GEOTECHNICAL &
GEO- ENVIRONMENTAL REPORT
CELSA, ROVER WAY, CARDIFF

Prepared for:
CELSA Manufacturing UK Limited

January 2019

Job No: 14958

REPORT TITLE	**:**	**Geotechnical and Geo-environmental Report: CELSA, Rover Way, Cardiff**
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Executive Summary

CELSA Manufacturing UK Ltd are proposing an industrial development at their scrap yard site on the southern side of rover way, Cardiff.

The site currently comprises an area or made up ground.

The site is underlain by a mantle of made ground over alluvium. The Mercia Mudstone Group locates beneath the alluvium.

A site investigation comprising nine trial pits (of which, three were observed by Terra Firma Wales Ltd) two hand dug trial pits and six rotary probe boreholes (three shallow, three deep). Groundwater wells were installed in the boreholes and the shallow wells were also used for soil gas monitoring.

Soil Chemical Testing of the made ground detected PCBs and asbestos. We understand that the site will have a cap of granular aggregate and hard-standing (concrete floor-slab) and the pathway between the source and receptor will be broken.

Several minor exceedances were recorded in groundwater which are not considered significant. In addition, elevated cyanide was recorded during monitoring on 2nd and 15th January 2019. Soil chemical testing did not identify a cyanide source at the site and we anticipate that the elevated levels originate off-site.

The first two rounds of gas monitoring placed the site in Gas Characteristic Situation 1, requiring no specialist gas protection measures. Photo-Ionisation Detector monitoring did not detect organic vapours.

An Envirocheck Report for the site revealed that No Radon Protection is required for new development at the site.

Given the deposits of made ground and shallow superficial deposits are unsuitable for founding, we would recommend piled foundations extending to the Mercia Mudstone Group. We understand that the ground-slab will be ground-bearing and should, therefore, be designed as structurally independent of the frame of the building.

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SECTION 1 Introduction and Proposed Development

CELSA Manufacturing UK Limited are proposing the development of An industrial unit at their site located south of Rover Way, Cardiff.

Terra Firma (Wales) Limited has been commissioned by James and Nicholas, on behalf of CELSA Manufacturing UK Limited, to undertake a geo-environmental assessment and geotechnical investigation of the site.

The main objectives of the geo-environmental assessment programme were to:

- Identify the potential environmental liabilities at the site associated with any soil contamination from past site uses.
- Provide a summary of the environmental conditions at the site, together with any necessary remediation works to render the site fit for its intended use.
- Provide recommendations with regard to radon.

The main objectives of the geotechnical site investigation were to:

- Determine the type, strength and bearing characteristics of the shallow superficial deposits.
- Provide recommendations for a suitable and economic foundation/floor slab solution for the development.
- Provide recommendations with regard to any other geotechnical aspects pertaining to the development.

In order to achieve the above objectives, Terra Firma (Wales) Limited carried out an assessment programme including a review of existing data, followed by a field investigation to determine the prevailing ground conditions and also to collect and analyse soil samples from selected locations around the site.

1.1 Limitations and Exceptions of Investigation

The geo-environmental and geotechnical investigation was conducted and this report has been prepared for the sole internal reliance of CELSA Manufacturing UK Limited and their design and construction team. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Terra Firma (Wales) Limited. If an unauthorised third party comes into possession of this report they rely on it at their peril and the authors owe them no duty of care and skill.

The report represents the findings and opinions of experienced geo-environmental and geo-technical consultants. Terra Firma (Wales) Limited does not provide legal advice and the advice of lawyers may also be required.

The subsurface geological profiles, any contamination and other plots are generalised by necessity and have been based on the information found at the locations of the exploratory holes and depths sampled and tested.

Machine excavations could not be performed in the far south of the site due to wet weather and very soft clay. It is beyond the scope of this report to assess the demolition material currently stockpiled neat the centre of the site.

SECTION 2 Review of Existing Data

2.1 Physical Setting, Current Use and Site Conditions

The site locates to the south side of Rover Way, Cardiff, centred on an approximate National Grid Reference of 321573, 176413. The proposed development occupies an approximate plan area of 0.14 hectares. The location of the site is presented in **Figure 2.1**.

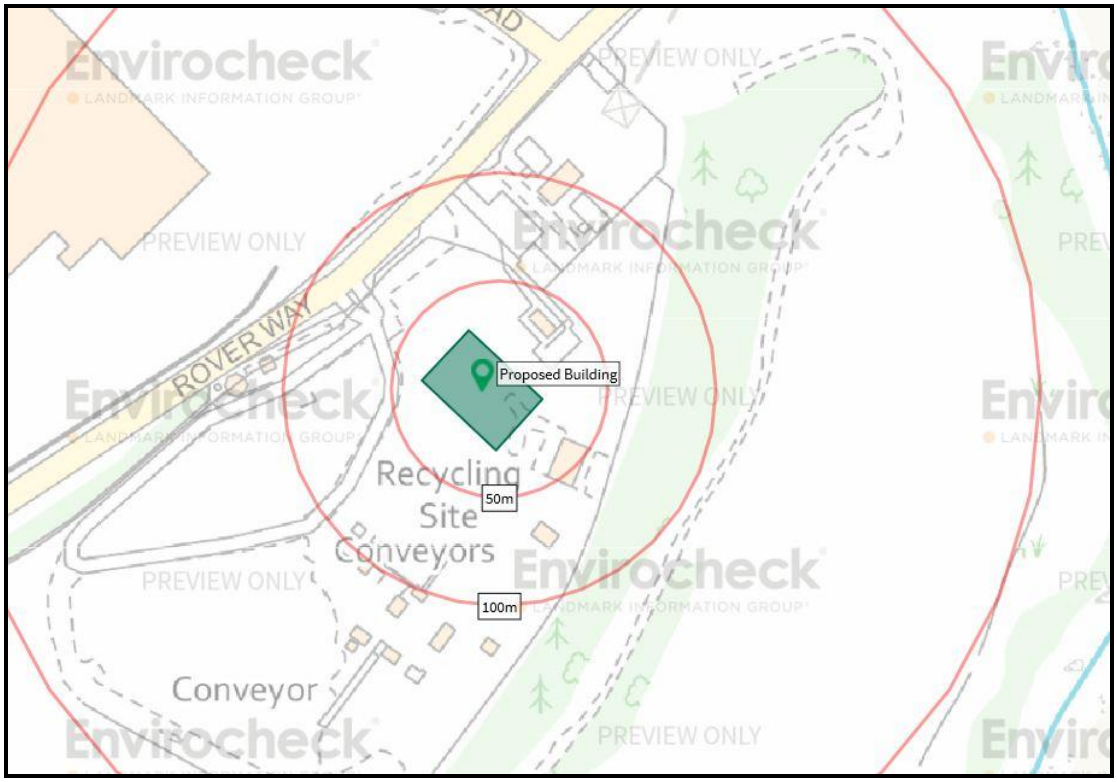


Figure 2.1: Site Location (NTS)

The site was visited in September 2018. The site was seen to comprise a large relatively flat open area comprising recovered land made of slag.

The flat area extends beyond the current study site and the area is surrounded by a high metal security fence. An electricity sub-station locates immediately north of the site and a gantry passes over the entrance to the site.

2.2 Site History

The history of the site has been traced using historical Ordnance Survey maps obtained from Landmark Information Group. The maps are presented in **Annex A**. A summary of the sites history is presented in **Table 2.1**;

Table 2.1. Summary of Historical Plans

Dates	On-Site	Off-Site
1880	The site locates on a salt marsh in the estuary. A channel crosses the site. The site locates below Mean High Water	Land locates immediately north and west of the site. The land is undeveloped.
1885/1886	As Previously	Tharsis Copper Works locates 1.43 km southwest of the site.
1900/1901	As Previously	Urban development and a Railway Line locate over 1km west of the site.
1919/1920	As Previously	As Previously
1922	As Previously	As Previously
1938/1947	As Previously	Further urban expansion is shown 500m northwest of the site in Splott
1947 (Aerial Photo)	Site can be seen to comprise mud flats	Evidence of Cardiff Airport 500m north of the site.
1947/1954	As Previously	Sewage outfalls locate 150m north and 350m northeast of the site.
1952/1957	As Previously	Tremorfa Rolling Mill locates 700m southwest of the site. A pumping station locates 370m northeast of the site.
1965	The site comprises part of a large tip extending onto the flats. Mean High Water locates to the east of the reclaimed land	
1975		The tip is shown to have extended southeast. Tracks traverse the tip. A steel rolling will and other unspecified works locate 450m southwest. Rover Works locate 650m north on Pengam Moor. A school locates 500m northwest.
1982	Study site is undeveloped..	Shows buildings on the current CELSA Works site.
1989	The tips are traversed by railway/tram lines	A substationlocates immediately north of the stie. Extensive development of industrial buildings at the current CELSA site. A caravan site locates 500m northeast of the site.
1992	As Previously	
2003	As Previously	A superstore locates on Pengam Green 650m northnortheast of the site.
2009	Study site is labelled as a scrap yard	
2018	Site labelled as a Recycling Site	
Note: Distances are approximate		

2.3 Geological

2.3.1 Geology

The 1:50,000-scale geological map (British Geological Survey Sheet 263, (1977)) shows the site to be underlain by rocks of the Mercia Mudstone Group. The bedrock is shown to have a superficial cover of estuarine alluvium.

Made Ground is known to cover the site.

2.3.2 Coal Mining

The study site locates outside the South Wales Coal Field.

2.3.3 Radon

The Envirocheck Report states that No Radon protective measures are necessary in the construction of new dwellings or extensions

A copy of the Envirocheck Report is included in **Annex A**.

2.4 Environmental Setting

2.4.1 Hydrogeology and Hydrology

The Envirocheck Report records that the bedrock deposits are beneath the site are classified as a Secondary B Aquifers. Superficial deposits are recorded as Secondary (Undifferentiated).

The nearest surface water feature recorded by the Envirocheck Report locates 275m northeast of the site.

2.4.2 Flooding

The Envirocheck agency and Hydrological Map shows the study site to be affected by Extreme (i.e. Zone 2) Flooding.

The Surface Water Flood Risk Map shows areas in the vicinity of the site to be affected by low and medium risk (i.e 1,000 yr and 100 yrs return) flooding. A site specific assessment is recommended.

A site specific assessment is recommended to ascertain necessary development levels

2.4.3 Waste

The study site is shown to locate within a landfill operated by British Steel Corporation. The site is shown to have received Inert and Industrial Waste. Numerous other landfills locate within 250m of the study site with wastes including Inert, Household, Industrial and Special Waste.

SECTION 3 Preliminary Qualitative Human Health and Environmental Risk Assessment

3.1 General

The contaminated land regime is set out in Part IIA of the Environmental Protection Act (EPA) 1990 and was introduced on the 1st April 2000 in England and 1st July 2001 in Wales. A similar regime was introduced in Scotland on 14th July 2000. Part IIA was introduced to achieve two aims:

(1) The identification of contaminated land
(2) The remediation of contaminated land that poses an unacceptable risk to human health and/or the environment

Under Part IIA the statutory definition of 'contaminated land' is: any land which appears to the local authority in whose area it is situated, to be in such a condition, by reason of substances in, on, or under the land, that:

(a) Significant harm is being caused or there is a significant possibility of such harm being caused; or
(b) Pollution of controlled waters is being, or is likely to be, caused."

For land to be classified as 'Contaminated Land' there must be a 'pollutant linkage'.

For our definitions of pollution linkage and how we define risk please refer to **Annex B** which includes our classifications of consequence and probability and risk assessment matrix.

3.2 Preliminary Site Conceptual Model

The preceding sections enable a preliminary conceptual model of the site to be drawn up, to illustrate the likely ground conditions beneath the site together with a preliminary assessment of the nature of any underlying aquifer and groundwater movement. The preliminary site conceptual model is used as a model for the design and implementation of the site investigation, whereby areas of potential contamination can be targeted as well as investigating the site as a whole.

3.2.1 Potential Sources of Contamination and Gas

The potential contamination beneath the site, whether in the matrix of soil or any groundwater will be related to site past use and the history of the surrounding area.

Historical map review has revealed that the site comprises recovered land, built up with imported material, most probably from the nearby steel works (i.e. slag). The ground is therefore likely to reflect this origin. The site was more recently described as a scrap yard and recycling site and this is likely to be reflected in the soils chemistry.

There are numerous landfills within 250m of the site and the site itself locates within an area of fill.

We would therefore consider there to be a **high risk** of contamination being present at the site and the risk from soil gas to be **high** on account of the nearby landfills and potential natural peat deposits within the alluvium.

3.2.2 Potential Receptors, Pathways and Risks

There are both human and hydrological receptors to any contamination that may be present on site.

Construction workers will be excavating in soils and will be exposed via dermal contact with soils and dust, ingestion of soil dust and inhalation of soil dust.

Inhalation of asbestos fibres is also a possible risk, if present in the made ground, as is inhalation of vapours.

A commercial end use is proposed. Once developed, future site users will potentially be at risk from the same pathways.

Neighbouring site users and passers-by may potentially be exposed to soil dust, asbestos fibres and vapours during the earthworks phase.

If any contamination is identified this may be leachable, enabling it to mobilise through groundwater within site soils although thick deposits of alluvium are likely to hinder significant migration of dissolved contaminants.

SECTION 4 Field Investigation

4.1 Site Works

A geotechnical and geo-environmental site investigation was carried out between 6th November 2018 and 4th January 2019. James and Nicholas performed nine trial pits across the site, and Terra Firma Wales Ltd were in attendance for three of these. In addition, Terra Firma Wales Ltd took two hand dug samples on 4th January 2018.

Six rotary boreholes were performed at the site between 4th December 2018 and 11th December 2018 to prove the depth of rock-head and to allow the installation of deep and shallow groundwater and gas monitoring wells.

The fieldworks were supervised by Terra Firma (Wales) Limited.

The Machine Excavated and Hand Excavated Trial Pit Logs are presented in **Annex C**.

The Rotary Borehole Logs are presented in **Annex D**.

Exploratory Hole positions are given on **Figure 4.1.**

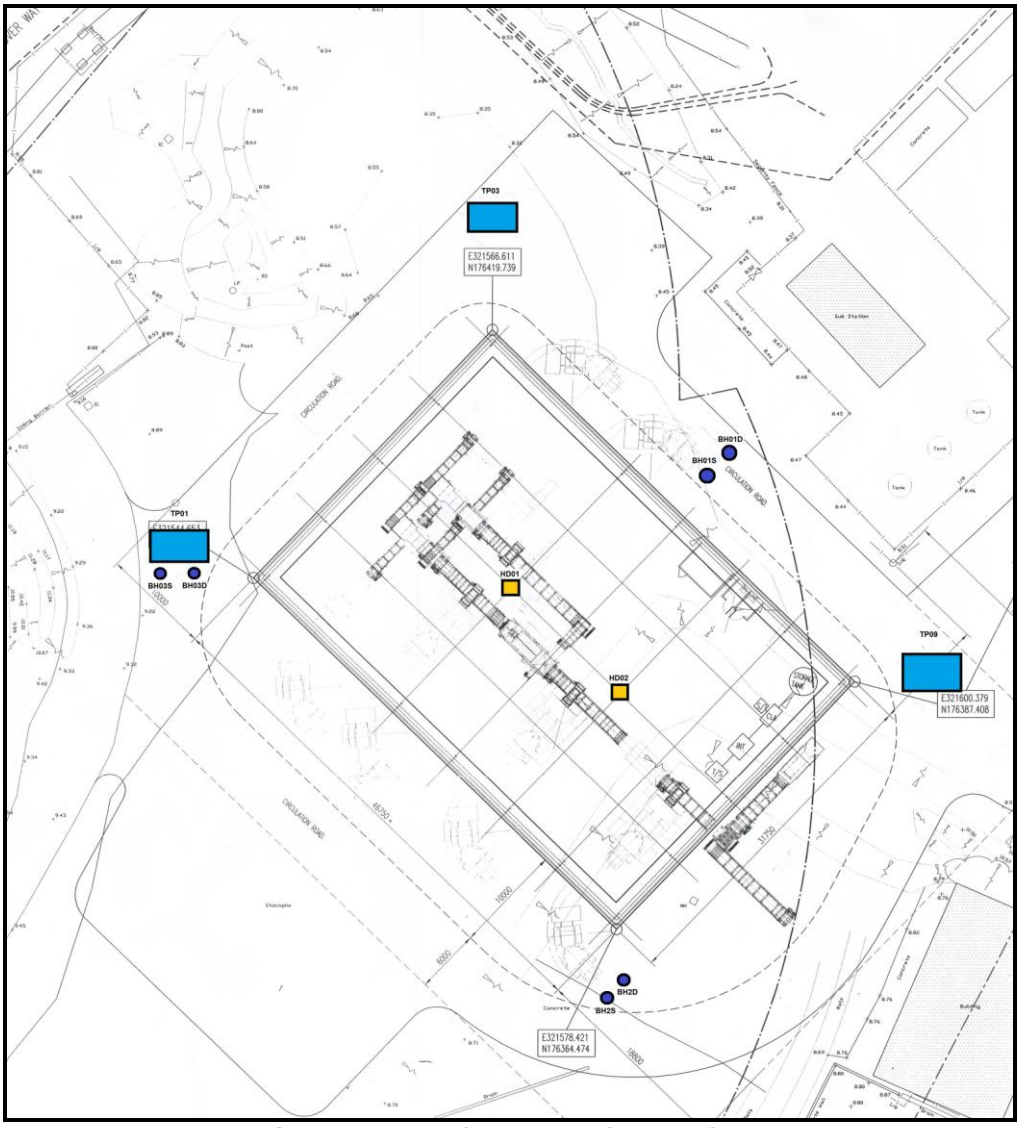


Figure 4.1. Exploratory Hole Locations

4.2 Ground Conditions

A summary of the ground conditions identified in the boreholes is given in **Table 4.1** below.

Table 4.1 Summary of Ground Conditions

Depth (m)	Thickness (m)	Stratum
0.00 - 4.70/6.50	4.70/6.50	**MADE GROUND:** Generally dense to very dense (requiring breaker) sandy GRAVEL to BOULDER including slag, concrete, brick.
4.70/6.50 - 17.60/22.30	11.20/17.60	**ALLUVIUM:** Grey clay. Gravels noted in some locations. Possible channels deposits noted in BH01D and BH02D (black to brown silty sand with gravel)
18.30 - >19.00	>0.70	**BASAL GRAVEL (BH01D Only):** Silty sandy GRAVEL
17.6/22.30	-	**WEATHERED MARL:** .

4.3 Groundwater

Trial Pits were dry during excavation. Groundwater was encountered within the deep groundwater wells rising to c. 10m below ground level (i.e. sub-artesian pressure). The wells were monitored between 10th December 2108 and 2nd January 2019. Perched groundwater was not initially encountered within the shallow wells although groundwater appeared in the base of BH03S by the second monitoring visit.

4.4 Laboratory Chemical Testing

4.4.1 Exploratory Strategy and Sampling Regime

During the trial pitting, small disturbed soil samples were collected.

The sample locations and depths are listed in **Table 4.2.**

Table 4.2 Sample Locations and Depths

Sample	Depth (m)
TP01	1.0
TP03	0.4
TP03	0.7
TP03	1.8
TP09	0.3
TP09	1.1
HD01	0.1
HD02	0.1

4.4.2 Soil Laboratory Analysis

The soil samples taken were despatched to the laboratories of Derwentside Environmental Testing Services Limited.

The following chemical tests were undertaken:

Metals and Metalloids	**In-Organics**	**Others**
Lead	Cyanide	pH (acidity)
Arsenic	Sulphate	Organic Matter
Mercury		Asbestos
Chromium		
Copper		
Nickel		
Zinc		
Boron		
Beryllium		
Antimony		

Organic Chemicals
Phenol
Polycyclic Aromatic Hydrocarbons (PAHs)
Petroleum Hydrocarbons

The laboratory soil chemical test results are presented in **Annex E**.

4.4.3 Groundwater Laboratory Analysis

On 10th – 12th December 2018 one round of groundwater monitoring was performed on deep wells BH01D, BH02D and BH03D. Shallow wells were found to be dry during monitoring on 10th to 12th of December 2018. A second round was performed on 2nd January 2019 which included the groundwater which appeared at the base of shallow well BH03S. A third round was performed on 15th January 2019.

Groundwater samples were tested for the following determinants;

Metals and Metalloids
Lead
Arsenic
Mercury
Cadmium
Chromium
Copper
Nickel
Zinc
Selenium
Antimony
Beryllium
Boron
Manganese
Molybdenum

In-Organics
Cyanide
Sulphate
$CaCO_3$
BOD
Sulphide

Others
pH (acidity)
Organic Matter
COD
Conductivity

Organic Chemicals
Phenols
Polycyclic Aromatic Hydrocarbons (Speciated)
Petroleum Hydrocarbons

The laboratory groundwater chemical test results are presented in **Annex F**.

SECTION 5 Soil and Groundwater Analytical Results

5.1 Soil Assessment Methodology

Comparison of the analytical results have been made with Soil Guideline Values (SGVs) for an Industrial/Commercial setting, sourced from Suitable 4 Use Levels (S4ULs) provided by Land Quality Management Limited, Category 4 Screening Levels (C4SLs) and the Chartered Institute of Environmental Health (CIEH) or CLEA Guidelines. Sulphate results have been compared to British Research Establishment (BRE) guidelines as sulphate levels need only be considered for buried concrete risk assessment only, not human health related.

5.2 Soil Test Results

Table 5.1 Summary of Soil Chemical Test Results Standard Suite and Asbestos

Substance	SGV/ GAC/ S4UL (mg/kg)	Source	Measured Concentrations of Tested Substances (mg/kg)		Number of exceedences
			Minimum	Maximum	
Antimony			3.2	27	0
Arsenic	640	S4UL	3.1	150	0
Beryllium			0.3	0.9	0
Boron			2.6	13	0
Cadmium	190	S4UL	0.4	20	0
Chromium III	8,600	S4UL	82	1200	0
Chromium VI	33	S4UL	<1.0	<1.0	0
Copper	68,000	S4UL	61	4300	0
Lead	2,330	C4SL	40	1700	0
Manganese			1000	3200	-
Mercury	1,100	S4UL	0.07	1.7	0
Molybdenum			3.2	26	-
Nickel	980	S4UL	29	370	0
Selenium	12,000	S4UL	2.5	11	0
Zinc	730,000	S4UL	110	8300	0
Cyanide	480	CLEA	<0.1	3.8	0
Organic matter	-	S4UL	0.4	>25	-
Sulphate	-	-	1100	5500	-
pH	-	S4UL	9.8	11.5	-
Phenol	440	S4UL	<0.3	1.0	0
Total PAH	-		<6.36	21	-
Asbestos	-		Not Detected	0.026%	-

Notes
- *See speciated PAH results (Table 5.2)
- 8 samples were tested

5.2 Soil Test Results (Continued)

A summary of the speciated PAH results are given in **Table 5.2** below.

Table 5.2 Summary of Soil Chemical Test Results Speciated PAH

Substance	GAC (mg/kg)	Source	Measured Concentrations of Tested Substances (mg/kg)		Exceedences
			Minimum	Maximum	
Naphthalene	190	S4UL	<0.03	0.44	0
Acenaphthylene	83,000	S4UL	<0.03	0.05	0
Acenaphthene	84,000	S4UL	<0.03	0.05	0
Fluorene	63,000	S4UL	<0.03	0.45	0
Phenanthrene	22,000	S4UL	0.11	1.00	0
Anthracene	520,000	S4UL	<0.03	4.9	0
Fluoranthene	23,000	S4UL	0.15	3.10	0
Pyrene	54,000	S4UL	0.13	2.90	0
Benzo(a)anthracene	170	S4UL	<0.03	1.40	0
Chrysene	350	S4UL	<0.03	1.50	0
Benzo(b)fluoranthene	44	S4UL	0.06	1.70	0
Benzo(k)fluoranthene	1,200	S4UL	<0.03	0.84	0
Benzo(a)pyrene	35	S4UL	0.03	1.20	0
Indeno(123cd)pyrene	500	S4UL	<0.03	0.67	0
Dibenzo(ah)anthracene	3.5	S4UL	<0.03	0.15	0
Benzo(ghi)perylene	3,900	S4UL	0.04	0.87	0

Notes:
- GAC based on 1% soil organic matter content (SOM)
- 8 samples were tested

5.2 Soil Test Results (Continued)

A summary of the speciated Petroleum Hydrocarbon results are given in **Table 5.3** below.

Table 5.3 Summary of Soil Chemical Test Results Speciated Petroleum Hydrocarbons

Substance	GAC (mg/kg)	Source	Measured Concentrations of Tested Substances (mg/kg)		Exceedences
			Minimum	Maximum	
ALIPHATIC					
C5 – C6	3,200	S4UL	<0.01	<0.01	0
C6 – C8	7,800	S4UL	<0.01	<0.01	0
C8 – C10	2,000	S4UL	<0.01	<0.01	0
C10 – C12	9,700	S4UL	<1.5	1.6	0
C12 – C16	59,000	S4UL	<1.2	7.2	0
C16 – C21	1,600,000	S4UL	<1.5	59	0
C21 – C35	1,600,000	S4UL	<3.4	360	0
C35 – C44	1,600,000	S4UL	<3.4	33	0
AROMATIC					
C5 – C7	26,000	S4UL	<0.01	<0.01	0
C7 – C8	56,000	S4UL	<0.01	0.01	0
C8 – C10	3,500	S4UL	<0.01	<0.01	0
C10 – C12	16,000	S4UL	<0.9	1.8	0
C12 – C16	36,000	S4UL	<0.5	11	0
C16 – C21	28,000	S4UL	<0.6	51	0
C21 – C35	28,000	S4UL	<1.4	310	0
C35 – C44	28,000	S4UL	<1.4	47	**0**

Notes:
- GAC based on 1% soil organic matter content (SOM)
- 8 samples were tested

5.2 Soil Test Results (Continued)

A summary of the Polychlorinated Biphenyl results are given in **Table 5.4** below.

Table 5.4 Summary of Soil Chemical Test Results Polychlorinated Biphenyls

Substance	GAC (mg/kg)	Source	Measured Concentrations of Tested Substances (mg/kg)		Exceedences
			Minimum	Maximum	
PCB 28 + PCB 31	-		<0.01	1.10	
PCB 52	-		<0.01	0.57	
PCB 101	-		<0.01	0.42	
PCB 118	-		<0.01	0.27	
PCB 153	-		<0.01	0.20	
PCB 138	-		<0.01	0.34	
PCB 180	-		<0.01	0.07	
Total PCB	0.240	CLEA	<0.01	2.9	**1**

Notes:
- 8 samples were tested

In the absence of Toxic Equivalence Factor (TEF) data for the specific compounds encountered at the site it has been necessary to employ the generic CLEA Soil Guideline Value (SGV) for a commercial setting.

5.3 Groundwater Test Results

A water sample was recovered from BH03D on 11/12/2018. A round was performed on 2nd January 2019 involving all deep wells and BH03S. The results of these rounds of groundwater testing are presented in **Table 5.5** along with the corresponding Water Framework Directive (WFD) Guidelines or, in their absence, WHO Drinking Water Standards.

						1435398	1441557	1441558	1441559	1441560	1445474	1445475	1445476	1445477
					Lab No									
					Sample ID	BH03 D	BH01 D	BH02 D	BH03 D	BH03 S	BH01 D	BH02 D	BH03 D	BH03 S
					Depth									
					Other ID									
					Sample Type	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
					Sampling Date	11/12/18	02/01/19	02/01/19	02/01/19	02/01/19	15/01/19	15/01/19	15/01/19	15/01/19
					Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
Test	**Method**	**LOD**	**Units**	**Guidleine**	**Source**									
Metals														
Arsenic, Dissolved	DETSC 2306	0.16	ug/l	25	Saltwater WFD	14	48	10	16	21	25	12	18	22
Cadmium, Dissolved	DETSC 2306	0.03	ug/l	0.25	Surface Water (Hardness >200)	0.07	< 0.03	< 0.03	< 0.03	0.04	< 0.03	< 0.03	0.04	< 0.03
Chromium, Dissolved	DETSC 2306	0.25	ug/l			15	< 0.25	0.85	0.37	0.74	< 0.25	< 0.25	11	< 0.25
Chromium III, Dissolved	DETSC 2306*	1	ug/l	4.7	Freshwater WFD	15	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	11	< 1.0
Chromium, Hexavalent	DETSC 2203	0.007	mg/l	0.0006	Saltwater WFD	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Copper, Dissolved	DETSC 2306	0.4	ug/l	3.76	Saltwater WFD	4.4	1.3	1.9	1.4	0.8	< 0.4	< 0.4	2.2	< 0.4
Lead, Dissolved	DETSC 2306	0.09	ug/l	1.2	Freshwater WFD	1.2	0.60	0.10	< 0.09	1.1	< 0.09	< 0.09	0.40	0.41
Mercury, Dissolved	DETSC 2306	0.01	ug/l	0.07	Inland Surface Water	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel, Dissolved	DETSC 2306	0.5	ug/l	4	Inland Surface Water	23	3.1	1.6	1.4	4.7	2.6	0.8	4.2	2.2
Selenium, Dissolved	DETSC 2306	0.25	ug/l	10	DWD	1.9	1.0	16	6.8	8.4	0.25	0.34	6.4	2.3
Zinc, Dissolved	DETSC 2306	1.3	ug/l	6.8	Saltwater WFD	270	16	12	9.2	4.3	16	150	30	1.8
Inorganics														
Conductivity	DETSC 2009	1	uS/cm			27500	2510	2210	2240	1820	2550	2150	885	1500
pH	DETSC 2008					7.4	6.5	8.3	8.1	11.7	7.0	10.3	7.0	11.6
Biochemical Oxygen Demand, Total	DETSC 2031	1	mg/l			36	5.4	5.7	12	13	7.3	5.5	5.5	46
Chemical Oxygen Demand, Total	DETSC 2032	10	mg/l			890	25	72	42	150	59	10	11	310
Cyanide, Total	DETSC 2130	40	ug/l	1	Saltwater WFD	< 40	93	220	320	220	46	420	80	190
Hardness	DETSC 2303	0.1	mg/l			2760	337	425	456	225	413	487	157	206
Sulphate as SO4	DETSC 2055	0.1	mg/l			500	300	450	490	150	230	450	120	120
Sulphide	DETSC 2208	10	ug/l			< 10	< 10	< 10	< 10	60	13	< 10	< 10	410
Petroleum Hydrocarbons														
Aliphatic C5-C6	DETSC 3322	0.1	ug/l	15000	WHO DWS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Aliphatic C6-C8	DETSC 3322	0.1	ug/l	15000	WHO DWS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Aliphatic C8-C10	DETSC 3322	0.1	ug/l	300	WHO DWS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Aliphatic C10-C12	DETSC 3072*	1	ug/l	300	WHO DWS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic C12-C16	DETSC 3072*	1	ug/l	300	WHO DWS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic C16-C21	DETSC 3072*	1	ug/l			< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic C21-C35	DETSC 3072*	1	ug/l			< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic C5-C35	DETSC 3072*	10	ug/l			< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Aromatic C5-C7	DETSC 3322	0.1	ug/l	10	WHO DWS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Aromatic C7-C8	DETSC 3322	0.1	ug/l	700	WHO DWS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Aromatic C8-C10	DETSC 3322	0.1	ug/l	300	WHO DWS	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Aromatic C10-C12	DETSC 3072*	1	ug/l	90	WHO DWS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic C12-C16	DETSC 3072*	1	ug/l	90	WHO DWS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic C16-C21	DETSC 3072*	1	ug/l	90	WHO DWS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic C21-C35	DETSC 3072*	1	ug/l	90	WHO DWS	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic C5-C35	DETSC 3072*	10	ug/l			< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
TPH Ali/Aro Total	DETSC 3072*	10	ug/l			< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
EPH (C10-C40)	DETSC 3311	10	ug/l			< 10	180	87	83	140	110	< 10	150	38
PAHs														
Naphthalene	DETSC 3304	0.05	ug/l			< 0.05	< 0.05	< 0.05	< 0.05	0.95	0.07	0.10	0.16	0.41
Acenaphthylene	DETSC 3304	0.01	ug/l			< 0.01	< 0.01	< 0.01	0.01	0.26	< 0.01	0.05	< 0.01	0.06
Acenaphthene	DETSC 3304	0.01	ug/l			0.04	0.12	< 0.01	< 0.01	3.5	0.12	0.04	0.57	0.34
Fluorene	DETSC 3304	0.01	ug/l			0.03	0.06	< 0.01	< 0.01	3.3	0.08	0.03	0.09	0.32
Phenanthrene	DETSC 3304	0.01	ug/l			0.07	0.03	< 0.01	0.02	5.0	0.12	0.04	< 0.01	0.62
Anthracene	DETSC 3304	0.01	ug/l	0.1	Inland Surface Water	0.01	0.02	< 0.01	< 0.01	7.0	0.02	< 0.01	< 0.01	0.12
Fluoranthene	DETSC 3304	0.01	ug/l	0.0063	Inland Surface Water	0.02	0.02	< 0.01	< 0.01	0.90	0.03	0.02	0.03	0.28
Pyrene	DETSC 3304	0.01	ug/l			< 0.01	< 0.01	< 0.01	< 0.01	0.50	< 0.01	0.02	< 0.01	0.19
Benzo(a)anthracene	DETSC 3304	0.01	ug/l			< 0.01	< 0.01	< 0.01	< 0.01	0.16	< 0.01	< 0.01	< 0.01	0.12
Chrysene	DETSC 3304	0.01	ug/l			< 0.01	< 0.01	< 0.01	< 0.01	0.24	< 0.01	< 0.01	< 0.01	0.13
Benzo(b)fluoranthene	DETSC 3304	0.01	ug/l	0.017	Inland Surface Water	< 0.01	< 0.01	< 0.01	< 0.01	0.27	< 0.01	< 0.01	< 0.01	0.18
Benzo(k)fluoranthene	DETSC 3304	0.01	ug/l	0.017	Inland Surface Water	< 0.01	< 0.01	< 0.01	< 0.01	0.37	< 0.01	< 0.01	< 0.01	0.09
Benzo(a)pyrene	DETSC 3304	0.01	ug/l	0.00017	Inland Surface Water	< 0.01	< 0.01	< 0.01	< 0.01	0.14	< 0.01	< 0.01	< 0.01	0.13
Indeno(1,2,3-c,d)pyrene	DETSC 3304	0.01	ug/l			< 0.01	< 0.01	< 0.01	< 0.01	0.15	< 0.01	< 0.01	< 0.01	0.09
Dibenzo(a,h)anthracene	DETSC 3304	0.01	ug/l			< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Benzo(g,h,i)perylene	DETSC 3304	0.01	ug/l	0.0082	Inland surface Water	< 0.01	< 0.01	< 0.01	< 0.01	0.15	< 0.01	< 0.01	< 0.01	0.09
PAH Total	DETSC 3304	0.2	ug/l			0.23	0.28	< 0.20	< 0.20	23	0.44	0.30	0.85	3.2
PCBs														
PCB 28 + PCB 31	DETSC 3402	0.3	ug/l			< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
PCB 52	DETSC 3402	0.2	ug/l			< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
PCB 101	DETSC 3402	0.3	ug/l			< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
PCB 118 + PCB 123	DETSC 3402	0.6	ug/l			< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6
PCB 138	DETSC 3402	0.2	ug/l			< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
PCB 153	DETSC 3402	0.2	ug/l			< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
PCB 180	DETSC 3402	0.2	ug/l			< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
PCB 7 Total	DETSC 3402	1	ug/l			< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Phenols														
Phenol	DETSC 3451*	0.1	ug/l	7.7	Saltwater WFD	< 0.10	< 0.10	< 0.10	< 0.13	< 0.10	< 0.20	< 0.20	< 0.50	< 0.20
4-Chloro-3-methylphenol	DETSC 3451*	0.1	ug/l			< 0.10	< 0.10	< 0.10	< 0.13	< 0.10	< 0.20	< 0.20	< 0.50	< 0.20
2,4-Dichlorophenol	DETSC 3451*	0.1	ug/l			< 0.10	< 0.10	< 0.10	< 0.13	< 0.10	< 0.20	< 0.20	< 0.50	< 0.20
2,4-Dimethylphenol	DETSC 3451*	0.1	ug/l			< 0.10	< 0.10	< 0.10	< 0.13	< 0.10	< 0.20	< 0.20	< 0.50	< 0.20
p-cresol	DETSC 3451*	0.1	ug/l			< 0.10	< 0.10	< 0.10	< 0.13	< 0.10	< 0.20	< 0.20	< 0.50	< 0.20
2,6-Dimethylphenol	DETSC 3451*	0.1	ug/l			< 0.10	< 0.10	< 0.10	< 0.13	< 0.10	< 0.20	< 0.20	< 0.50	< 0.20
2,6-Dichlorophenol	DETSC 3451*	0.1	ug/l			< 0.10	< 0.10	< 0.10	< 0.13	< 0.10	< 0.20	< 0.20	< 0.50	< 0.20
2,4,6-Trichlorophenol	DETSC 3451*	0.1	ug/l			< 0.10	< 0.10	< 0.10	< 0.13	< 0.10	< 0.20	< 0.20	< 0.50	< 0.20

Table 5.5. Groundwater

5.4 Soil Gas Monitoring

Two rounds of Soil Gas Monitoring were performed prior to the issue of this report. The results are summarise in **Table 5.6** and are presented in **Annex G**.

Table 5.6. Summary of Gas Monitoring

	CH4 (%)	CO2 (%)	O2 (%)	CO ppm	H2S ppm	FLOW (l/hr)	AP (mb)
Minimum	0.0	0.0	8.7	0	0	0	1021
Maximum	0.2	0.2	20.1	0	0	0	1041

With reference to Table 8.5 of CIRIA C665, the site falls into Gas Characteristic Situation 1, requiring no special gas protection measures. Further rounds of gas monitoring should be performed, under low-air pressure scenarios, to confirm the Characteristic Situation.

Organic material within the alluvium can form a potential natural sources for soil gas and monitoring should be performed during and after the piling to confirm that the piling has not created pathways.

SECTION 6 Quantitative Risk Assessment

6.1 Contaminants of Concern in Soil

It can be seen from Section 5 that all determinants tested were present at concentrations below the published Generic Assessment Criteria for a Commercial/Industrial Setting with the exception of PCB s being encountered at an elevate level in TP09 at 1.10m depth.

Asbestos was encountered in TP09 at 0.30m and 1.10m. Quantification revealed that the asbestos was at a concentration of between <0.001% and 0.026%.

Determinants of interest are presented in **Table 6.1**.

Table 6.1. Summary of Soil Exceedances

Determinant	Generic Assessment Criteria (mg/kg)	Recorded Concentration	Location
PCB's (Total)	0.240	2.90	TP09, 1.10m
Asbestos	-	<0.001%	TP09, 0.30m
	-	0.026%	TP09, 1.10m

Vapour monitoring during trial pitting, using a Photo-Ionisation Detector (P.I.D.), did not detect and organic vapours. Gas wells BH01S to BH03S were also analysed with a P.I.D. on 11/12/2018. No vapours were detected.

6.2 Contaminants of Concern in Groundwater

During the 11/12/2018 round of monitoring slightly elevated chromium (15 ug/l), nickel (23 ug/l) and fluoranthene (0.02 ug/l) were detected in BH03D. Petroleum hydrocarbons, PCBs and phenols were not detected.

During the second round on monitoring (02/01/2019) the shallow well BH03S recorded slightly elevated nickel (4.7 ug/l) elevated cyanide (220 ug/l) and elevated anthracene (7.0 ug/l) fluoranthene (0.90 ug/l) benzo(b)fluoranthene (0.27 ug/l) benzo(k)fluoranthene (0.37 ug/l) benzo(a)pyrene (0.14 ug/l) and benzo(ghi)perylene (0.15 ug/l). Petroleum hydrocarbons, PCBs and phenols were not detected.

During the second round of monitoring (02/01/2019) the deep wells recorded slightly elevated selenium in BH02D (16 ug/l), elevated cyanide in all deep wells (93 ug/l, 220 ug/l and 320 ug/l in BH01D, BH02D and BH03D respectively). Petroleum hydrocarbons, PCBs and phenols were not detected.

During the third round (15/01/2019) shallow borehole BH03S recorded elevated fluoranthene (0.28 ug/l) benzo(b)fluoranthene (0.18 ug/l) benzo(k)fluoranthene (0.09 ug/l) benzo(a)pyrene (0.13 ug/l) and benzo(ghi)perylene (0.09 ug/l). Elevated cyanide (190 ug/l) was also detected. Petroleum hydrocarbons, PCBs and phenols were not detected.

During the third round (15/01/2019) deep boreholes recorded slightly elevated Cr III and nickel in one location (BH03D at 11 ug/l and 4.2 ug/l respectively). Slightly elevated zinc was recorded in all deep boreholes, (16ug/l, 150 ug/l and 30 ug/l in BH01D, BH02D and BH03D respectively). Elevated fluoranthene was recorded in all deep boreholes (0.02 – 0.03 ug/l). Elevated cyanide was recorded in all deep boreholes (46ug/l, 420 ug/l and 80 ug/l in BH01D, BH02D and BH03D respectively).

6.2 Contaminants of Concern in Groundwater (Continued)

A summary of exceedances in shallow groundwater is presented in **Table 6.2**.

Table 6.2. Summary of Shallow Groundwater Exceedances

Determinant	Assessment Criteria (ug/l)	Recorded Concentration (ug/l)	Location
Round 02/01/2019			
Nickel	4	4.7	BH03S
Cyanide	1	220	BH03S
Anthracene	0.1	7.0	BH03S
Fluoranthene	0.0063	0.90	BH03S
Benzo(b)fluoranthene	0.017	0.27	BH03S
Benzo(k)fluoranthene	0.017	0.37	BH03S
benzo(a)pyrene	0.00017	0.14	BH03S
benzo(ghi)perylene	0.0082	0.15	BH03S
Round 15/01/2019			
Cyanide	1	190	BH03S
Fluoranthene	0.0063	0.28	BH03S
Benzo(b)fluoranthene	0.017	0.18	BH03S
Benzo(k)fluoranthene	0.017	0.09	BH03S
benzo(a)pyrene	0.00017	0.13	BH03S
benzo(ghi)perylene	0.0082	0.09	BH03S

A summary of exceedances in deep groundwater is presented in **Table 6.3**.

Table 6.3. Summary of Deep Groundwater Exceedances

Determinant	Assessment Criteria (ug/l)	Recorded Concentration (ug/l)	Location
Round 11/12/2018			
Chromium III	4.7	15	BH03D
Nickel	4	23	BH03D
Fluoranthene	0.0063	0.02	BH03D
Round 02/01/2019			
Selenium	10	16	BH02D
Cyanide	1	93	BH01D
		220	BH02D
		320	BH03D
Round 15/01/2018			
Chromium III	4.7	11	BH03D
Nickel	4	4.2	BH03D
Zinc	6.8	16	BH01D
		150	BH02D
		30	BH03D
Cyanide	1	46	BH01D
		420	BH02D
		80	BH03D
Fluoranthene	0.0063	0.03	BH01D
		0.02	BH02D
		0.03	BH03D

6.3 Potential Receptors and Pathways

6.3.1 Human Receptors

Construction workers may be in intimate contact with the site soils and are potentially at risk from exposure to determinants within the made ground through dermal contact, ingestion and inhalation pathways.

Neighbouring site users and passers-by are potentially exposed to soil dust during earthworks.

Future site users are potentially at risk from determinants exceeding the Generic Assessment Criteria via dermal contact with soils, inhalation of soils and asbestos. Development offers an opportunity to address the issues.

6.3 2 Aquatic Environment

Shallow groundwater was only encountered in BH03S. The wells of BH01S and BH02S were dry during the monitoring. Slightly elevated nickel was encountered This is not considered significant given the sites setting. Several exceedances of PAH guidelines were also recorded although the guidelines are very stringent. The High Molecular Weight PAHs have very low solubilities and low mobility characteristics and are unlikely to impact significantly beyond their source. Elevated cyanide (220 ug/l) was noted in the shallow groundwater.

During the first round of monitoring slightly elevated chromium III and nickel were recorded in BH03D although these did not appear during the 02/01/2019 round. Slightly elevated selenium was recorded in BH02D during the second water monitoring round. These are not considered to be significant given the levels and the site setting. Elevated PAHs were recorded in BH01D although the guidelines are very stringent and the High Molecular Weight PAHs have very low solubilities and low mobility characteristics and are unlikely to impact significantly beyond their source. Elevated cyanide (93 ug/l to 320 ug/l) was recorded in all deep wells.

Slightly elevated Cr III, and nickel wass recorded in BH03D by the round on 15/01/2019and zinc was recorded in all deep boreholes (up to 150 ug/l). This is not considered significant given the sites setting. Elevated PAH’s were recorded in all boreholes during the round on 15/01/2019 although the High Molecular Weight PAHs have low mobility characteristics. Elevated cyanide was recorded in all wells on 15/01/2019, ranging from 46 ug/l to 420 ug/l.

6.4 Mitigation and Remedial Measures

6.4.1 Site Workers

In order to protect construction workers good site management, COSHH, good standards of hygiene and appropriate health & safety on site should be adhered to, with personal protection equipment (PPE) and dust suppression where appropriate. The elected contractor should provide their own risk assessment to mitigate these risks including asbestos.

6.4.2 Neighbouring Site Users

Appropriate dust suppression should be employed to present the migration soil dust and asbestos during the earthworks phase. Consideration should be given to personal and perimeter asbestos monitoring if deemed necessary.

6.4.3 Site End Users

Elevated levels of PCBs, in excess of the published Generic Assessment Criteria for a Commercial setting, were detected at one location. In addition, asbestos was detected in one location.

We understand that the proposed development will include the installation of hard standing cover in the development area and this should interrupt the pathway between the contaminants and the site end users.

Some of the lower molecular weight PCBs are considered potentially volatile although vapour monitoring during the trial pitting, and later monitoring of the shallow wells, using a Photo-Ionisation Detector (P.I.D.) did not detect organic vapours.

A Potable Water Supply Pipe Material Assessment should be carried out by the water provider.

If during development works any other unexpected ground conditions or evidence of contamination is found, inspection by a geo-environmental engineer should be made, and any required testing or investigation carried out prior to continuation of works.

6.4.4 Aquatic Environment

Several minor exceedances of metals and PAH were noted during the initial groundwater monitoring although these are not considered to be significant given their magnitude and also the low mobility characteristics of the PAHs.

Elevated cyanide was noted in the deep and shallow groundwater during monitoring on 02/01/2019 and 15/01/2019. However, during soil chemical testing cyanide was either not detected or detected at low levels (i.e. up to 3.8 mg/kg) and all cyanide detected on-site was in a complex form. We therefore anticipate that the cyanide in the groundwater is from an off-site source.

There are not considered to be significant risks to the aquatic environment from site soils.

During the construction period, there is a risk to the environment/adjacent sites from de-watering, digging foundations, moving soil, drainage misconnections, discharges to local surface waters or the ground, runoff from construction materials and/or exposed ground, wheel washings and oil or chemical spills.

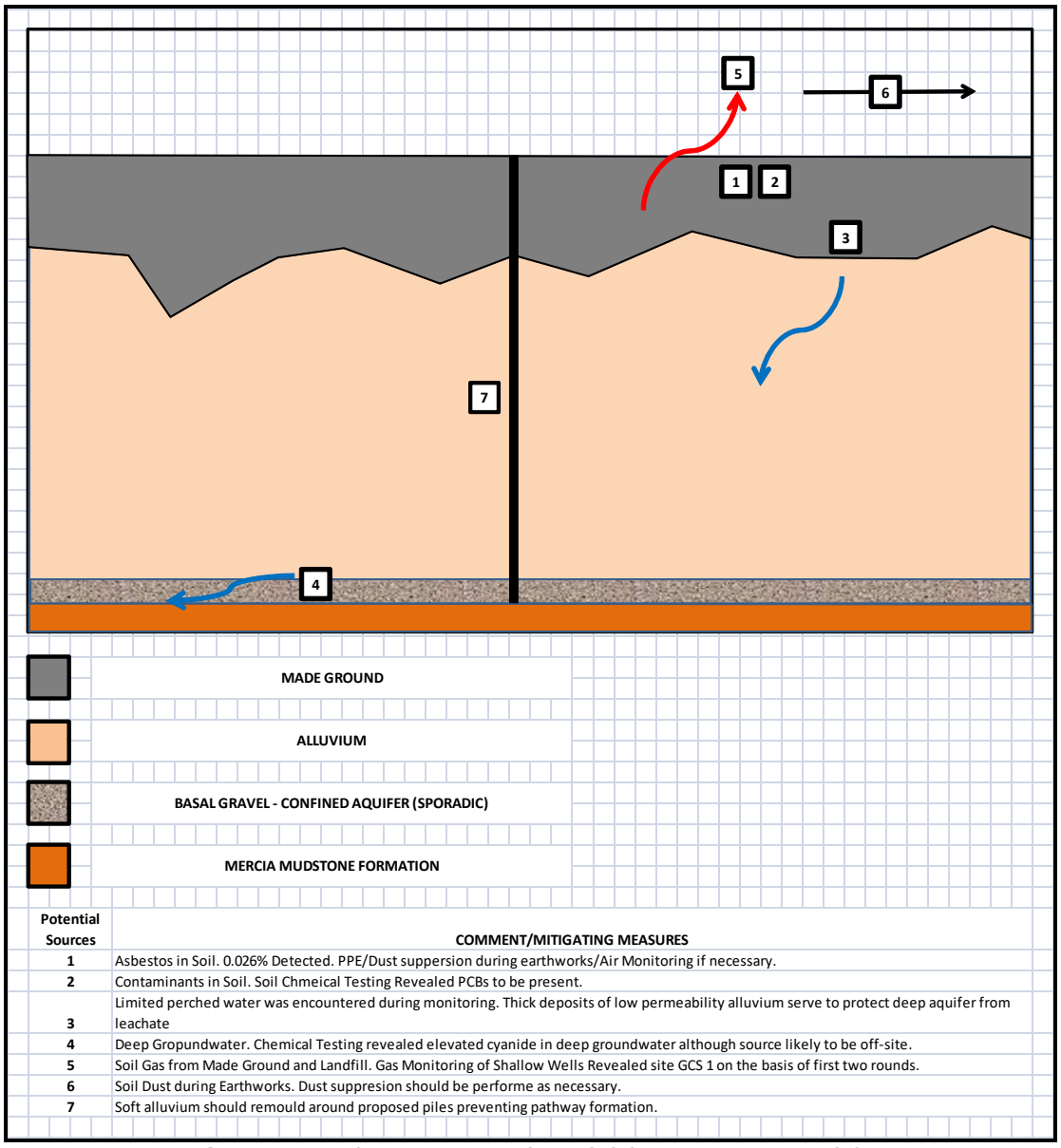
The risk is considered to be negligible as any adverse effects will be easily preventable by due diligence to good construction practise and housekeeping in preventing surface runoff and the spillage of materials.

The basic measures that should be taken are as follows:

- Prepare a drainage plan and mark the manholes to prevent pollutants accidently reaching the surface water sewers;
- Carry out any activities that could cause pollution in a designated, bunded area, away from rivers or boreholes. Where possible it should drain to the foul sewer;
- Use settlement ponds or separators to remove silty water;
- Store all oils and chemicals in a fully bunded area to prevent leaks or spills;
- Get advice on whether you need an environmental permit and apply in good time

6.5 Site Conceptual Model

A Site Conceptual Model is presented below;



Potential Sources	COMMENT/MITIGATING MEASURES
1	Asbestos in Soil. 0.026% Detected. PPE/Dust suppersion during earthworks/Air Monitoring if necessary.
2	Contaminants in Soil. Soil Chmeical Testing Revealed PCBs to be present.
3	Limited perched water was encountered during monitoring. Thick deposits of low permeability alluvium serve to protect deep aquifer from leachate
4	Deep Gropundwater. Chemical Testing revealed elevated cyanide in deep groundwater although source likely to be off-site.
5	Soil Gas from Made Ground and Landfill. Gas Monitoring of Shallow Wells Revealed site GCS 1 on the basis of first two rounds.
6	Soil Dust during Earthworks. Dust suppresion should be performe as necessary.
7	Soft alluvium should remould around proposed piles preventing pathway formation.

Figure 6.1. Site Conceptual Model (note: Not to Scale)

SECTION 7 Engineering Recommendations

7.1 Preparation of Site

Allowances should be made for removing any 'soft spots/areas' as well as any buried obstructions that may remain.

Contingencies should be made for the protection/diversion of any underground services present beneath the site brought about as a result of the proposed works.

Contingencies should also be made for the protection and any necessary temporary/permanent support of structures adjacent to the site.

Any reduced levels should be brought up to the required levels with well compacted imported granular materials. Department of Transport (DoT) Type 2 sub-base or similar may be used and should be compacted in layers, in accordance with the Specification for Highway Works.

All materials to be removed from site should be taken to an appropriately licensed landfill facility. In accordance with EC Regulation 1272/2008 and Environment Agency Guidance WM3 (v. 1.1/2018) soils and other materials destined for off-site disposal should be classified on the basis of their hazard phrases prior to disposal.

7.2 Foundation and Floor Slab Solution

Ground Investigations have encountered a generally dense horizon of made ground over a thick deposit of alluvium. The alluvium in the region is generally soft to very soft silt/clay. Given the settlement characteristics of the alluvium, and the present of a proposed variable load due to a gantry crane, a raft foundation is not recommended at the site as the width of the raft would mean loads transferred to the alluvium.

Foundation loads should be transferred to competent horizons within the Mercia Mudstone Group.

It is understood that hollow round section steel piles are proposed for the site. Piles driven to a suitable set would be expected to perform satisfactorily with loads of 400kN per pile, at which intensity total settlement should not exceed 10mm and differential settlement between adjacent piles should not exceed half this value. Due to the presence of dense made ground deposits and buried obstructions beneath the site piles are likely to require pre-bored holes or trial pits through the made ground.

Vibrations should be monitored during piling and if vibrations cannot be kept within limits consideration should be given to deeper pre-drilling or end-driven piles.

We understand that the ground floor slab will be ground-bearing, constructed on a bed of compacted granular fill. The settlement characteristics of the floor-slab has not been calculated b y Terra Firma although it is likely to differ from the frame of the building which is piled. Therefore, the floor slab should be designed as structurally independent of the building frame. We recommend that differential settlement between the floor slab and the structure be kept below 25mm to limit disruption to the building.

7.2 Foundation and Floor Slab Solution

All foundation formations should be inspected by a suitably qualified Engineer before pouring. The piling contractor may request additional site specific testing/boreholes to confirm the piling design.

7.3 Excavations and Formations

Due to the density of the made ground breakers have been necessary for excavation at the site. Buried obstructions may be encountered within the made ground and provision should be made for the use of a breaker to deal with such obstructions.

The sides of any excavations deeper than 1.0m should be supported by planking and strutting or other proprietary means.

The sub-formations/formations will be susceptible to loosening, softening and deterioration by exposure to weather (rain, frost and drying conditions), the action of water (flood water or removal of groundwater) and site traffic.

Formations should never be left unprotected and continuously exposed to rain causing degradation, or left exposed/uncovered overnight, unless permitted by a qualified engineer. All formations should be inspected by a suitably qualified engineer before pouring.

Construction plant and other vehicular traffic should not be operated on unprotected formations. Allowances should be made for special precautions to prevent formation deterioration in addition to the above.

7.4 Foundation Risk Assessment

The soft alluvial clays should remould around the round section piles, thus maintaining the current status quo in respect to hydrological protection. This should be confirmed by groundwater monitoring during and after the piling works.

Gas monitoring should also be performed during and after the piling operations to confirm that the piling has not affected the gas regime.

If hollow piles are employed any void space in the centre of the pile should be backfilled with a bentonite cement to achieve a hydrological seal.

A detailed Piling Risk Assessment is presented in a separate document.

7.5 Protection of Buried Concrete

Six samples of soil were subject to Total Sulphate (as SO_4) Aqueous Sulphate (as SO_4) and pH analysis.

Total Sulphate ranged from 1100 mg/kg to 5500 mg/kg and pH values ranged from 9.8 to 11.5. Sulphate Aqueous Extract ranged from 59 mg/l to 270 mg/l.

Based on the highest level of sulphate recorded and with reference to Table C2 of BRE Special Digest 1:2005, these soils fall into Design Sulphate Class AC-1s.

Chemical Test Results are presented in **Annex E**.

7.6 Soil Gas Protection

Two rounds have been performed since well installation. The following assessment is based on the testing performed thus far.

The site currently falls into Gas Characteristic Situation (GCS) 1 requiring no specialist gas protection measures.

Peat horizons within the alluvium present a potential source of soil gas and monitoring should be performed during and after piling to confirm that the piles have not created a preferential pathway for the gas.

Gas Monitoring Results are presented in **Annex G**.