



Design & Access Statement

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APPENDIX B-3

Land Survey:

3-6671 - Phase 3 Remediation Report Rev 03

PHASE 3 REMEDIATION STRATEGY

Proposed Educational Development

Ranikhet Academy, Pey Road, Tilehurst, Reading

Prepared for: Hampshire County Council

Date: February 2021

Report No: 6671/P3



Consulting Geo-Technical &
Geo-Environmental Engineers
Site Investigation Contractors

The Slate Barn, Lower Lowley, Dunsford, Devon, EX6 7BP

Tel: 01647 252414

Email: info@terrafirmasouth.co.uk

Web: www.terrafirmasouth.co.uk

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Proposed Educational Development
Ranikhet Academy, Pey Road, Tilehurst, Reading

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PREPARED BY :



Kevin Scanlon B.Eng.(Hons), M.Sc.
kevin@terrafirmasouth.co.uk

REVIEWED BY :



Paul Standish B.Sc.(Hons), FGS

APPROVED BY :



Steven Hill B.Sc.(Hons), M.Sc., CGeol, EurGeol, FGS

Executive Summary

Proposals		Reading Borough Council is proposing to demolish and replace the existing school buildings at Ranikhet Academy, Spey Road, Tilehurst, Reading. The new school buildings will be located in the central section of the site and will likely require retaining walls.
Summary of Phase 1 and 2 Contaminated Land Risk Assessment	Potential Sources	A Phase 1 Contaminated Land Desk Study produced by Terra Firma (South) (Report 6671/P1) identified several historical contaminative sources at or within the surrounding area. These include allotments, car parking areas, made ground, gravel pits (offsite) and a brick and tile works (offsite). A Phase 2 Investigation was undertaken by Terra Firma (South) (6671/GIR) and the soil chemical testing undertaken as part of these works recorded localised elevations of dibenzo(ah)anthracene and asbestos fibres. Post fieldwork gas monitoring also recorded locally raised CO₂ concentrations. A Phase 3 Remediation Strategy, the objective of which is to reduce the human health risks and any risks to the aquatic environment, using the best practicable option is therefore required to control the risks associated with these contaminants.
	Potential receptors	<u>During Construction</u> Construction workers, neighbouring site users and passers-by. <u>Post Construction</u> Maintenance contractors, employees, child students, vegetation from phytotoxic contaminants and building materials from aggressive ground conditions.
	Potential Risks, Pathways and Pollution Linkages	• Ingestion of soil and soil dust • Consumption of site grown produce • Dermal contact (Inc. eye uptake) with soil, soil dust and water • Inhalation of soil particles, dust, asbestos, vapours and ground gases both indoors and outdoors • Contaminant permeation of drinking water pipes and ingestion of contaminated water supply
Summary of Phase 3 Remedial Strategy	Site Workers	Additional investigation to confirm absence of impacted soils beneath existing building footprints and existing boiler room post demolition. Compliance with H&S Regulations, COSHH Assessment, Good standards of hygiene, PPE and Dust suppression.
	Site End Users	Containment of impacted soils via: 1. Containment via excavate and dispose. 2. Containment via a cover system. Appropriate water pipe selection Ground gas protection measures in the form of • All joints and penetrations through the floor slab or membrane must be sealed. • Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200 g DPM² or beam and block or pre-cast concrete slab and 2000 g DPM²/ reinforced gas membrane and underfloor venting
	Aquatic Environment	Due diligence to good construction practice and housekeeping in preventing surface runoff and spillages.

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SECTION 1 Introduction and Proposed Development

Reading Borough Council is proposing to demolish and replace the existing school buildings at Ranikhet Academy, Spey Road, Tilehurst, Reading. The new school buildings will be located in the central section of the site.

Hampshire County Council are the consulting engineers for the project.

The site is centred approximately on National Grid Reference (NGR) SU 68377 73603. The site location is presented in **Drawing 2.1** below.



Drawings 1.1: Site Location Plan

A Phase 1 Desk Study Report was completed by Terra Firma (South) in April 2020 (report reference 6671/DS) for the proposed development. This study determined that there was a Low to Moderate risk to site receptors.

A Phase 2 Ground Investigation Report was completed by Terra Firma (South) in October 2020 (report reference GIR). The contamination risk assessment undertaken as part of this report confirmed that there were unacceptable risks at the site and that these needed to be managed to render the site fit for its intended use.

To this end, Terra Firma (South) has now been commissioned to prepare a Phase 3 Remediation Strategy for the site.

The objective of the Remediation Strategy is to reduce the human health risks and any risks to the aquatic environment previously identified, using the best practicable option.

1.1 Limitations and Exceptions of Investigation

Hampshire County Council has requested that a Remediation Strategy be prepared, detailing the remedial steps which need to be undertaken to render the site fit for its intended use.

This report has been prepared for the sole internal reliance of Hampshire County Council 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 (South). 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 (South) does not provide legal advice and the advice of lawyers may also be required.

It is not within the scope of Terra Firma (South) to:

- Provide Method Statements and Risk Assessments for the site preparation and development.

SECTION 2 Summary of Phase 2 Site Investigation

2.1 Site Summary

The site history, as detailed within the Phase 1 Contaminated Land Desk Study Report produced by Terra Firma (South) in April 2020, is summarised in the table below:

Table 2.1: Summary of Phase 1 Desk Study Report		
Geology		The northern half of the site is indicated to be underlain by the Seaford and Newhaven Chalk Formation. The BGS describes this formation as typically comprising of soft to medium hard, smooth white chalks with conspicuous semi-continuous nodular and tabular flint seams. The southern half of the site comprises the Lambeth Group, which typically comprises sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate. A fault lies approximately 150m to the east of the site. Made Ground is expected due to the previous cut and fill that has taken place across the site.
Mining		The risk from underground and/or surface mining activity is likely to be Moderate due to localized chalk, clay and gravel pits in the surrounding area.
Potential Sources of Contamination	On-site	Historical land usages and features identified within the site have included allotments, car parking areas and potential made ground. These are considered to potential sources of contamination.
	Off-site	Land usages in the surrounding area with potential to impact the site include surface gravel pits, and a brick and tile works.
	Aquifer Designation	The Seaford and Newhaven Chalk Formations are designated as Principal Aquifers whereas the Lambeth Group is designated as a Secondary Aquifer.
	Surface & Groundwater Flow	Groundwater is anticipated to flows eastwards following the topography of the region.

2.2 Ground Investigation

Terra Firma (South) produced a Ground Investigation Report in October 2020 and the findings are presented in the table below:

Table 2.2: Summary of Phase 2 Ground Investigation Report	
Field Investigation	The field investigation comprised 3no cable percussive boreholes, 9no. mini percussive boreholes, 12no. hand excavated trial pits and 1no. dynamic probe. The ground conditions encountered by the investigation generally comprised Made Ground underlain by the Lambeth Group and/or Seaford and Newhaven Chalk Formations. The Made Ground was variable and extended to depths ranging from 0.23m to 2.40m bgl. The Lambeth Group comprised firm to stiff clays and loose to dense sands that extended to depths ranging from 0.15m to 14.30m bgl. The Seaford and Newhaven Chalk Formations comprised structureless chalks of Grade Dm that became structured with depth and extended to the maximum investigated depth of 20m bgl.

		Groundwater was encountered at a depth of between 17.90 and 18.00m bgl from within the chalk
Contamination Risk Assessment	Chemical Testing & Evaluation	12 soil samples were tested for a site-specific suite of contaminants. The soil chemical testing revealed elevated levels of dibenzo(ah)anthracene in the Made Ground at TP9 and WS3. Asbestos fibres were also found in the Made Ground at TP2 located near the existing boiler room. Statistical analysis indicates that the elevations are localised and can be treated as hotspots when considering remediation.
	Gas Migration	Ground gas flows and concentrations were largely low. However, slightly elevated (>5%) CO ₂ concentrations were found in one installation and therefore it is conservatively recommended that the site's ground gas regime be designated as "Gas Characteristic Situation 2" in accordance with CIRIA C665.

2.3 Qualitative Risk Assessment

2.3.1 Contamination Sources

Asbestos fibres and elevated concentrations of dibenzo(ah)anthracene have been found at the site within the Made Ground. However, they are locally present rather than widespread with the asbestos fibres found at TP2(near the existing boiler room) and raised dibenzo(ah)anthracene levels at TP9 and WS3. As such the subsoils at and surrounding TP2, TP9 and WS3 are considered to be "hotspot" sources of contamination.

2.3.2 Potential Receptors

The potential receptors at the site during construction are summarised in the table below:

Table 2.3: Summary of Potentially Affected Receptors During Construction	
Potentially Affected Receptors	
Construction Workers	
Neighbouring Site Users	
Passers-by	

The potential receptors at the site potentially affected following construction of the development are summarised in the table below:

Table 2.4: Summary of Potentially Affected Receptors Following Construction	
Potentially Affected Receptors	
Future Residents/ Visitors	
Maintenance Contractors	
Employees	
Child Students	

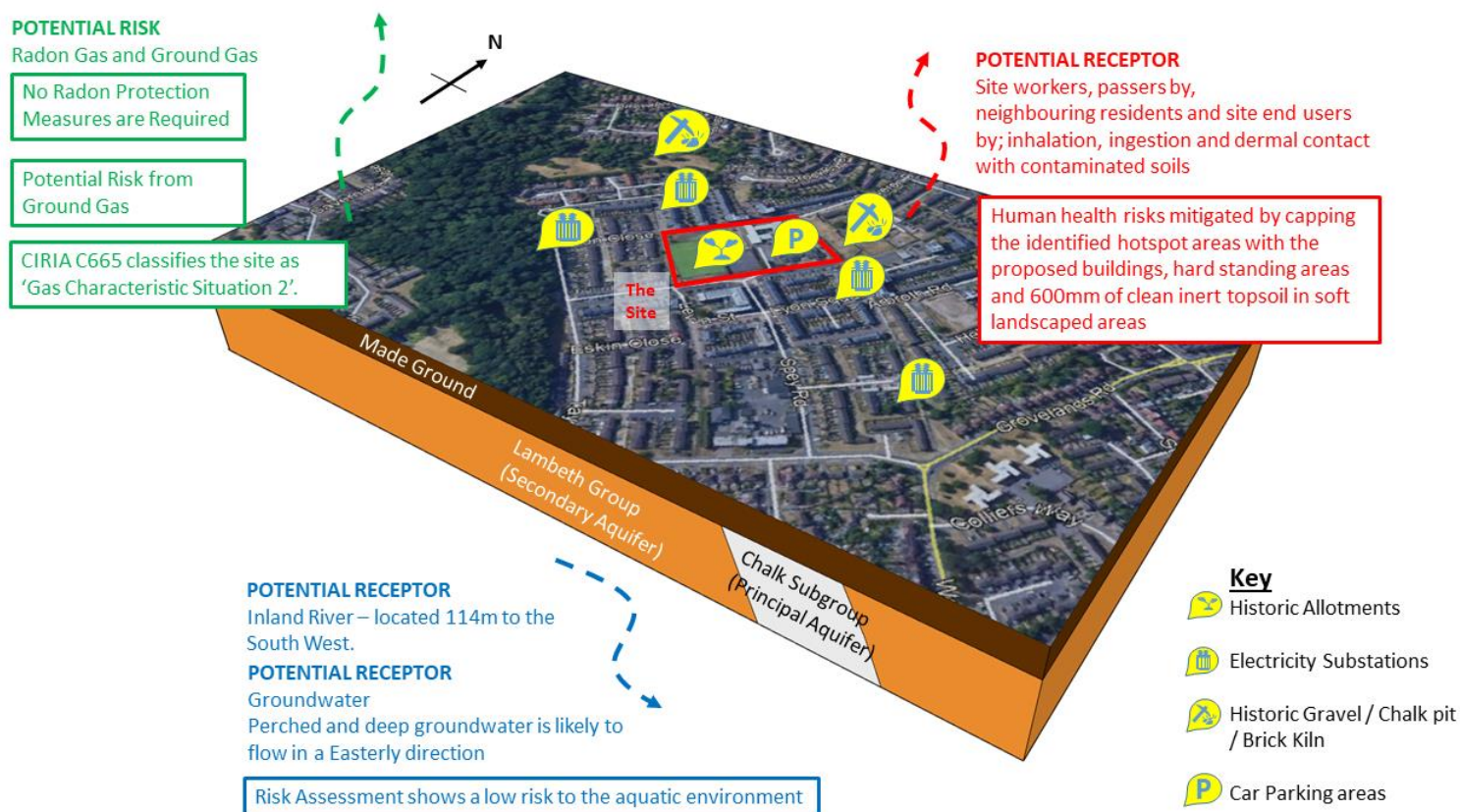
2.3.3 Potential Pathways

The following potential risks to human health and aquatic environment were identified:

Table 2.5: Summary of Potential Contamination Pathways

Potential Contamination Pathway	
Human Health	1) Ingestion of soil and soil dust
	2) Consumption of site grown produce
	3) Dermal contact (Inc. eye uptake) with soil, soil dust and water
	4) Inhalation of soil particles, dust, asbestos and vapours, both indoors and outdoors
	5) Inhalation of ground gas, accumulation and risk of explosion

2.3.4 Conceptual Model

**Drawing 2.1: Revised Conceptual Site Model**

SECTION 3 Options Appraisal

The contamination risk assessment undertaken as part of the Phase 2 investigation demonstrated that there were unacceptable risks associated with the raised CO₂ concentrations and the Made Ground locally impacted with asbestos and dibenzo(ah)anthracene. In accordance with CLR 11 (2004) the management of these risks focuses primarily on the relevant pollutant linkages that were shown to represent unacceptable risks to human health.

In practice, there may be a number of ways to reduce or control unacceptable risks, all of which have advantages and limitations in any particular case. The role of options appraisals is to establish, taking all the circumstances of the site into account, which options (either singly or in combination) offer the best overall approach to remediation for the site as a whole.

3.1 Remediation Options

In the context of this site, several remediation options were considered feasible for each of the potential pathways identified in Table 2.6. These feasible remediation options have been summarised in Table 3.1 below.

Table 3.1: Feasible Remediation Options					
Remediation Option				Linkage Applicability	
				Asbestos ¹	Dibenzo(ah)anthracene
Containment	Excavate and dispose	- Off-site landfill - On-site landfill		Pathways 1, 3 & 4	Pathways 1 - 5
	Physical	2-D	- Cover - Vertical barriers - Liners	Pathways 1, 3 & 4	Pathways 1 - 5
		3-D	- Solidification - Vitrification	-	Pathways 1 – 5
	Chemical	Stabilisation		-	Pathways 1 – 5

Note – Only pathways 1,3 & 4 are applicable to asbestos. Pathways 1 to 5 are applicable for PAH's.

3.2 Remediation Evaluation

As several feasible remediation options were identified for each of the pollution linkages identified, a detailed site-specific evaluation of the options was made in order to identify the most appropriate option for any particular linkage. The remediation options evaluation criteria has been summarised in Table 3.2 below.

Table 3.2: Remediation Options Evaluation Criteria			
Process		Limitations	Cost
Containment	Excavate and dispose	Considered non-sustainable and if proposed to landfill on-site is subject to EA exemptions	Low/Medium
	Cover system	Waste is not treated and environmental risks may still persist	Low
	Vitrification	Limited volume application	High
	Stabilisation/Solidification	Not effective with waste containing mostly organic compounds as they may break down in the long-term	Low

3.3 Site Specific Remedial Options Viability

The specific circumstances of the site which influenced the appropriate remediation options to be chosen are outlined in Table 3.3 below.

Table 3.3 Site-Specific Circumstances and Associated Remedial Options Viability		
Attributes	Site-specific Circumstances	Remediation Options Not Viable
Time	Development is due to start shortly.	Thermal Desorption / Engineered Biopiles
Space	Due to the relatively small size of development and nature of the site the amount of space is limited.	Landfarming / Bio-venting / Biosparging / Pump and Treat
Access	There will be no long-term access.	Monitored Natural Attenuation (MNA)
Cost	The proposals are for a relatively small development and therefore remediation has to be cost-effective with limited expenditure in mind	Vitrification / Incineration / Bioreactor
Volume	The volume of contaminated material requiring remediation is limited.	Vitrification / Steam stripping / Vacuum and solvent extraction / Incineration / Bioreactor
Contaminants	Material to be remediated includes asbestos which is largely chemically inert. Furthermore, some remediation techniques may result in asbestos fibres becoming airborne and should be avoided	Stabilisation / Solidification / Soil washing / Steam stripping / Vacuum and solvent extraction
By-products	It is preferred to undertake remediation without generating additional by-products requiring disposal	Soil washing / Steam stripping / Vacuum and solvent extraction
Permeability	The underlying ground conditions include cohesive soils likely to be of low permeability.	Thermal desorption / Soil washing / Steam stripping / Vacuum and solvent extraction
Efficiency	It is preferred to undertake remedial options which deal with risks associated with both human health and the wider environment	Hydraulic treatments

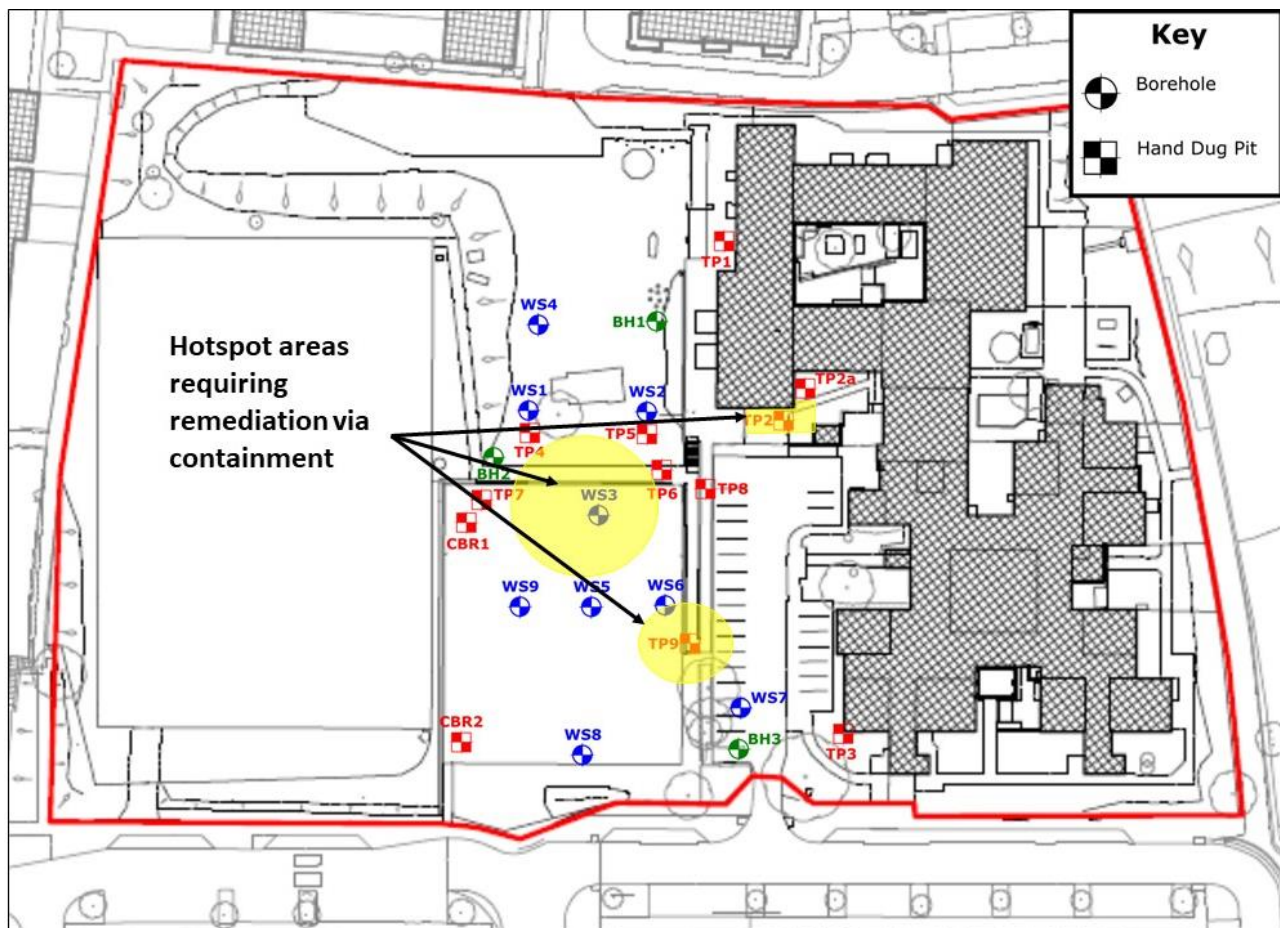
Based on the evaluation criteria outlined in Table 3.2 and the specific circumstances of the site outlined in Table 3.3 it was considered that the most appropriate remediation option, or combination of options, included:

3. Containment via excavate and dispose.
4. Containment via a cover system.

The above containment remediation options involve establishing a physical barrier between the pollution and the potential receptor.

SECTION 4 Remediation Specification and Subsequent Receptor Risk

Based on the evaluation criteria outlined in Table 3.2 and the specific circumstances of the site outlined in Table 3.3, it is considered that containment in the form of either excavating and disposing or capping of the locally impacted Made Ground would be the most suitable remediation option for this contamination source. Specifications for these two containment options are detailed below. Locations and approximate extents of where remediation is considered to be required is shown in yellow in the figure below.



Drawing 4.1: Hotspot areas of contamination that require remediation

4.1 Remediation Specification

4.1.1 Containment via Excavate and Dispose

Any Made Ground to be removed and disposed of offsite should be done using a suitable landfill or other waste management facility.

Any materials to be removed should be subject to the Waste Acceptance Procedure (WAP) in order to appropriately classify the waste for the correct type of landfill. All transfer and tip receipts should be kept on record.

The hotspot removal should be supervised by a qualified geo-environmental engineer.

Following removal of the contaminated material, the engineer should obtain two samples of soil from beneath the excavated area. These should be subjected to laboratory analysis for Asbestos and PAH

concentrations. If unacceptable levels of any contaminants are identified in the samples taken, then the area of removal should be extended and further testing carried out.

Validation testing should include analysis for the suite of contaminants given in the Table 4.1 below, with measured concentrations below the threshold values stated. These values are based upon those for a residential with plant uptake land usage scenario.

Once this has been achieved all hazard-receptor pathways will have been broken and no human health risks will remain.

All remedial works and all findings of the validation testing should be presented to the local authority in the form of a Validation Report (see Section 6).

If required, the removed soils should be replaced with inert soils. Any imported soils should be subject to validation testing to confirm their suitability before being brought onto site.

It is in the Client's interest to test material which is due to be imported at source by the supplier prior to being emplaced to prove its inertness. However, imported soils should be logged in situ in each soft landscaped area down to the original site soils. Soil samples should be obtained and analysed for a suite of contaminants to prove compliance with soil guidance values for the site, detailed in Tables 4.1.

Waste transfer tickets should be obtained from the supplier for all materials imported and exported from site and the quantities should be tallied. For a volume of soil up to 25m³, 1No. sample will be required per source. It is expected that for a volume exceeding 25m³, 2 samples per source or per 500m³ (whichever is the greater quantity), will be required. However, sampling quantity of verification samples will be confirmed once the quantities and source of imported materials is confirmed.

Table 4.1: Soil Chemical Threshold Values for imported Soils	
Substance	Threshold Value (mg/kg) – RwHP
Metals	
Arsenic	37
Cadmium	22
Chromium III	910
Chromium VI	21
Copper	2400
Lead	200
Mercury (Total)	40
Nickel	180
Selenium	250
Zinc	3700
PAH Compounds	
Naphthalene	2.3
Acenaphthylene	170
Acenaphthene	210
Fluorene	170
Phenanthrene	95
Anthracene	2400
Fluoranthene	280
Pyrene	620
Benzo(a)anthracene	7.2
Chrysene	15

Benzo(b)fluoranthene	2.6
Benzo(k)fluoranthene	77
Benzo(a)pyrene	5
Indeno(1,2,3-c,d)pyrene	27
Dibenzo(a,h)anthracene	0.24
Benzo(g,h,i)perylene	320
Hydrocarbons	
Total EPH C ₁₀ -C ₄₀	74*
Other Contaminants	
Cyanide	8
Asbestos	NAD

Notes

- C4SL - Provisional Category 4 Screening Levels
- S4UL - Suitable for Use Levels
- SGV – Soil Guideline Value
- NAD – No Asbestos Detected
- RwHP – Residential with Plant Uptake and based on worse-case 1% SOM
- * Based on worse-case Aromatic C₁₀-C₁₂ fraction

4.1.2 Containment via Cover System

The cover system could comprise capping the Made Ground with either the floor slab of the proposed buildings or any hard standing associated with the development e.g. car parking areas and internal access roads. Where these are not proposed, such as in the areas of soft landscaping, then the Made Ground should be capped with a 600mm thick layer of inert material.

If a 600mm capping layer is installed then any materials imported to form it should be logged insitu and proven down to the original site soils. Samples of these materials/soils should be obtained and analysed to prove compliance with the soil guidance values detailed in Table 4.1 above. Analysis should be in accordance with the testing frequencies detailed in section 4.1.1. It would also be prudent to test at source any materials/soils to be used as capping to confirm their suitability before they are transported to site and placed.

The local authority may also require further testing of the capping soils once they have been spread on site and verification of the capping thickness.

4.2 Additional Control Measures

Good Working Practice During Construction Phase

The ground works contractor(s) should comply with all current Health and Safety Regulations, and provide Method Statements, Risk Assessments and Health and Safety Plans to deal with the above remedial measures.

The appointed contractor(s) should as a minimum;

1. Comply with all current Health and Safety regulations
2. Provide Method Statements and Risk Assessments in place to deal with measures set out in this section
3. Comply with Control of Substances Hazardous to Health (COSHH) Assessment
4. Maintain a good level of Personal Protection Equipment (PPE)
5. Maintain a good level of hygiene by site workers

6. Put in place dust suppression measures when necessary

The contractor(s) must also strictly adhere to any current Pollution Prevention Guidelines, which aim to minimise detrimental harm to the environment. Consideration should be given to the planning and preparation of site works, site drainage, delivery and storage of construction materials, the management of waste, good housekeeping in particular to prevent runoff of silt and other fines into nearby water courses, refuelling, concrete and what to do in the event of an emergency.

Within the documentation prepared by the contractor(s), the following information should be provided, but not limited to:

1. Project Description
2. Key participants/contractor(s)
3. Technical procedures
4. Phasing of works and approximate timescales
5. Site plans to scale
6. Details of consents or license needed
7. Health and Safety, COSHH Assessment, Method Statements and Risk Assessments
8. Emergency contingencies

In addition, the following precautions should also be taken:

1. All potential chemicals and associated risks and emergency procedures for spills/leaks should be considered in the site risk assessment and the details provided to all site employees
2. Any potential pollutant materials or chemicals/detergents used on site should be adequately stored in suitable containers, with clear labelling.
3. Any oil or hazardous substance containers and associated pipe works should be enclosed within a bund.
4. Care taken during delivery of materials, with correct supervision and labelling detailing the substance and its quantities.
5. All delivery drivers should be informed of procedures and restrictions
6. Any materials on delivery should be covered to ensure no spillage from the vehicle.
7. Any detergents, paints, chemicals etc. should not be allowed to be discharged into surface drains or water courses
8. Washing out and cleaning of concrete/cement plant should be carried out in a contained area with adequate measures to collect all run-off water.
9. Security and prevention of vandalism, especially of oil drums/containers.

It should be noted that the appointed contractor should provide Method Statements and Risk Assessments to deal with these matters.

If during the development materials or abnormal ground conditions are encountered that are significantly different to those encountered in the Phase 2 Investigation, the occurrence should be reported to the Engineer and appropriate action taken prior to continuing with the works.

Protection of site workers from soil dust inhalation can be minimised by simple health and safety measures and dust suppression.

During construction the following precautions should be taken given that asbestos was found locally within the site soils:

1. A watching brief by the site manager (appropriately trained with asbestos awareness training) should take place during the groundworks phase of the works. If there is deemed a significant risk to

employees or the general public then activities should be suspended pending a specific Asbestos Survey and risk assessment undertaken in accordance with the 2012 Control of Asbestos Regulations (CAR 2012).

2. No stockpiling of material should take place so as to avoid the airborne spread of potential asbestos containing materials
3. Any material due to be removed from site should be immediately placed within suitable covered/lockable skips so as to prevent the airborne spread of asbestos containing material.
4. Due to the potential risk to contractors, employees are required, as a minimum, to use appropriate PPE and Respiratory Protective Equipment (RPE). These can include:
 - a. Disposable Respirators to standard EN149 (Type FFP3) or EN1827 (Type FMP3)
 - b. Half Mask Respirators to standard EN140 with P3 filter
 - c. Semi Disposable Respirators to standards EN405 with P3 filter

It is recommended further testing is undertaken within the vicinity of the existing boiler room to confirm the level of asbestos contamination.

Discovery Strategy

If unexpected contamination is found at any time then it must be reported to Terra Firma (South) immediately. This discovery strategy sets out the actions that must be taken if suspected contamination is encountered during the course of the development.

A significant observation includes the following:

Table 4.2: Discovery Strategy (Significant Observations)	
Evidence	Description
Visual	- Fuel or oil like substances mixed in with or smeared on the soil or floating on perched, groundwater or surface waters. - Waste materials (refuse, barrels, industrial wastes, ash, tar, etc.) buried at specific location or across the site. - Marked variation in colour. For example, red, orange, yellow, green, light or dark blue, etc. may indicate contamination from a variety of contaminants. - Soils including large amounts of ash and clinker where such contamination of soils wasn't expected. - Evidence of asbestos
Odours	- Fuel, oil and chemical type odours. - Unusual odours such as sweet odours or fishy odours.
Wellbeing	- Light headedness and/or nausea when in excavations, at the working face of an excavation, when visual or olfactory evidence of contamination exists, etc. - Burning of nasal passages, throat, lungs or skin. - Blistering or reddening of skin due to contact with soil

The following table sets out the actions that must be taken if significant or suspected land, water or air contamination is observed by site staff, contractors or visitors:

Table 4.3: Discovery Strategy (Actions)		
Person observing contamination	To be reported to:	Action to be taken
Site Visitor	Must report observation to the site manager	Stop work and where possible, make area safe and secure before reporting to site manager

Contractor	Must report observation to the site manager	Stop work and where possible, make area safe and secure before reporting to site manager
On site manager	Must report observations to Terra Firma (South).	Stop work and where possible, make area safe and secure before reporting to Terra Firma (South)
Geo-environmental Consultant	Must report observations to the local authority and their Contaminated Land Officer from Reading Borough Council	Provide remedial strategy/ validation and waste protocol if required.

If gross contamination is encountered during groundworks the advice of a geo-environmental consultant must be sought. Soil arisings from areas where visual or olfactory evidence of contamination is observed should be handled as potentially hazardous and temporarily stockpiled.

All stockpiled soils should be contained on and covered by visqueen sheeting to prevent rainwater infiltration and possible leaching of soil contaminants to the ground. Stockpiled soils will then require validation testing to determine whether they can be used elsewhere on the Site or require off-site disposal.

The Contaminated Land Officer for Reading Borough Council is required to be contacted to agree any further remedial works that become necessary during the course of the development before the agreed works being implemented.

4.3 Potable Water Supplies

If plastic pipes are to be laid beneath the site an assessment should be made, by the water of soils along the route of the pipe with reference to the material selection criteria 'UKWIR Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites'.

When laying underground services, the made ground in the service trench should be removed and replaced with clean fill to prevent human contact during future maintenance works.

It is recommended that laboratory test results are forwarded to the water authority so that water supply pipes can be correctly specified. Receipts and detail of the specification of any barrier water supply pipe used should be included within a verification report.

4.4 Gas Protection Measures

Ground gas concentrations of CO₂ were found to be locally in excess of 5%. These levels would designate the site's ground gas regime as "Gas Characteristic 2" as per guidance issue by the British Standards Institute (BS8485: 2015 + A1: 2019) and CIRIA (CIRIA C665).

4.4.1 Gas Membrane Installation

The residential land usage scenario is considered to be the most applicable for the site for the purposes of the human health risk assessment. Table 8.6 of the CIRIA guidance (guidance reference C665 dated 2007) states that for a residential scenario with a gas characteristic situation of 2 any occupied buildings should have the following

- All joints and penetrations through the floor slab or membrane must be sealed.
- Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200 g DPM². Or,

- Beam and block or pre-cast concrete slab and 2000 g DPM²/ reinforced gas membrane and underfloor venting

Current construction proposals are for an underfloor void which will have a closed void and a solid upper and lower slab. For this construction the gas membrane should be placed over the surface of the upper slab using an appropriate membrane, which may incorporate a liquid tanking system.

Before commencement of the works, the installer contractor should produce a detailed installation plan including a method statement, CQA procedures and qualifications of installers. It is also recommended that the membrane installer fill out a daily log sheet to be submitted to the Verifier on completion of the works.

The design and specifications as to the installation of the gas membrane and gas venting centres should be undertaken by a specialist contractor in accordance with BS 8485: 2015 + A1: 2019 'Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.

The relevant duties of the gas membrane contractors, in accordance with CIRIA C735 Tables A1-A3, is given below:

- **Groundworker** to provide Verifier photographic evidence of ventilated void space prior to covering with beam and block flooring system for plots 3-12.
- **Skilled Membrane Installer** to provide daily log sheets, or sign-off sheets to be submitted to the Verifier.
- **Independent Verifier** to conduct a thorough visual verification of membrane installation, prior to placement of insulation protection. Photographic evidence to be collected and inspection proforma to be prepared.
- **Independent Verifier** to air lance all joins, pipe penetrations etc to ASTM D4437. Results to be recorded on inspection proforma.
- **Independent Verifier** to consider further need for/scope of in-situ integrity testing based on inspection findings. Additional in-situ testing might include leak detection (i.e. smoke, tracer gas or dielectric). Results to be recorded on inspection proforma.
- **Groundworker** to provide Verifier photographic evidence of service entry sealing to BRE Report 414 standards upon completion.

4.4.2 Gas Protection System Validation Report

Section 8 of BS8485: 2015 + A1: 2019 outlines the steps that should be taken in the construction and on-site verification of the gas protection measures, documentation of the design and construction, and long-term maintenance of the measures (if needed).

Verification of protection measures should be in accordance with CIRIA C735.

The Validation Report should present a detailed description of the ground gas protection measures applied and lines of evidence gathered during verification processes to confirm that protection measures have been installed as per the installation plan and satisfy the remedial objectives, severing the pathway between the source and receptor.

The Validation Report should include, but is not limited to:

- Description of the as-built protection measures installed and any variation in design from the installation plan.
- Details of the Installer and relevant qualifications
- Details of the Verifier independency and relevant qualifications
- Verifier proformas and integrity testing results
- Visual inspection photographic evidence
- Installer daily log sheets
- Details of non-conformances and how they were rectified
- Statement based on the presentation of lines of evidences and review of the site conceptual model confirming that the discussed gas protection measures have been achieved.

4.5 Subsequent Receptor Risk

The risk to receptors has been re-assessed incorporating the remediation measures detailed above. The findings from this are summarised in the tables below.

4.5.1 Site Workers

Table 4.4: Site Workers				
Source	Pathway	Current Level of Risk	Proposed Mitigation Measures	Level of Risk with Mitigation Measures
In-situ Impacted Soils	Ingestion of soil/soil dust	Low to Moderate	1. Compliance with health and safety regulations 2. Provision of Method Statements and Risk Assessments 3. Compliance with Control of Substances Hazardous to Health (COSHH)Assessment 4. Good level of Personal Protection Equipment (PPE) 5. Good level of hygiene by site workers 6. Dust suppression measures 7. Measures to limit contact with any contaminated soils	Low
	Dermal contact with soil/soil dust	Low to Moderate		Low
	Inhalation of soil dust	Low to Moderate		Low

4.5.2 Passers-by and Neighbouring Site Users

Table 4.5: Passers-by and Neighbouring Site Users				
Source	Pathway	Current Level of Risk	Proposed Mitigation Measures	Level of Risk with Mitigation Measures
In-situ Impacted Soils	Inhalation of soil dust	Low	1. Dust suppression measures 2. Site Screening using temporary partitions and screens	Negligible
	Ingestion of soil dust	Low		Negligible
	Dermal contact with soil dust	Low		Negligible

It is considered that the site will be sufficiently fenced off during development and that dust suppression measures will be made if required, meaning there will be a no risk to neighbouring site occupants and passers-by.

4.5.3 Site End Users

Table 4.6: Site End Users				
Source	Pathway	Current Level of Risk	Proposed Mitigation Measures	Level of Risk Post-Remediation
In-situ Impacted Soils	Inhalation of soil dust/vapours	Low to Moderate	1. Containment via excavate and dispose or cover system 2. Containment via excavate and dispose or cover system	Negligible
	Ingestion of soil/soil dust/	Low to Moderate		Negligible
	Dermal contact with soil/soil dust	Low		Negligible
	Contamination of potable water supply	Low to Moderate	1. Assessment of soils by water provider to suitability of plastic pipes 2. Removal of made ground in service trenches for new water pipes and replacement with clean fill	Negligible
	Inhalation of ground gases	Moderate	1. Installation of ground gas barrier for CS2 ground gas regime	Negligible
	Direct contact with made ground during maintenance of service lines	Low	1. When laying underground services, the made ground in the service trench should be removed and replaced with clean fill	Negligible

4.5.4 Aquatic Environment

Table 4.7: Aquatic Environment				
Source	Pathway	Current Level of Risk	Proposed Mitigation Measures	Level of Risk with Mitigation Measures/ Post-Remediation
In-situ Impacted soils	Direct contamination	Low	Low Risk due to the environmental setting and low concentrations identified.	Negligible
	Leaching		Reduced risk of contaminant migration and deep transmission is due to the insoluble nature of PAH's	
	Migration of Perched Groundwater			
Construction Work	Accidental spillage and surface runoff	Low	1. Measures to avoid accidental spillage of materials during earthmoving activities 2. Measures to control surface run- off	Negligible

Following remediation and with new and old drainage systems, as well as capping of the site, the migration of any surface waters into the underlying impacted soils will be minimal.

SECTION 5 General Remediation Strategy and Sequence

In order to reduce the risk of cross-contamination the remediation strategy should be executed in a controlled and timely manner. Therefore, the following remediation sequence is recommended:

1. Any existing asphalt hard standing beneath the proposed buildings should be broken up and removed or crushed and re-used where possible. However, it should be noted that if proposals are to re-use then appropriate chemical testing should be undertaken to confirm the absence of PAH's / coal tars that may be present within historical macadam. Materials which may contain asphalt or historic macadam should not be reused due to potential presence of PAHs. Further, any materials exhibiting visual or olfactory evidence of contamination are not to be considered suitable for re-use until testing and assessment (in accordance with the outlined assessment criteria) is undertaken. The underlying soils should be inspected by a qualified geo-environmental engineer to confirm the absence of any additional, currently unidentified contamination hotspots.
2. The identified contamination should be contained as per the methodologies set out in Section 3.3, comprising excavate and dispose or a cover system.
3. Finished floor levels should be obtained using balanced cut and fill exercises using site won material. Any enabling earthworks comprising appropriate compaction methods, verification density testing and supervision should be supervised by a qualified geo-technical engineer.
4. The appropriate foundation solution should be installed as per the recommendations outlined in the Ground Investigation Report by Terra Firma (South) (Report No 6671/GIR/Rev02).
5. The installation and verification of the gas membrane should be installed once foundations and floor slabs are constructed but before final screed floor levels are completed. The proposed gas membrane specification should be approved prior to installation by qualified installer.
6. Before further construction of the main build, the gas membrane should be verified by a qualified company and verification report produced.
7. The existing school buildings should be demolished (subject to an asbestos survey) and the site cleared.
8. After demolition of the existing buildings further investigation, comprising sampling of the material beneath the floor slabs and around the existing boiler room, should take place to confirm the absences of any unknown contaminants in these areas.
9. Final hard and soft landscaping should be undertaken on confirmation of no further contamination under the existing building. If required, further remediation may be required in these areas.

SECTION 6 Validation Works

All remedial measures implemented at the site will require validation and the findings accepted by local authority prior to site occupation.

Validation Reports or equivalent documentation should be compiled by the appropriate Specialist/Contractor/Consultant for each of the proposed remedial measures.

Validation Reports should contain, but not be limited to the following:

- Information as detailed within the Remedial Strategy/Method Statement about works undertaken, including scaled site plans;
- Details and justification of any changes from the original Remedial Strategy/Method Statement (if applicable);
- Details of who carried out the remedial works;
- Substantiating data, for example, laboratory test results, monitoring of performance of remedial measures introduced, scaled plans of the site/area subject to remediation;
- Clean cover system – photographs of materials emplaced on site (soil profile) and records of chemical analysis proving compliance with soil guidance thresholds for the site;
- Foundation Excavation Watching Brief - photographic record demonstrating absence of additional contamination at the site;
- Verification that installed gas membranes are suitable and have been correctly installed.
- Details of any further remedial works that may be required following post-remedial monitoring;
- On-site and contractor registers;
- Waste transfer delivery tickets for imported materials confirming quantity and type;
- Documentation for any waste disposal including muck-away tickets and certificates of WAC testing if conducted;
- Confirmation that remediation objectives have been met.

It is recommended that Terra Firma (South) will oversee the works and provide all specific validation information in a final validation report upon completion.

