

Our Ref: 15568

Your Ref:

Contact: James Rhys-Williams

7th December 2020

Kingfisher Developments (Wales) Ltd

For the attn. of Ashley Eley (by e-mail: ashley@kingfisherwales.co.uk)

Dear Ashley

REVIEW OF CAPPING SYSTEM REMEDIAL MEASURES: PARK ROW, CWMAVON, PORT TALBOT

Terra Firma Wales Ltd were retained by Kingfisher Developments (Wales) Ltd to assess the appropriateness of remedial measures installed in all garden/landscape areas of the recently developed residential flats at Park Row, Cwmavon, SA12 9PD.

The Client has confirmed that remedial measures with regards to identified soil contamination have deviated from the agreed Outline Remediation Strategy (Integral Geotechnique, Nov2018, Ref:12331/RAH/18/ORS).

The remediation scheme for the site required a 600mm capping layer of clean imported soils over a high visibility anti-mixing geotextile in all garden and soft landscaped areas.

Subsequent site visits undertaken by the author have confirmed that cover soils have a thickness of 400mm with a bark mulch topping. An anti-mixing membrane has not been installed at the site. Appropriate chemical testing of imported soils has been undertaken and capping soils demonstrated to be suitable for use, see Terra Firma Wales letter report referenced 15568/VAL, dated 25th August 2020.

The Outline Remediation Strategy assumed a residential (with home grown produce) site end use. As the plots will be managed, with a restriction on tenants planting, a residential (without home grown produce) would be considered more appropriate.

The initial Site Investigation Report (Integral Geotechnique, June 2017, Ref: 12000/PB/17/SI) identified a risk to future site users from asbestos fibres, identified in made ground soil. It is however apparent that the risk to future site uses was not quantitatively assessed. It is considered that the scheme would benefit from a suitable assessment of the risk.

The scope of this report is to:

1. Re-assess identified soil contamination with reference to published guideline for a residential (without home grown produce) end use.
2. Undertake an asbestos risk assessment for identified Chrysotile fibres in made ground soils.
3. Prepare a updated conceptual site model for the development.

4. Asses the installed capping solution based on the updated conceptual site model with reference to published soil capping thickness determination calculations.

1.0 Evaluation of Geoenvironmental Analytical Results

Comparison of the analytical results has been made with the 2015 Suitable 4 Use Levels (S4UL) provided by Land Quality Management (LQM) Limited and the Chartered Institute of Environmental Health (CIEH) or provisional Category 4 Screening Levels (pC4SL).

A summary of the chemical test results which include the regulatory soil guideline values used in a residential setting without plant uptake are given in the following tables. The complete results can be found in the relevant site investigation report.

Six samples of made ground were tested for a standard suite of inorganics, pH and TOC. The summarised results are in **Table 1.1**.

Table 1.1 Summary of Soil Chemical Test Results – Inorganics & Miscellaneous

Substance	Threshold Value (mg/kg)	Source	Measured Concentrations (mg/kg)		Number of Exceedances
			Minimum	Maximum	
Arsenic	40	LQM/CIEH	19	57	1
Cadmium	85	LQM/CIEH	<0.2	2.8	0
Chromium	910	LQM/CIEH	16	60	0
Chromium VI	6	LQM/CIEH	<4	<4	0
Copper	7100	LQM/CIEH	49	190	0
Lead	310	pC4SL	53	150	0
Mercury (inorganic)	56	LQM/CIEH	<0.3	0.4	0
Nickel	180	LQM/CIEH	20	34	0
Selenium	430	LQM/CIEH	<1.0	<1.0	0
Zinc	40000	LQM/CIEH	110	2400	0
Beryllium	1.7	LQM/CIEH	0.69	1.0	
Boron	11000	LQM/CIEH	0.4	0.9	0
TOC (%)	-	-	3.6	7.5	-
pH	-	-	7.1	8.2	-
Notes: - No available guideline					

Six samples were tested for speciated polycyclic aromatic hydrocarbons and phenol. The summarised results are in **Table 1.2**.

Table 1.2 Summary of Soil Chemical Test Results – Speciated Polycyclic Aromatic Hydrocarbons and Phenol

Substance	Threshold Value (mg/kg)	Source	Measured Concentrations (mg/kg)		Number of Exceedances
			Minimum	Maximum	
Naphthalene	13	LQM/CIEH	<0.05	0.99	0
Acenaphthylene	6000	LQM/CIEH	<0.05	1.3	0

Acenaphthene	6000	LQM/CIEH	<0.05	0.24	0
Fluorene	4500	LQM/CIEH	<0.05	0.96	0
Phenanthrene	1500	LQM/CIEH	1.2	11	0
Anthracene	37000	LQM/CIEH	0.2	1.7	0
Fluoranthene	1600	LQM/CIEH	1.7	15	0
Pyrene	3800	LQM/CIEH	1.5	11	0
Benzo(a)anthracene	15	LQM/CIEH	1	6.1	0
Chrysene	32	LQM/CIEH	1.3	5.8	0
Benzo(b)fluoranthene	4.0	LQM/CIEH	0.85	7.3	1
Benzo(k)fluoranthene	110	LQM/CIEH	0.59	3.4	0
Benzo(a)pyrene	3.2	LQM/CIEH	0.60	5.4	2
Indeno(123cd)pyrene	46	LQM/CIEH	0.38	3.0	0
Dibenzo(ah)anthracene	0.32	LQM/CIEH	0.25	0.91	3
Benzo(ghi)perylene	360	LQM/CIEH	0.50	3.3	0
Total Phenols	120	LQM/CIEH	<1.0	<1.0	0
Total PAH	-	-	12.2	77.0	-

Notes:

Thresholds based on 6.0% soil organic matter where applicable

- No available guidelines

Asbestos (chrysotile) fibres were identified in two made ground samples, subsequent quantification testing revealed a quantity by mass of <0.001%.

2.0 Asbestos Risk Assessment

The chemical testing of the soils on site has identified asbestos to be present in the made ground materials.

Exposure to airborne asbestos fibres is known to cause lung cancer and mesothelioma. Paragraph 4.5 of the Welsh Government guidance document 'Contaminated Land Statutory Guidance - 2012' states that death, life threatening diseases (e.g. cancers), other diseases likely to have serious impacts on health, serious injury, birth defects and the impairment of reproductive functions constitute 'significant harm' to human health.

A potentially contaminant linkage has therefore been identified at the site, as summarised in **Table 2.3**.

Table 2.3 Contaminant Linkage for Assessment

Source	Pathway	Receptor
Asbestos fibres (Chrysotile) in Made ground soils S1	Inhalation of asbestos fibres P12	Construction and maintenance workers R1
		Future site users (residents) R2
		Passers-by or neighbouring site users R3

2.1 Risk Assessment Methodology

2.1.1 General

A quantitative risk assessment has been carried out for the site in accordance with CIRIA C733:2014 - Asbestos in Soil and Made Ground: A Guide to Understanding and Managing Risks. In the assessment, site investigation data along with published soil to air relationships have been used to calculate airborne fibre concentrations.

Overall excess lifetime cancer risks for a critical human health receptor have been calculated based upon exposure levels calculated using the airborne fibre concentrations.

2.1.2 Local Climate

Asbestos fibres within asbestos containing soils (ACS) are only likely to be released when the soil surface is dry and dusty. The local temperature and rainfall have a significant influence over the period of time soils remain dry and dusty.

The number of days with an average daily rainfall of over 1mm has been obtained for the period of 1981-2010 at the Bute Park, Cardiff climate station. The data shows that the Cardiff area has 148.6 days a year where the average rainfall exceeded 1mm or conversely 216.4 dry days.

2.1.3 Calculation of Airborne Respiratory Fibre Concentration

Addison et al:1988 has been used to calculate airborne respirable fibre concentrations based upon bulk soil asbestos concentrations obtained through sample quantification.

This approach is considered acceptable on the basis that:

- The site soil is similar to the 'clay', 'sandy' or 'intermediate' soils prepared by Addison et al;
- Measured soil concentrations of asbestos fibres (per cent) are available; and
- The likely soil dust in air concentrations (mg/m³) can be estimated or measured.

2.1.4 Calculation of Exposure

The exposure of an event is the product of the airborne concentration of asbestos during the event and the period of time that the exposure lasts. The annual exposure (E_i) from each event, i, can be expressed in fibre/ml.hours as:

$$E_i = C_i \times F_i \times T_i$$

Where:

C_i is the estimated concentration (f/ml) for the event

F_i is the frequency of the event per year

T_i is the period of time that the event lasts in hours

Cumulative exposure for each event is the sum of the relevant annual exposures. So, the cumulative exposure for event i, CE_i, is the annual exposure for the event multiplied by the number of years that the event is predicted to occur.

$$CE_i = E_i \times Y_i$$

Where:

Y_i is the number of years that exposure event i will occur.

2.2 Risk Assessment

Overall excess lifetime cancer risks have been estimated in accordance with the guidance published in CIRIA C733:2014. For the assessment, the worst case of asbestos contamination was used to produce two models with varying exposure times. A summary of the models is presented in **Table 2.4**.

Table 2.4 Model Data – Chrysotile

Parameter	Units	Model Run 1		Model Run 2	
		Model Data	Justification	Model Data	Justification
Soil Type	-	CLAY	As defined in logs	CLAY	As defined in logs
Appropriate test soil prepared by Addison <i>et al</i>	-	CLAY	As defined in Addison <i>et al</i>	CLAY	As defined in Addison <i>et al</i>
Highest measured Chrysotile concentration	Mass %	0.001	Laboratory gravimetric analysis	0.001	Laboratory gravimetric analysis
Predicted normalised fibre concentration	fibres/ml per mg/m ³	0.02	As per Graph a, Figure 6 of Addison <i>et al</i>	0.02	As per Graph a, Figure 6 of Addison <i>et al</i>
The concentration of soil dust during gardening activities in dry and dusty conditions	mg/m ³	0.1	Based on ambient urban dust levels and ART modelling of shovelling dry powders	0.1	based on ambient urban dust levels and ART modelling of shovelling dry powders
Airborne fibre concentration due to garden activities	f/ml	0.002	The product of the predicted normalised fibre concentration and concentration of soil dust during activities	0.002	The product of the predicted normalised fibre concentration and concentration of soil dust during activities
How long are residents/visitors assumed to be outside in dry and dusty conditions	h/yr	101	216.4 dry days per year based on Met office data. (170 days per year exposure based upon C4SL)	130	280 dry days considered a reasonable worst case. (170 days per year exposure based upon C4SL)
Annual exposure	f/ml.hours/year	0.202	Product of airborne fibre concentration due to activities and child exposure time	0.26	Product of airborne fibre concentration due to activities and child exposure time
Cumulative exposure	f/ml.hours	1.212	6 years based on assumptions in C4SL final report	1.56	6 years based on assumptions in C4SL final report
Unit converted cumulative exposure	fibre/ml.years	0.0006	assuming an occupational year is 2,000 hours (CIRIA C733)	0.0008	assuming an occupational year is 2,000 hours (CIRIA C733)

2.3 Results

The quantitative risk assessment results based upon information published by Hodgson & Darnton:2000 is presented in **Table 2.5**.

Table 2.5 Quantitative Risk Assessment Results

Health Risk	Lifetime Risk (per 100,000 exposed)	
	Model Run 1	Model Run 2
Age adjusted cumulative exposure (2.8 adjustment factor taking into account exposure from 0 to 60 years) fibre/ml.years	0.002	0.002
Mesothelioma Risk	Insignificant	Insignificant
Lung Cancer Risk	Below probably insignificant	Below probably insignificant

2.4 Acceptable Level of Risk

At present there is a lack of UK guidance as to what acceptable levels of lifetime cancer risk posed by ACS are. The HSE:2001 categorise levels of risk as shown below:

- Unacceptable
- Tolerable
- Broadly Acceptable

For occupational activities, the HSE:2001 suggest that “an individual risk of death of one in a million per annum for both workers and the public corresponds to a very low level of risk and should be used as a guideline for the boundary between the broadly acceptable and tolerable regions”. Assuming a 70 year lifetime, this equates to a risk of death of 7 in 100 000 over a lifetime (CIRIA C733:2014).

The quantitative risk assessment revealed the level of risk is insignificant. The worst case cumulative exposure of 0.002 fibre/ml.years is therefore considered Broadly Acceptable. Therefore no further remedial measures are required with regards to identified asbestos at the site.

3.0 Quantitative Risk Assessment

3.1 Contaminants of Concern

Contaminants identified as part of this assessment are summarised in **Table 3.6**, along with an interpretation of the likely contamination source. Where applicable, the contaminant, source relationship is based on the inferences made in the preliminary conceptual site model in previous reports by others.

Table 3.6 Contaminants of Concern

Location	Depth	Contaminant	Source
WS1	0.0-0.2	Dibenzo(ah)anthracene	Made ground soils S1
WS2	0.3-1.3	Arsenic, Benzo(b)fluoranthene, Benzo(a)pyrene, Dibenzo(ah)anthracene	
WS4	0.2-1.0	Benzo(a)pyrene, Dibenzo(ah)anthracene	

3.2 Pollutant Linkages

Based on the findings of this assessment, previous assessments and the fact that the development has been constructed, the conceptual site model has been revised. Remaining pollutant linkages are tabulated in the refined conceptual site model **Table3.7**. Identified pollutant linkages will require appropriate mitigation or remedial measures.

Table3.7 Refined Conceptual Site Model

Source	Pathway	Receptor
Made ground soils containing PAH and Arsenic S1	Direct soil and dust ingestion P1	Future site users (residents) R1
	Dermal contact with soil P3	
	Inhalation of soil dust P4	

3.3 Mitigation and Remedial Measures

The following sections summarise the likely mitigation and remedial measures suitable for the identified contamination and development end usage.

3.3.1 Human Health

3.3.1.1 Contaminated Soils

To protect future site users from the identified contamination the site will need to be capped. The capping should consist of the proposed buildings and hard standings. In garden and soft landscaped areas the capping should consist of suitable inert topsoil, and subsoil if desired.

All imported soils should be validated as clean and suitable for use in accordance with 'Requirements for the Chemical Testing of Imported Soils for Various End Uses and Validation Cover Systems'.

For proposed new supply water pipes, the UK Water Industry Research publication 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites (Report 10/WM/03/21)' should be consulted.

In accordance with EC Regulation 1272/2008 and Environment Agency Guidance WM3 soils destined for off-site disposal should be classified on the basis of their hazard phrases prior to disposal. Soils are classified as a mirror entry waste and should be classified on the basis of their specific chemical properties.

3.3.2 Aquatic Environment

Site specific mitigation and remedial measures are not required with respect to the aquatic environment.

4.0 Installed Remedial Measures & Assessment

An inspection of the installed capping system was undertaken on the 7th December 2020, comprising the hand excavation of four inspection pits in garden and landscaped areas surrounding the development.

During the inspection photographs showing the topsoil thickness were taken and present in **Annex A**.

Imported topsoil was observed to have a thickness of 400mm topped with bark mulch.

4.1 Capping Soils Thickness Assessment

Capping soil thickness assessment is carried with reference to Cover Systems For Land Regeneration – Thickness Design of Cover Systems for Contaminated Land, BRE, March 2004.

The assessment model assumes that over time there will be a complete intermixing of made ground soils with overlying cover materials. It is considered that the mixed zone (cover + made ground soils) would not exceed 600mm for this type of residential development. Concentration of contaminants in made ground soils exceeding guideline levels have been averaged for this assessment.

For clarification of abbreviations refer to above reference publication.

M = 600mm

Tv (arsenic) = 40mg/kg 57

Tv (benzo(b)fluoranthene) = 4mg/kg 7.3

Tv (benzo(a)pyrene) = 3.2mg/kg 4.4

Tv (dibenzo(ah)anthracene) = 0.32mg/kg 0.69

Cc (arsenic) = 0.45

Cc (benzo(b)fluoranthene) = 0.025

Cc (benzo(a)pyrene) = 0.031

Cc (dibenzo(ah)anthracene) = 0.313

Cg (arsenic) = 1.425

Cg (benzo(b)fluoranthene) = 1.825

Cg (benzo(a)pyrene) = 1.375

Cg (dibenzo(ah)anthracene) = 2.156

$X \text{ (cover thickness)} = M(Cg-1)/(Cg-Cc)$

$X \text{ (arsenic)} = 600(1.425-1)/(1.425-0.45) = 249\text{mm}$

$X \text{ (benzo(b)fluoranthene)} = 600(1.825-1)/(1.825-0.025) = 275\text{mm}$

$X \text{ (benzo(a)pyrene)} = 600(1.375-1)/(1.375-0.031) = 167\text{mm}$

$X \text{ (dibenzo(ah)anthracene)} = 600(2.156-1)/(2.156-0.313) = 376\text{mm}$

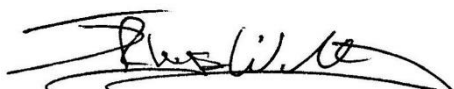
It is therefore considered that a capping layer of 380mm would be suitable to sever the pathway between the contaminant source and receptor at the development site.

Given that capping soils have a recorded thickness of 400mm, the site has been suitably remediated and fit for its intended use.

We trust that the above is to your satisfaction, however, if you have any queries or require any further information please do not hesitate to contact us. In the meantime, we await your further instructions.

Yours sincerely

for: Terra Firma (Wales) Ltd



J. Rhys-Williams BSc (Hons) FGS

Enc.

Annex A – Site Photographs

ANNEX A
Site Photographs



To south (front) of development



To west (side) of development



To north (rear) of development



To east (side) of development

