28,000	
TPH Aromatic C21-C35	131-1,386	7,800		28,000	
TPH Aromatic C35-C44	14-161	7,800		28,000	
TPH Aliphatic C5-C6	<0.1 (all 4)	130,000 (558*)		12,000 (1,150*)	
TPH Aliphatic C6-C8	<0.1 (all 4)	220,000 (322*)		40,000 (736*)	
TPH Aliphatic C8-C10	<0.1-0.2	18,000 (190*)		11,000 (451*)	
TPH Aliphatic C10-C12	<4-15	23,000 (118*)		47,000 (283*)	
TPH Aliphatic C12-C16	56- 458	25,000 (59*)		90,000 (142*)	
TPH Aliphatic C16-C35	783-10,949	480,000		1,800,000	
TPH Aliphatic C35-C44	262-1,569	480,000		1,800,000	

*For "public open space – parkland" use, at 2.5% organic matter where relevant.

**Estimates soil saturation limit above which potential for free phase contamination *might* exist

Exceedances of target values for POS 2 have been noted for some PAH species in all samples of made ground save for the dolomitic limestone subbase layer below the asphalt.

The sample of suspected old asphalt recovered from a depth of 0.50m in BH1 contained by some margin the highest PAH levels, and was the only sample to return exceedances of the higher commercial land use target values. This sample also returned an exceedance of the estimated soil saturation limit for aliphatic hydrocarbons of carbon number C₁₂-C₁₆ (though no exceedance of the target value was noted for any petroleum hydrocarbon fractions).

Further discussion of these results is included in Section 5.3 later.

5.2.2 Contamination Risk to Controlled Waters

The new GSH boreholes are being drilled to 150m into the bedrock and underlying principal aquifer (Wilmslow Sandstone Formation). It was therefore important to assess the risk to this resource because it was feasible that the drilling exercise could create a potential pathway for migration of mobile contaminants to the aquifer.

As such leachate was analysed from five (5) samples of made ground and topsoil. Initially, analysis was undertaken for the metal/metalloid suite and PAHs on samples of the dark fill (from BH1 and TPA), the grey-brown fill (from BH3) and of topsoil (from BH5), with a sample of the suspected old asphalt (from BH2) inspected only for PAHs. Following receipt of the analysis results, a further leachate test was requested on the other sample of suspected old asphalt (from BH1) due to the highest *soil* PAH levels being returned for that sample.

Levels for domestic water supply or the protection of aquatic life levels as published by the Environment Agency are presented as the assessment criteria, but these are not strictly target values. They are not directly applicable to leachates because these standards would represent the total concentration in the receiving water bodies following mixing of leached contaminants. As such the standards are included as an example of good water quality for consideration of how leachable contamination might affect such waters. The results of the testing and the assessment criteria are shown Table 2 on the following page.

Table 2: Chemical Determinands in Leachate

	Returned Concentrations (µg/l)	UK Standard for Surface Waters intended for Drinking Water Abstraction* (DW) and/or protection of Aquatic Life in surface waters* (Aq) (µg/l)
<i><u>Inorganic Chemicals</u></i>		
Arsenic	1.99-5.24	50-100 (DW, range: 50-100) / 50 (Aq)
Boron	8-11	1000 (DW & Aq)
Cadmium	<0.07 (all 4)	5 (DW & Aq)
Chromium	0.3-2.9	50 (DW) / 5-250 (Aq, range: 5-250)
Copper	2.6-3.6	50 (DW) / 5-112 (Aq, range: 5-112)
Lead	1.3-5.5	50 (DW) / 4-250 (Aq, range: 4-250)
Mercury (elemental Hg)	<0.008 (all 4)	1 (DW & Aq)
Nickel	<0.5-2.0	20** (DW) / 50-200 (Aq, range: 50-200)
Selenium	0.28-0.74	10 (DW) (No Aq standard)
Zinc	1-8	3000 (DW, range: 3000-5000) / 30-2000 (Aq, range: 30-2000)
pH	7.2-9.2	Range 5.5 to 10 (UK drinking water standards)
<i><u>Organic Chemicals</u></i>		
Cyanide (free and total)	<20 (all 4)	50 (DW) / 5 (Aq)
Phenols	<10 (all 4)	50** (DW) / 300 (Aq)
PAHs (total)	<1.6*** - 112.0	0.2 (DW, range: 0.2-1.0) (No Aq standard)
PAH Species at detectable concentrations		
Acenaphthene	<0.1-14.5	No applicable UK standard
Acenaphthylene	<0.1-0.4	No applicable UK standard
Anthracene	<0.1- 7.2	0.4 (surface water quality, max. allowable)
Benzo(a)anthracene	0.3-3.1	No applicable UK standard
Benzo(a)pyrene	<0.1- 5.7	0.1 (surface water quality, max. allowable)
Benzo(b)fluoranthene	<0.1- 5.5	0.03 (surface water quality, annual average)
Benzo(ghi)perylene	<0.1- 4.6	0.002 (surface water quality, annual average)
Benzo(k)fluoranthene	<0.1- 2.4	0.03 (surface water quality, annual average)
Chrysene	<0.1-4.0	No applicable UK standard
Dibenzo(a,h)anthracene	<0.1-0.7	No applicable UK standard
Fluoranthene	0.4- 12.5	1 (surface water quality, max. allowable)
Fluorene	<0.1-12.4	No applicable UK standard
Indeno(123-cd)pyrene	<0.1- 5.3	0.002 (surface water quality, annual average)
Naphthalene	<0.1-0.7	10 (Aq, UK inland waters)
Phenanthrene	<0.1-35.9	No applicable UK standard
Pyrene	0.2-9.3	No applicable UK standard

*sourced from Environment Agency database at <http://evidence.environment-agency.gov.uk/ChemicalStandards/home.aspx>.

If more than one option is available (dependent on other water properties or environmental setting) the lowest value has been adopted.

**Standard for water supply as no standard available for surface water abstraction for drinking water.

***Sum of 16 US EPA PAH species, each at a lowest detectable limit of 0.1ppb.

Slightly elevated PAH levels have been returned for leachate from the samples of the dark fill recovered from BH1 (0.50m) and TPA (0.50m), and unexpectedly from the sample of topsoil from BH5 (0.20m). These are often in excess of the surface water quality standard but, where available (for naphthalene), the standard for protection of aquatic life was not exceeded.

More discussion is presented in Section 5.3 later.

5.3 Review of Results

Soil

Natural subsoils and topsoil, together with the dolomitic limestone gravel fill have all returned contaminant concentrations within the target values for “public open space – parkland” and so no contamination issue is considered to exist in the area to the northwest of the leisure centre building where grassed open space is present. No made ground was present in this area, only topsoil and natural subsoils.

The car park area to the northeast of the leisure centre building is considered to classify as a commercial end use because no real opportunity exists in that area for use of the soft landscaped areas by the public.

Here, several samples of the fill material contained elevated PAH levels, but the only sample to return noteworthy contaminant levels above the commercial target values was the sample of (presumed) old asphalt recovered from a depth of 0.50m in BH1.

As discussed earlier, where they exist, the DEFRA C4SL target values are used in preference to the S4UL target values. Benzo(a)pyrene (B(a)P) is the only PAH species to have a corresponding C4SL and so Geoinvestigate normally adopts the surrogate marker method for PAH contamination assessment. i.e. the level of B(a)P in each sample is taken as representative of the overall PAH risk and is compared with the C4SL target value. Exceedances of the more stringent S4UL target values for other PAH species are therefore not necessarily representative of any significant risk to site users.

The surrogate marker methodology is set out and justified in Public Health England guidance* and that guidance/research found no examples of UK sites where this approach would not be appropriate. As such, an SM assessment allows for a simplified PAH contamination assessment for this site.

*“Contaminated Land Information Sheet: risk assessment approaches for polycyclic aromatic hydrocarbons (PAHs)” (PHE 2017).

The only exceedance of the commercial C4SL for B(a)P was in the sample recovered from a depth of 0.50m in BH1. Two other samples returned levels slightly in excess of one or two other PAH species but, given the SM approach outlined above, these are not considered to be representative of any overall contamination issue.

It can therefore be concluded that the deeper old asphalt layer at BH1 could be considered unsuitable for use at the site. This may sporadically be the case in other locations below the car park following the discovery of similar material at BH2. It is likely that the elevated PAH levels in this material is due to a coal tar content.

However, none of the other made ground returned any significant exceedances of commercial assessment criteria (specifically the C4SL for B(a)P) and so can probably be assumed to be acceptable.

It is considered likely that the old asphalt is only present below the asphalt car park area, and possibly at depth below the soft landscaped areas and verged around the car park. Where this material is below existing hardstanding surfaces, no pathway for contaminant exposure will exist and so it will not pose any risk to human health. The material was not found in the full 0.75m depth of TPA and so may not be present below the soft landscaped areas, or may be sufficiently deep to not pose any risk to surface receptors.

It is therefore unlikely that any remedial works will be required to address risks to human health or other surface receptors at the site.

Leachate

Slightly elevated PAH levels have been returned for leachate from the samples of the dark fill recovered from BH1 (0.50m) and TPA (0.50m), and unexpectedly from the sample of topsoil from BH5 (0.20m). These are often in excess of the surface water quality standard but, where available (for naphthalene), the standard for protection of aquatic life was not exceeded.

Regardless, as discussed earlier, these are not target values for leachate, only for the receiving water bodies. As such, the potential for these soils to adversely affect those receptors needs to be considered, including whether these soils might cause these target values to be exceeded in the receiving waters.

The reason for the slightly elevated PAHs in leachate from the topsoil at BH5 is unclear. The levels in soil at that location are negligibly low. A very minor ash content was noted in the topsoil in this part of the site, but it is unusual to see leachate concentrations at these levels given the low soil PAH levels. Nonetheless, they are not particularly high levels.

This likelihood of significant risk being posed by these soils to ground or surface waters is considered low for a number of reasons:

- The leachate levels are not alarmingly high with maximum (total) PAH levels in leachate being only 112 parts per billion ($\mu\text{g l}^{-1}$).
- The total quantity of these soils below the site will be relatively small given their limited depth and extent, and hence the total potential for leached contaminants (in terms of overall quantity over time) will also be low and unlikely to have any measurable effect on the potentially receiving water bodies.
- The vast majority of these soils are covered by asphalt hardstanding and so negligible water ingress from above will be possible. This significantly reduces the likelihood that contaminants might be mobilised.
- Where excavation was extended to greater depth at BH3, a natural clay horizon was encountered. Wherever present, this would provide a very low permeability barrier to potential contaminant migration. A clay horizon was discovered in most, but not all, of the 2013 investigation excavations (9 out of 11 locations encountered clay soils at depth).

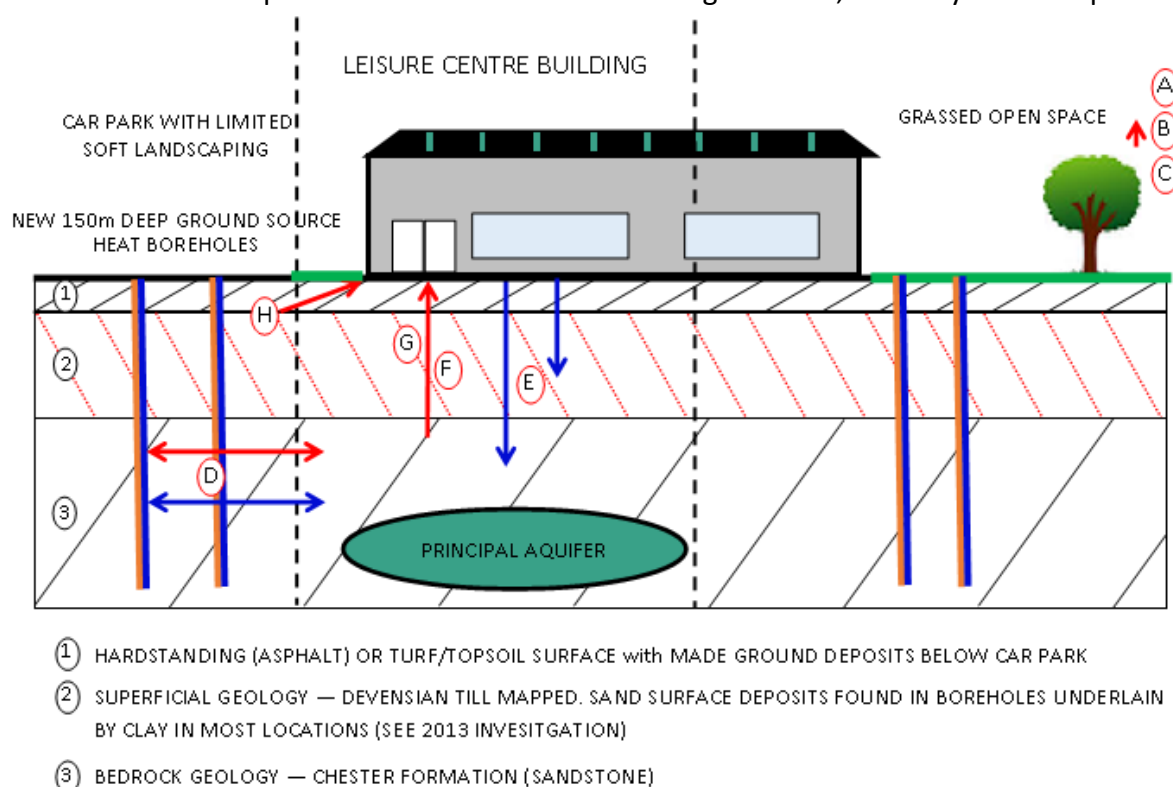
It is not expected that the installation of the GSH boreholes will produce any significant pathway to the underlying aquifer, or cause any mobilisation of contamination. If groundwater levels were high and within the made ground strata, some risk might be considered possible in terms of mobilising contamination along a pathway adjacent to or within the boreholes, but the groundwater monitoring undertaken as part of the 2013 site investigation found groundwater levels to be between 1.92m and 2.83m below ground level. Regardless, the potential presence of a feasible pathway does not suggest an elevated risk of a complete pollutant linkage given the contaminant levels in leachate and the above discussion.

A single location of the 2013 investigation (TP1) encountered shallower ground water at 0.70m BGL but this was at the far opposite (south) end of the larger site and well beyond the current study area.

5.3.1 CGHM

The conceptual ground hazard model (CGHM) presented below shows the potential hazards and pollutant linkages which have been considered at the site.

Figure 2: CGHM – Conceptual cross section of site including a Source, Pathway and Receptor Model



IDENTIFIED HAZARDS Including Potential CONTAMINATION SOURCES

-Made ground and potential contamination thereof.

(probably insufficient made ground to constitute a serious potential hazardous gas source but ground gas risk assessment is beyond the scope of these works).

-Former land use as residential (prefab) housing, including subsequent demolition works.

IDENTIFIED RECEPTORS and ASSOCIATED PATHWAY

A— End Users through Direct Contact / Inhalation / Ingestion. Buildings and hard standing encompasses much of the study area, removing any pathway to end users through direct contact.

B— Plants and Trees through uptake.

C— End Users through cultivation and consumption of vegetables / fruit. Impossible given the intended use/layout of the site.

Low risk concluded with regard to linkages A-C. No significantly elevated contaminant levels discovered in open space and no complete pollutant linkage likely in car park (single sample found to contain elevated PAH levels but this material is confined below an asphalt surface).

D— Neighbouring Sites through lateral migration (in soil and water, including surface water run off).

E— Ground water through leaching of sub-soil.

Linkages D-E also concluded to be low risk. No significantly elevated contaminant levels in leachate and no significant likelihood of contaminant mobilisation where higher PAH levels have been returned (asphalt cover preventing water ingress).

F— Buildings and services through direct contact.

G— End users and buildings through ground gas migration.

Linkages F-G are beyond the scope of this exercise.

6. Conclusions

6.1 Contamination

Following a review of the soil and leachate analysis results, and an assessment of the ground conditions at the site, there is not considered to be any likely situation where soils at the site will pose any significant risk to identified receptors.

As such, it is our opinion that no remedial works will be required.

Soils to the northwest of the leisure centre building have been assessed with regard to a public open space land use, and have been shown to be free from any elevated levels of potential contaminants.

Soils within and around the car park areas to the northeast of the leisure centre building have been assessed with regard to commercial land use. One sample (from BH1) has been discovered to contain levels of contaminants in excess of the target values, but this was located below the current asphalt car park (as was the only other comparable sample from BH2).

It is thought likely that no such materials are in a position whereby they could potentially cause harm to surface receptors (being below hardstanding or sufficiently deep), and they are not considered capable of leaching significant overall quantities of contamination which might affect local ground and surface waters in any measurable way, not least because they are confined below asphalt where water ingress will be virtually impossible.

Further to the above, if hitherto unencountered contamination is discovered during the ongoing GSH installation works, works should be halted and both Geoinvestigate and the Local Planning Authority should be notified.

END OF REPORT

The findings and contents of this (intrusive) Site Investigation Report pertain solely to the study area(s) outlined herein and are based solely on the findings of the excavations undertaken as part of the current exercise unless otherwise stated. The findings and/or recommendations of this report do not take into account any ground conditions that may be present but have hitherto not been encountered and as such further investigation and/or a reconsideration of the findings of this report should be undertaken if such conditions are subsequently encountered or an alternative development plan or land use is subsequently proposed.

This report considers various environmental and/or geological risks posed to the site and/or proposed development and offers advice accordingly as guidance only. The findings of this report will remain valid provided no change of ground or groundwater conditions, either natural or anthropogenic, take place and no warrantee is offered or implied.

No copying of this report or any part of its contents is permitted without written permission of Geoinvestigate Ltd. nor should the report be made available to any third party without similar prior arrangement.



Units 3a and 4 Terry Dicken Industrial Estate
Ellerbeck Way
Stokesley
North Yorkshire
TS9 7AE

Tel. 01642 713779

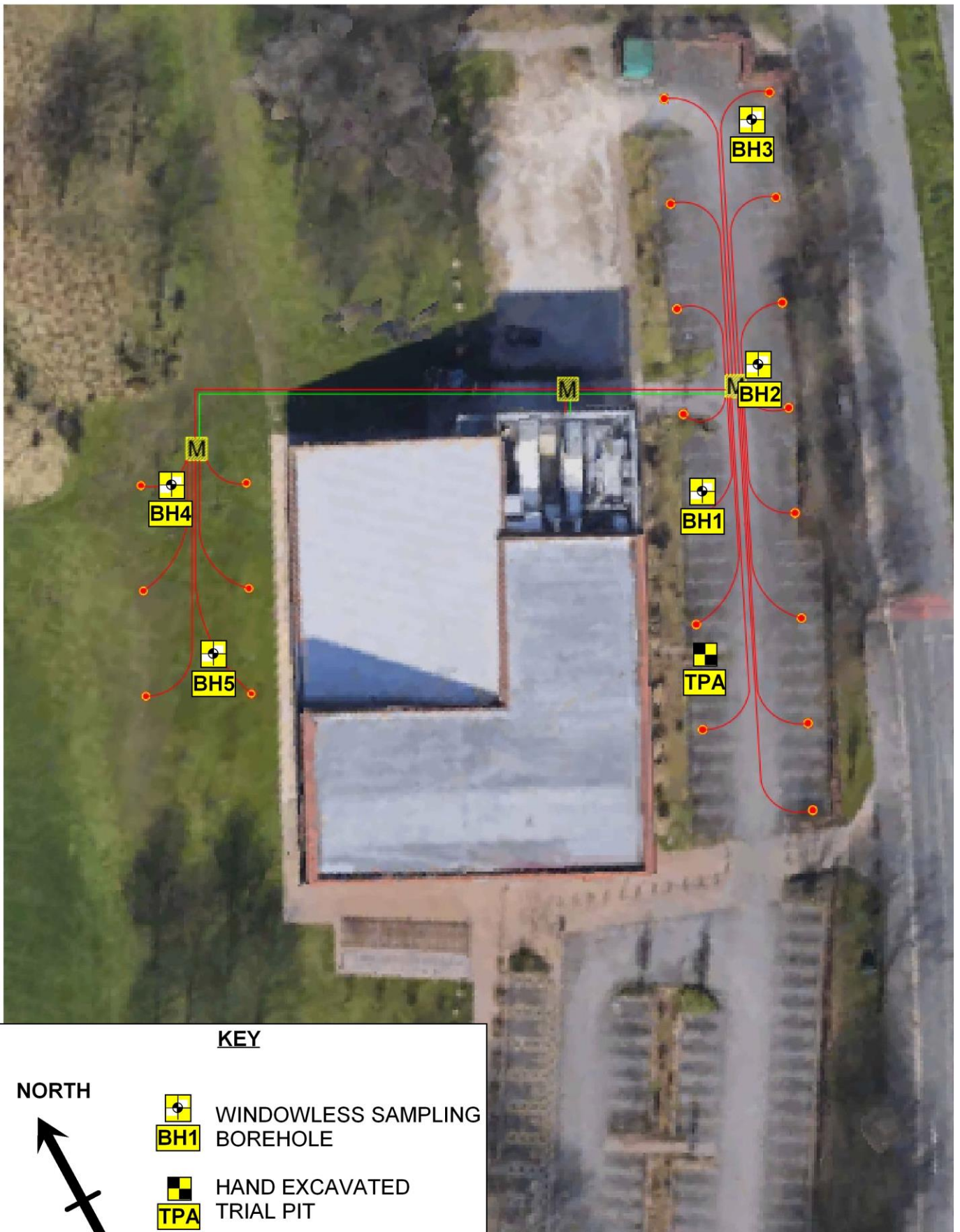
Fax 01642713923

Email enquiries@geoinvestigate.co.uk

APPENDIX 1
Site Plan
and
Borehole / Trial Pit Logs

GEOINVESTIGATE Ltd.

OUR REF: G22017	YOUR REF:	SITE PLAN (NOT TO SCALE)
DATE: 25/01/2022	LOCATION: Hough End Leisure Centre, 480 Princess Road, Manchester, M20 1HD	



DATE: 25/01/22



BH1

GEOINVESTIGATE Ltd.

Your Ref. 4001038

Our Ref. G22017

BH No.2 Sheet No. 1 of 1

Location: Hough End Leisure Centre, 480 Princess Road, Manchester, M20 1HD

DATE: 25/01/22

[illegible]

Remarks:

No borehole casing used
Dynamic windowless sampling by Terrier Rig to 1.00m
Borehole remained open and dry on completion

Key:

Legend for Figure 10.1:

- Slotted Pipe
- Plain Pipe
- Bentonite
- Gravel Filter

O	Disturbed sample
Cv	Shear vane
W	Water sample
S	Standard Penetration Test using solid cone

BH2

GEOINVESTIGATE Ltd.**Your Ref.** 4001038**Our Ref.** G22017**BH No.3 Sheet No. 1 of 1****Location:** Hough End Leisure Centre, 480 Princess Road, Manchester, M20 1HD**DATE:** 25/01/22

Depth (m)	Description of Strata	Thickness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.130	ASPHALT	130				Cv kN/m ²			
0.50	MADE GROUND. Compact yellowish grey sandy gravel of dolomitic limestone.	370			O				0.25
1.00	MADE GROUND. Compact grey-brown sandy gravel. Gravel is fine to coarse of sandstone, limestone, brick, concrete, coal and ash.	500			O				0.50
1.60	Medium dense yellowish brown medium SAND. Slightly clayey in places.	600			O				0.75
2.00	Firm brown very sandy gravelly CLAY. Gravel is fine to coarse of sandstone.	400			O				1.00
	Borehole terminated at 2.00m								1.25
	Cores recovered from borehole:								1.50
									1.75
									2.00

Remarks:

Casing to 1.00m

Dynamic windowless sampling by Terrier Rig to 4.00m

Borehole remained open and dry on completion

Key:
 Slotted Pipe
 Plain Pipe
 Bentonite
 Gravel Filter
O Disturbed sample**Cv** Shear vane**W** Water sample**S** Standard Penetration Test using solid cone**BH3**

DATE: 25/01/22

BH4

GEOINVESTIGATE Ltd.

Your Ref. 4001038

Our Ref. G22017

BH No.5 Sheet No. 1 of 1

Location: Hough End Leisure Centre, 480 Princess Road, Manchester, M20 1HD

DATE: 25/01/22

[illegible]

Remarks:

Casing to 0.50m

Dynamic windowless sampling by Terrier Rig to 0.50m

Borehole remained open and dry on completion

Key:

	Slotted Pipe
	Plain Pipe
	Bentonite
	Gravel Filter

O Disturbed sample

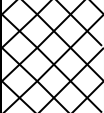
Cv Shear vane

W Water sample

S Standard Penetration Test
using solid cone

BH5

GEOINVESTIGATE Ltd.**Your Ref.** 4001038**Our Ref.** G22017**TP A****Sheet No. 1 of 1****Location:** Hough End Leisure Centre, 480 Princess Road, Manchester, M20 1HD**DATE:** 25/01/22

Depth (m)	Description of Strata	Thickness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.15	TOPSOIL. Loose dark brown silty sand. Many roots.	150			O	Cv kN/m ²			0.25
0.40	MADE GROUND. Loose pale yellowish brown sandy fine to coarse dolomitic limestone gravel.	250			O				0.50
0.75	MADE GROUND. Loose dark grey to black sandy gravel. Gravel is mostly fine to medium of sandstone, limestone, probable asphalt, brick and slag. Some coarse gravel also present. Slight ashy odour, probably mostly road planings. Trial pit terminated at 0.75m	350							0.75
Trial pit location:  Close up of trial pit:  Soils excavated from trial pit: 									

Remarks:

Hand excavated to 0.75m

Trial pit remained stable and dry on completion

Key: O Disturbed sample
Cv Shear vane
W Water sample

TPA

APPENDIX 2
Chemtech Analytical Test Report



ANALYTICAL TEST REPORT

Contract no: 105207(1)

Contract name: Hough End Leisure Centre, 480 Princess Road, Manchester, M20 1HD

Client reference: G22017

Clients name: Geo Investigate

Clients address: Units 3a & 4 Terry Dicken Industrial Estate
Ellerbeck Way, Stokesley
North Yorkshire
TS9 7AE

Samples received: 28 January 2022

Analysis started: 28 January 2022

Analysis completed: 17 February 2022

Report issued: 17 February 2022

This is a supplementary report to report number 105207 issued 07 February 2022.

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:

Rachael Burton

Reporting Team Lead

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.

Lab ref	Sample id	Depth (m)	Sample description	Material removed	% Removed	% Moisture
105207-1	BH1	0.30	Sandy Clayey Loam with Gravel	-	-	10.2
105207-2	BH1	0.50	Sandy Clayey Loam with Gravel	-	-	5.8
105207-3	BH2	0.60	Sandy Clayey Loam with Gravel	-	-	5.1
105207-4	BH3	0.30	Clayey Sand with Gravel	-	-	2.4
105207-5	BH3	0.80	Sandy Clayey Loam with Gravel	-	-	11.7
105207-6	BH3	1.50	Clayey Sand with Gravel	-	-	10.0
105207-7	BH5	0.20	Sandy Loamy Clay with Roots	-	-	24.3
105207-8	TPA	0.50	Sandy Clayey Loam with Gravel	-	-	6.7

Chemtech Environmental Limited

SOILS

Lab number Sample id Depth (m) Date sampled			105207-1 BH1 0.30 25/01/2022	105207-2 BH1 0.50 25/01/2022	105207-3 BH2 0.60 25/01/2022	105207-4 BH3 0.30 25/01/2022	105207-5 BH3 0.80 25/01/2022	105207-6 BH3 1.50 25/01/2022
Test	Method	Units						
Arsenic (total)	CE127 ^M	mg/kg As	6.2	-	-	1.4	11	2.2
Boron (water soluble)	CE063 ^M	mg/kg B	<0.5	-	-	<0.5	<0.5	<0.5
Cadmium (total)	CE127 ^M	mg/kg Cd	0.6	-	-	1.1	0.3	<0.2
Chromium (total)	CE127 ^M	mg/kg Cr	59	-	-	15	65	155
Chromium (III)	CE208	mg/kg CrIII	59	-	-	15	65	155
Chromium (VI)	CE146	mg/kg CrVI	<1	-	-	<1	<1	<1
Copper (total)	CE127 ^M	mg/kg Cu	31	-	-	3.8	32	5.9
Lead (total)	CE127 ^M	mg/kg Pb	58	-	-	31	39	5.5
Mercury (total)	CE127 ^M	mg/kg Hg	<0.5	-	-	<0.5	<0.5	<0.5
Nickel (total)	CE127 ^M	mg/kg Ni	36	-	-	4.2	29	10
Selenium (total)	CE127 ^M	mg/kg Se	0.9	-	-	<0.3	0.8	<0.3
Zinc (total)	CE127 ^M	mg/kg Zn	72	-	-	27	43	11
pH	CE004 ^M	units	8.2	-	-	9.0	9.0	8.8
Sulphate (2:1 water soluble)	CE061 ^U	mg/l SO ₄	102	-	-	12	71	15
Sulphide	CE079	mg/kg S ²⁻	<10	-	-	<10	<10	<10
Cyanide (free)	CE077	mg/kg CN	<1	-	-	<1	<1	<1
Cyanide (total)	CE077	mg/kg CN	<1	-	-	<1	<1	<1
Thiocyanate	CE145 ^M	mg/kg SCN	3.3	-	-	<1	2.2	<1
Phenols (total)	CE078	mg/kg PhOH	<0.5	-	-	<0.5	<0.5	<0.5
Total Organic Carbon (TOC)	CE197	% w/w C	3.6	-	-	0.1	1.6	0.2
Estimate of OMC (calculated from TOC)	CE197	% w/w	6.3	-	-	0.2	2.8	0.3
PAH								
Acenaphthene	CE087 ^M	mg/kg	6.90	55.69	-	<0.02	2.36	<0.02
Acenaphthylene	CE087 ^M	mg/kg	0.67	3.16	-	<0.02	0.22	<0.02
Anthracene	CE087 ^U	mg/kg	21.93	205.12	-	<0.02	12.11	<0.02
Benzo(a)anthracene	CE087 ^U	mg/kg	40.04	296.07	-	0.07	26.99	0.04
Benzo(a)pyrene	CE087 ^U	mg/kg	40.54	246.62	-	0.08	22.50	0.05
Benzo(b)fluoranthene	CE087 ^M	mg/kg	38.73	252.72	-	0.09	23.82	0.05
Benzo(ghi)perylene	CE087 ^M	mg/kg	29.09	160.32	-	0.06	12.96	0.05
Benzo(k)fluoranthene	CE087 ^M	mg/kg	23.40	108.12	-	0.04	12.82	0.03
Chrysene	CE087 ^M	mg/kg	37.69	272.18	-	0.06	25.30	<0.03
Dibenz(ah)anthracene	CE087 ^M	mg/kg	7.18	28.91	-	<0.02	2.72	<0.02
Fluoranthene	CE087 ^M	mg/kg	100.94	740.27	-	0.12	63.61	0.06
Fluorene	CE087 ^U	mg/kg	7.67	73.49	-	<0.02	3.37	<0.02
Indeno(123cd)pyrene	CE087 ^M	mg/kg	30.49	180.09	-	0.08	15.65	0.06
Naphthalene	CE087 ^M	mg/kg	0.40	1.45	-	<0.02	0.10	<0.02
Phenanthrene	CE087 ^M	mg/kg	64.96	629.43	-	0.04	28.37	0.04
Pyrene	CE087 ^M	mg/kg	86.00	598.62	-	0.11	51.31	0.05
PAH (total of USEPA 16)	CE087	mg/kg	537	3852	-	0.75	304	0.44

Chemtech Environmental Limited

SOILS

Lab number			105207-1	105207-2	105207-3	105207-4	105207-5	105207-6
Sample id			BH1	BH1	BH2	BH3	BH3	BH3
Depth (m)			0.30	0.50	0.60	0.30	0.80	1.50
Date sampled			25/01/2022	25/01/2022	25/01/2022	25/01/2022	25/01/2022	25/01/2022
Test	Method	Units						
BTEX & TPH								
Benzene	CE192 ^u	mg/kg	<0.01	<0.01	-	-	<0.01	-
Toluene	CE192 ^u	mg/kg	<0.01	<0.01	-	-	<0.01	-
Ethylbenzene	CE192 ^u	mg/kg	<0.01	<0.01	-	-	<0.01	-
m & p-Xylene	CE192 ^u	mg/kg	<0.02	<0.02	-	-	<0.02	-
o-Xylene	CE192 ^u	mg/kg	<0.01	<0.01	-	-	<0.01	-
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	<0.01	<0.01	-	-	<0.01	-
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	<0.01	<0.01	-	-	<0.01	-
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	<0.01	<0.01	-	-	<0.01	-
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	<1	2	-	-	<1	-
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	9	60	-	-	4	-
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	283	2248	-	-	160	-
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	219	1386	-	-	131	-
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	30	161	-	-	14	-
VPH Aliphatic (>C5-C6)	CE067	mg/kg	<0.1	<0.1	-	-	<0.1	-
VPH Aliphatic (>C6-C8)	CE067	mg/kg	<0.1	<0.1	-	-	<0.1	-
VPH Aliphatic (>C8-C10)	CE067	mg/kg	<0.1	<0.1	-	-	<0.1	-
EPH Aliphatic (>C10-C12)	CE068	mg/kg	15	12	-	-	<4	-
EPH Aliphatic (>C12-C16)	CE068	mg/kg	249	458	-	-	56	-
EPH Aliphatic (>C16-C35)	CE068	mg/kg	5863	10949	-	-	783	-
EPH Aliphatic (>C35-C44)	CE068	mg/kg	1557	1569	-	-	262	-
Subcontracted analysis								
Asbestos (qualitative)	\$	-	NAD	-	-	-	NAD	-

Chemtech Environmental Limited

SOILS

Lab number			105207-7	105207-8
Sample id			BH5	TPA
Depth (m)			0.20	0.50
Date sampled			25/01/2022	25/01/2022
Test	Method	Units		
Arsenic (total)	CE127 ^M	mg/kg As	9.4	2.8
Boron (water soluble)	CE063 ^M	mg/kg B	<0.5	<0.5
Cadmium (total)	CE127 ^M	mg/kg Cd	0.2	0.5
Chromium (total)	CE127 ^M	mg/kg Cr	162	21
Chromium (III)	CE208	mg/kg CrIII	162	21
Chromium (VI)	CE146	mg/kg CrVI	<1	<1
Copper (total)	CE127 ^M	mg/kg Cu	29	10
Lead (total)	CE127 ^M	mg/kg Pb	65	62
Mercury (total)	CE127 ^M	mg/kg Hg	<0.5	<0.5
Nickel (total)	CE127 ^M	mg/kg Ni	17	9.1
Selenium (total)	CE127 ^M	mg/kg Se	0.7	0.3
Zinc (total)	CE127 ^M	mg/kg Zn	56	53
pH	CE004 ^M	units	8.3	8.8
Sulphate (2:1 water soluble)	CE061 ^U	mg/l SO ₄	37	103
Sulphide	CE079	mg/kg S ²⁻	<10	<10
Cyanide (free)	CE077	mg/kg CN	<1	<1
Cyanide (total)	CE077	mg/kg CN	<1	<1
Thiocyanate	CE145 ^M	mg/kg SCN	9.9	3.7
Phenols (total)	CE078	mg/kg PhOH	<0.5	<0.5
Total Organic Carbon (TOC)	CE197	% w/w C	3.4	3.1
Estimate of OMC (calculated from TOC)	CE197	% w/w	5.8	5.4
PAH				
Acenaphthene	CE087 ^M	mg/kg	0.04	2.85
Acenaphthylene	CE087 ^M	mg/kg	<0.02	0.84
Anthracene	CE087 ^U	mg/kg	0.13	9.91
Benzo(a)anthracene	CE087 ^U	mg/kg	0.42	31.62
Benzo(a)pyrene	CE087 ^U	mg/kg	0.39	34.29
Benzo(b)fluoranthene	CE087 ^M	mg/kg	0.46	31.09
Benzo(ghi)perylene	CE087 ^M	mg/kg	0.26	22.03
Benzo(k)fluoranthene	CE087 ^M	mg/kg	0.17	15.74
Chrysene	CE087 ^M	mg/kg	0.43	30.31
Dibenz(ah)anthracene	CE087 ^M	mg/kg	0.05	4.46
Fluoranthene	CE087 ^M	mg/kg	0.79	63.55
Fluorene	CE087 ^U	mg/kg	0.04	2.65
Indeno(123cd)pyrene	CE087 ^M	mg/kg	0.30	25.82
Naphthalene	CE087 ^M	mg/kg	<0.02	0.19
Phenanthrene	CE087 ^M	mg/kg	0.43	31.15
Pyrene	CE087 ^M	mg/kg	0.73	54.83
PAH (total of USEPA 16)	CE087	mg/kg	4.62	361

Chemtech Environmental Limited

SOILS

Lab number			105207-7	105207-8
Sample id			BH5	TPA
Depth (m)			0.20	0.50
Date sampled			25/01/2022	25/01/2022
Test	Method	Units		
BTEX & TPH				
Benzene	CE192 ^u	mg/kg	-	<0.01
Toluene	CE192 ^u	mg/kg	-	<0.01
Ethylbenzene	CE192 ^u	mg/kg	-	<0.01
m & p-Xylene	CE192 ^u	mg/kg	-	<0.02
o-Xylene	CE192 ^u	mg/kg	-	<0.01
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	-	<0.01
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	-	<0.01
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	-	<0.01
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	-	<1
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	-	5
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	-	163
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	-	174
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	-	23
VPH Aliphatic (>C5-C6)	CE067	mg/kg	-	<0.1
VPH Aliphatic (>C6-C8)	CE067	mg/kg	-	<0.1
VPH Aliphatic (>C8-C10)	CE067	mg/kg	-	0.2
EPH Aliphatic (>C10-C12)	CE068	mg/kg	-	7
EPH Aliphatic (>C12-C16)	CE068	mg/kg	-	87
EPH Aliphatic (>C16-C35)	CE068	mg/kg	-	3872
EPH Aliphatic (>C35-C44)	CE068	mg/kg	-	1529
Subcontracted analysis				
Asbestos (qualitative)	\$	-	NAD	-

Chemtech Environmental Limited

PREPARED LEACHATES

Lab number Sample id Depth (m)			105207-1L BH1 0.30	105207-2L BH1 0.50	105207-3L BH2 0.60	105207-5L BH3 0.80	105207-7L BH5 0.20	105207-8L TPA 0.50
Test	Method	Units						
Arsenic (dissolved)	CE128 ^U	µg/l As	5.24	-	-	1.99	3.76	2.18
Boron (dissolved)	CE128 ^U	µg/l B	11	-	-	11	10	8
Cadmium (dissolved)	CE128 ^U	µg/l Cd	<0.07	-	-	<0.07	<0.07	<0.07
Chromium (dissolved)	CE128 ^U	µg/l Cr	0.5	-	-	0.3	2.9	1.0
Copper (dissolved)	CE128 ^U	µg/l Cu	3.0	-	-	3.6	3.0	2.6
Lead (dissolved)	CE128 ^U	µg/l Pb	1.8	-	-	1.3	5.5	3.5
Mercury (dissolved)	CE128 ^U	µg/l Hg	<0.008	-	-	<0.008	<0.008	<0.008
Nickel (dissolved)	CE128 ^U	µg/l Ni	0.9	-	-	2.0	<0.5	1.0
Selenium (dissolved)	CE128 ^U	µg/l Se	0.74	-	-	0.28	0.57	0.32
Zinc (dissolved)	CE128 ^U	µg/l Zn	3	-	-	8	1	2
pH	CE213 ^U	units	9.2	-	-	7.2	7.5	7.7
Sulphate	CE049 ^U	mg/l SO ₄	5.0	-	-	2.2	2.6	2.0
Sulphur (dissolved)	CE128 ^U	mg/l S	2.1	-	-	0.9	1.1	0.9
Sulphide	CE079	µg/l S ²⁻	<100	-	-	<100	<100	<100
Cyanide (free)	CE147	µg/l CN	<20	-	-	<20	<20	<20
Cyanide (total)	CE147	µg/l CN	<20	-	-	<20	<20	<20
Thiocyanate	CE014	µg/l SCN	321	-	-	<200	<200	<200
Phenols (total)	CE148	µg/l PhOH	<10	-	-	<10	<10	<10
PAH								
Acenaphthene	CE051	µg/l	1.1	14.5	<0.1	0.2	0.8	1.4
Acenaphthylene	CE051	µg/l	<0.1	0.4	<0.1	<0.1	0.1	0.1
Anthracene	CE051	µg/l	0.3	7.2	<0.1	<0.1	0.9	1.5
Benzo(a)anthracene	CE051	µg/l	0.7	3.1	0.3	0.3	4.1	3.1
Benzo(a)pyrene	CE051	µg/l	0.7	3.2	0.5	<0.1	5.7	4.9
Benzo(b)fluoranthene	CE051	µg/l	0.7	3.3	0.5	<0.1	5.5	4.7
Benzo(ghi)perylene	CE051	µg/l	0.5	2.0	0.6	<0.1	4.6	3.7
Benzo(k)fluoranthene	CE051	µg/l	0.2	1.6	0.1	<0.1	2.4	1.7
Chrysene	CE051	µg/l	0.6	3.1	0.2	<0.1	4.0	3.2
Dibenz(ah)anthracene	CE051	µg/l	<0.1	0.3	<0.1	<0.1	0.7	0.6
Fluoranthene	CE051	µg/l	1.2	12.5	0.5	0.4	6.6	5.6
Fluorene	CE051	µg/l	0.7	12.4	0.1	<0.1	0.7	1.2
Indeno(123cd)pyrene	CE051	µg/l	0.5	2.6	0.5	<0.1	5.3	4.6
Naphthalene	CE051	µg/l	0.1	0.7	<0.1	<0.1	0.2	0.3
Phenanthrene	CE051	µg/l	0.6	35.9	0.3	<0.1	3.7	4.6
Pyrene	CE051	µg/l	1.0	9.3	0.4	0.2	5.8	5.0
PAH (total of USEPA 16)	CE051	µg/l	9.0	112.0	4.0	<1.6	51.1	46.1

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE127	Arsenic (total)	Aqua regia digest, ICP-MS	Dry	M	1	mg/kg As
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
CE208	Chromium (III)	Calculation: Cr (total) - Cr (VI)	Dry		1	mg/kg CrIII
CE146	Chromium (VI)	Acid extraction, Colorimetry	Dry		1	mg/kg CrVI
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
CE004	pH	Based on BS 1377, pH Meter	As received	M	-	units
CE061	Sulphate (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry	U	10	mg/l SO ₄
CE079	Sulphide	Extraction, Continuous Flow Colorimetry	As received		10	mg/kg S ²⁻
CE077	Cyanide (free)	Extraction, Continuous Flow Colorimetry	As received		1	mg/kg CN
CE077	Cyanide (total)	Extraction, Continuous Flow Colorimetry	As received		1	mg/kg CN
CE145	Thiocyanate	Weak acid extraction, Colorimetry	Dry	M	1	mg/kg SCN
CE078	Phenols (total)	Extraction, Continuous Flow Colorimetry	As received		0.5	mg/kg PhOH
CE197	Total Organic Carbon (TOC)	Carbon Analyser	Dry		0.1	% w/w C
CE197	Estimate of OMC (calculated from TOC)	Calculation from Total Organic Carbon	Dry		0.1	% w/w
CE087	Acenaphthene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Acenaphthylene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Anthracene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(a)anthracene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(a)pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Benzo(b)fluoranthene	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	Benzo(k)fluoranthene	Solvent extraction, GC-MS	As received	U	0.03	mg/kg
CE087	Chrysene	Solvent extraction, GC-MS	As received	M	0.03	mg/kg
CE087	Dibenz(ah)anthracene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Fluoranthene	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	Indeno(123cd)pyrene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Naphthalene	Solvent extraction, GC-MS	As received	M	0.02	mg/kg
CE087	Phenanthrene	Solvent extraction, GC-MS	As received	U	0.02	mg/kg
CE087	Pyrene	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
CE192	Benzene	Headspace GC-FID	As received	U	0.01	mg/kg
CE192	Toluene	Headspace GC-FID	As received	U	0.01	mg/kg
CE192	Ethylbenzene	Headspace GC-FID	As received	U	0.01	mg/kg
CE192	m & p-Xylene	Headspace GC-FID	As received	U	0.02	mg/kg
CE192	o-Xylene	Headspace GC-FID	As received	U	0.01	mg/kg
CE067	VPH Aromatic (>EC5-EC7)	Headspace GC-FID	As received		0.01	mg/kg

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
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		6	mg/kg
CE068	EPH Aliphatic (>C12-C16)	Solvent extraction, GC-FID	As received		6	mg/kg
CE068	EPH Aliphatic (>C16-C35)	Solvent extraction, GC-FID	As received		15	mg/kg
CE068	EPH Aliphatic (>C35-C44)	Solvent extraction, GC-FID	As received		10	mg/kg
\$	Asbestos (qualitative)	HSG 248, Microscopy	Dry	U	-	-

Chemtech Environmental Limited

METHOD DETAILS

METHOD	PREPARED LEACHATES	METHOD SUMMARY	STATUS	LOD	UNITS
CE002	Leachate preparation (EA)	L:S 10:1		-	-
CE128	Arsenic (dissolved)	ICP-MS	U	0.06	µg/l As
CE128	Boron (dissolved)	ICP-MS	U	8	µg/l B
CE128	Cadmium (dissolved)	ICP-MS	U	0.07	µg/l Cd
CE128	Chromium (dissolved)	ICP-MS	U	0.2	µg/l Cr
CE128	Copper (dissolved)	ICP-MS	U	0.4	µg/l Cu
CE128	Lead (dissolved)	ICP-MS	U	0.2	µg/l Pb
CE128	Mercury (dissolved)	ICP-MS	U	0.008	µg/l Hg
CE128	Nickel (dissolved)	ICP-MS	U	0.5	µg/l Ni
CE128	Selenium (dissolved)	ICP-MS	U	0.07	µg/l Se
CE128	Zinc (dissolved)	ICP-MS	U	1	µg/l Zn
CE213	pH	Based on BS 1377, pH Meter	U	-	units
CE049	Sulphate	Ion Chromatography	U	1.7	mg/l SO ₄
CE128	Sulphur (dissolved)	ICP-MS	U	0.2	mg/l S
CE079	Sulphide	Continuous Flow Colorimetry		100	µg/l S ₂ -
CE147	Cyanide (free)	Continuous Flow Colorimetry		20	µg/l CN
CE147	Cyanide (total)	Continuous Flow Colorimetry		20	µg/l CN
CE014	Thiocyanate	Colorimetry		200	µg/l SCN
CE148	Phenols (total)	Continuous Flow Colorimetry		10	µg/l PhOH
CE051	Acenaphthene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Acenaphthylene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Anthracene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(a)anthracene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(a)pyrene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(b)fluoranthene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(ghi)perylene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Benzo(k)fluoranthene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Chrysene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Dibenz(ah)anthracene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Fluoranthene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Fluorene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Indeno(123cd)pyrene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Naphthalene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Phenanthrene	Solvent extraction, GC-MS		0.1	µg/l
CE051	Pyrene	Solvent extraction, GC-MS		0.1	µg/l
CE051	PAH (total of USEPA 16)	Solvent extraction, GC-MS		1.6	µg/l

Chemtech Environmental Limited

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)
105207-1	BH1	0.30	N	
105207-2	BH1	0.50	N	
105207-3	BH2	0.60	N	
105207-4	BH3	0.30	N	
105207-5	BH3	0.80	N	
105207-6	BH3	1.50	N	
105207-7	BH5	0.20	N	
105207-8	TPA	0.50	N	

Chemtech Environmental Limited

ADDITIONAL INFORMATION

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.

For soils and solids, all results are reported on a dry basis. Samples dried at no more than 30°C in a drying cabinet.

For soils and solids, analytical results are inclusive of stones, where applicable.

Chemtech Environmental Limited

TEST REPORT REVISIONS

The table below identifies ammendments that have been made to this test report for each revision.

Test Report Reference	Details of amendments to test report	Issue Date
105207	Original report issued	07 February 2022
105207 (1)	Leachate PAH 16 testing on sample 105207-2.	17 February 2022