Remediation Statement
Appendix M

Validation of Remediation of Sub Z Transformers, former Albright and Wilson Works, Whitehaven Cumbria.

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EXECUTIVE SUMMARY

URS Corporation Ltd (URS) was commissioned by Rhodia UK Ltd (Rhodia) to undertake an intrusive soil and groundwater investigation at an area identified as "Sub Z" at the former Albright & Wilson site in Whitehaven, Cumbria.As the Sub Z area lies within a Special Site designation, this report addresses the validation of remediation in respect of impact on controlled waters.

The Sub Z area comprises an area of the site most recently occupied by transformers. The above ground structures have been demolished and remediated by removing 75m^3 of made ground in this area.

As part of the validation works undertaken by URS, a total of eight trial pits were excavated. Soil and groundwater grab samples were collected and scheduled for Total Petroleum Hydrocarbons (TPH-CWG method) and Polychorinated Biphenyls (PCBs) laboratory chemical analysis. The geological horizons observed were Made Ground (gravel backfill following the remediation) overlying reworked glacial till.

The key receptor identified for the controlled waters assessment was Sandwith Beck, located approximately 200m to the south east of the Sub Z area (Figure 1). A Stage 3 screening exercise for controlled waters utilising the CONSIM model was completed on data collected from within the Sub Z boundary. No potential significant risk to controlled waters was identified.

[1] ENVIRONMENTAL PROTECTION ACT 1990, SECTION 78H(7)

1. INTRODUCTION

1.1. General Introduction

URS was commissioned by Rhodia on 9th October 2007 to undertake an intrusive soil and groundwater investigation within a parcel of land defined as ''Sub Z'' at the former Albright & Wilson site in Whitehaven, Cumbria as detailed in URS Proposal 03048356 MALT0001 FW (dated 2nd October 2007). This report formalises the scope and context of investigations undertaken at the Sub Z site.

The location of the former Albright and Wilson Works is presented on Figure 1. This report presents URS' approach and rationale for investigations to validate the remediation of the Sub Z area including the sampling density, the suite of laboratory analysis and the number of samples to be tested, along with details of the works undertaken and the analysis of data collected from site work and subsequent laboratory chemical analysis in the context of the risk based setting as set out on the Remediation Statement.

URS Corporation were not present during the remediation works described in section 1.2.1 and the information contained herein is as reported to URS by Huntsman Ltd. All other investigatory, sampling and testing works commissioned for validation described in this report were undertaken by URS.

1.2. Project Background

The Rhodia site was determined by Copeland Borough Council as statutory "Contaminated Land" under Part IIA of the Environmental Protection Act 1990. The entire site was subsequently designated a "Special Site" and is now regulated by the Environment Agency.

URS has undertaken a variety of investigations on the site dating back to 1995. During this period, Rhodia's operations have diminished; the phosphate business has been closed down and over recent years the remaining production operations have ceased. Decommissioning of above ground structures relating to former Rhodia operations is now complete.

URS understands that the site is proposed for future use as a public open space. This report does not include any assessment of other actions to accommodate this anticipated future change of use, and is limited to validating the remediated Sub Z area in respect of impacts on controlled waters only. The controlled water body identified as a potential receptor is Sandwith Beck, located approximately 200m to the south east of the Sub Z area (Figure 1).

1.2.1. Site Investigation Area - Sub Z Transformers

The site layout and the Sub Z area boundary are presented in Figure 2. The Sub Z investigation area is approximately rectangular in shape and lies in the southwest corner of the Rhodia site within the Plot C site investigation area. Historically the Sub Z area contained only the electrical substation whose function was to supply the electricity for the Albright and Wilson and later the Rhodia plant. It is understood that there may have been earthworks involved with the levelling and preparation of the Sub Z area for this purpose.

Previous investigations within the area defined as Plot C[2] at the Whitehaven site confirmed no potentially significant pollutant linkages from detectable concentrations of potential contaminants identified in samples collected from the area of the Sub-Z transformers. However, it is understood by URS that the former Sub Z transformers were decommissioned and removed by United Utilities in 2007 on behalf of Huntsman Limited as part of Huntsman's lease agreement on the Whitehaven site. URS understands that oil spillage occurred within a bunded area during the dismantling and removal of the transformers. The bund floor was understood to comprise a gravel layer, but the construction of the bund is not known.

At the request of the Environment Agency, and as part of their lease agreement, Huntsman Limited undertook remedial works in order to remove the contaminated soil. The spilled oil and the affected soil at the base of the bund were removed by a contactor operating on behalf of United Utilities on Wednesday 26 September 2007 to a point where it was reported there was no further visual evidence of the oil. The maximum depth of the excavation is reported to have been up to 0.5 m bgl, however the exact area of the excavation was not recorded. URS understands that no validation of these remedial works was undertaken. The excavation was subsequently backfilled with gravel and the bund demolished.

1.2.1.1. Sampling Density

The estimated area of the Sub-Z transformer excavation was 30m^2. URS considered it reasonable, based on both technical guidance and professional judgement, that a minimum of 5 samples were required to provide sufficient data in support of future site assessment management decisions. The number of samples to be taken was based on obtaining a sample from each of the four boundaries of the investigation area, and one sample from the centre of the area, giving a total of 5.

It was proposed that vertical and lateral validation of the oil spillage removal be assessed through observations and field measurements during site work and through the collection of samples from a variety of depths. This was in order to assist in the vertical assessment of potential contaminant distribution, and also in the conceptualisation of the sub-surface environment and the significance of potential pollutant migration pathways. URS understood from previous investigations in this area a layer of glacial till had been reworked for the foundations of the transformer platforms and that underlying bedrock is located within 5m of ground surface. The lateral and vertical extent of the validation excavations was proposed to be to a minimum of 0.5m beyond the extent of the remediation excavation. Where the excavations had reached 0.5 m beyond the excavation but not encountered a low permeability horizon these excavations were continued until such a low permeability horizon was reached.

The St Bees Evaporites lie within ''deep'' groundwater below a layer of boulder clay approximately 20m thick (as confirmed by the borehole log for BH201 approximately 30m away from the Sub Z area). This boulder clay is consequently thought to provide a confining layer and a pathway to deep groundwater is considered unlikely; therefore

[2] Remediation Statement Appendix E Plot C Site Investigation: Former Albright and Wilson Facility, Whitehaven, Cumbria. 20 November 2007. 44319943/MARP0002

groundwater from the Sub Z area is likelier to migrate to the Irish Sea via the previously identified controlled waters receptor, Sandwith Beck.

The depth of soil samples was based on both technical guidance and professional judgement given the circumstances encountered during the investigation. It should be noted that more than 5 samples were obtained during the site investigation, with 8 samples taken, of which 7 were analysed.

1.2.1.2. Laboratory Chemical Analysis

Given the purpose of this investigation, which was to validate the extent of the remediation excavation conducted by Huntsman, the primary contaminant of concern was oil associated with the leakage/ spillage from the transformers. This investigation aimed to assess residual impacts on Sandwith Beck. Soil samples were submitted for soil analysis sufficient to undertake a controlled waters risk assessment and provide background information to the underlying soil quality.

2. INVESTIGATORY WORKS UNDERTAKEN BY URS

The following scope of works was performed in order to determine the effectiveness of the remediation works undertaken. An assessment of remaining risks to controlled waters was undertaken.

2.1. Trial Pitting

Field works were undertaken on 19 October 2007. Before excavation, at each location the presence of underground services was assessed using a Cable Avoidance Tool (CAT). Six trial pits (TP1 – TP6) were excavated with a backhoe excavator to either 0.5m beyond the extent of the remediation excavation undertaken on behalf of United Utilities or to a low permeability horizon. This was to a maximum depth of 1.5 m below ground level (bgl), each with an approximate area of 1m x 3.5m. Two further trial pits (TP7 and TP8) were excavated on 2 June 2008 to a maximum depth of 1.7m, thereby confirming the maximum depth of a low permeability horizon (0.7m at TP8).

On completion of inspection and sampling the trial pits were backfilled with arisings in the reverse order to their excavation, then informally compacted using the bucket and tracks of the excavator.

2.2. Soil Inspection and Sampling

The URS field engineer logged the geological sequence observed as the excavation progressed. To assess the potential for residual contamination, soil samples were taken at regular intervals (typically every 0.25m) for visual inspection and field screening by headspace analysis. Additional samples were taken for headspace analysis in the event that there was visual or olfactory evidence of contamination within the trial pit arisings, or where there were pertinent changes in the soil profile. These samples were screened using a photo-ionization detector (PID meter) fitted with a 10.6 eV bulb to assess the potential for chemical impact from volatile hydrocarbons.

In the October 2007 investigation, soil samples were selected for a suite of laboratory chemical analyses[3] at approximately 0.5m below ground level and from the base of the trial pits (12 samples in total). No sample was recovered from TP5A, which was abandoned at 0.3mbgl on encountering a buried concrete hardstand. As indicated in Table 3.2, slight foam was observed on the groundwater in TP2 but the samples did not display any visual or olfactory indication of contamination. As more than 5 samples were already available, the samples from TP2 were not analysed.

In the June 2008 investigation, samples were collected from the base of the made ground (maximum depth of 0.7m) and scheduled for analysis for total TPH and PCBs. The purpose of this sampling strategy was to collect representative samples from the base of the remediation excavation undertaken by United Utilities and from soils directly above the first low permeability horizon below the remediation excavation.

[3] PCBs and TPH – CWG.

Samples were placed directly into containers supplied by the laboratory and dispatched under chain of custody conditions to the URS-approved laboratory (Alcontrol Geochem, Chester). Data returned from laboratory chemical testing are presented in the Tables section at the end of this report.

3. FIELD OBSERVATIONS AND GROUND CONDITIONS ENCOUNTERED

3.1. Introduction

This section reviews the soil conditions observed during the fieldwork and also summarises the field evidence of impact identified as a result of visual/olfactory observations and/or the results of field screening.

3.2. Soil Conditions

The ground conditions underlying the Sub Z area are derived from the inspection of the arisings resulting from excavations advanced during the investigation. A summary of the ground conditions encountered is provided in Table 3.1 below.

Trial pit logs are presented in Appendix B, and the location of each trial pit is detailed on Figure 2.

Table 3.1 – Summary of Typical Geological Profile Encountered

Unit	Description	Depth Encountered- Top of Stratum (m bgl)	Maximum Thickness (m)
Made Ground	Angular, grey/purple medium to coarse limestone gravel.	0 – 0.2	0.2
	Brown/red sandy clayey gravel. Gravel is medium to coarse of limestone. Varying amounts of building rubble and ash.	0.2 – 1	1
	Stiff, brown, clay with occasional rounded to sub rounded fine gravel and rare cobbles.	0.3-0.7	0.4
Natural Ground	Very stiff, reddish brown, clay with occasional rounded fine to medium gravel and very weak weathered mudstone.	0.4 (In the south-eastern area of Sub Z)	Not Proven

The geological sequence observed is summarised below.

3.2.1. Made Ground

The maximum thickness of Made Ground was not proven due to the shallow target depth (of 1.5m bgl) at each location.

Outside the extent of the remediation excavation the surface layer comprised topsoil with rootlets, where remediation had taken place the surface comprised the coarse gravel of the fill materials. Beneath the surface layer the Made Ground typically comprised the following:

1. Within the remediation excavation: typically grey/purple medium to coarse limestone gravel.

2. Outside and beneath the remediation excavation (Made Ground): typically brown/red sandy clayey gravel. Gravel is medium to coarse of limestone. Varying amounts of building rubble.

3.2.2. Natural Ground

Natural Ground was found to comprise very stiff, reddish brown, clay with occasional rounded fine to medium gravel and very weak weathered mudstone. The thickness of this stratum was not proved due to the shallow target depth (of 1.5m bgl) at each location.

3.3. Groundwater Conditions

Groundwater strikes were observed in TP2 (0.35m bgl), TP3 (0.4m bgl), TP4 (0.35m bgl), TP7 (0.4m) and TP8 (0.7m). Water in trial pits TP3 and TP4 were observed to have an oily sheen.

3.4. Field Observations of Contamination

Field observations (visual and olfactory evidence) and Photo Ionisation Detector (PID) readings were recorded to provide information on the location and nature of potential contamination. This evidence is presented below in Table 3.2, which summarises areas of potential contamination:

Table 3.2 Field Observations of Contamination

Location	Made Ground
TP1	Slight HC odour
TP2	Foam on groundwater
TP3	Oily Sheen on Groundwater
TP4	Oily Sheen on Groundwater
TP5A	HC odour
TP5B	NVO
TP6	NVO
TP7	NVO
TP8	NVO

HC (hydrocarbon); NVO (no visual or olfactory evidence of contamination).

PID (photo ionisation detector) readings taken every 0.25m were typically at 0.0ppm, the highest reading was 1.5ppm at 0.75m in TP6.

4. CONCEPTUAL SITE MODEL

Details of the conceptual site model (CSM) for the area around Sub Z, known as Plot C, can be found in the URS report[4] for Plot C. However, due to the circumstances that only concern Sub Z, namely the possible, previously unidentified, operational leaks and spillages of transformer fluid and the formerly recognized spillage, it is necessary to consider an alternative conceptual model to Plot C. A conceptual drawing is therefore presented as Figure 3, showing representative conditions of Sub Z conditions before and after remediation.

4.1. Potential Current and Historical Sources of Contamination

Based on observations during the validation investigation these are considered to be the transformers that used to exist in the area and thus spillages, leaks and releases to ground of transformer oil containing TPH and PCBs. A conceptualised section of the Sub Z area prior to, and following remediation is presented as Figure 3.

4.2. Potential Pathways

The previous CSM developed for Plot C considers there to be two main hydrogeological regimes on site. In the area of the Site containing Sub Z, west of the fault, the dominant pathway is considered to be within the “shallow” groundwater which lies in the made ground and drift. Shallow groundwater flow is thought to be controlled by the topography, and follow a shallow valley running approximately along the middle of the site towards the Sandwith Beck. Given that the Sub Z remediation investigation is underlain by reworked clays, which are considered to be of low permeability, the migration of contaminated waters through these horizons to shallow groundwater is considered unlikely. However this very conservative pathway has been considered in the assessment.

The ‘’deep’’ groundwater within which the St Bees Evaporites lies is below a layer of boulder clay approximately 20m thick (as confirmed by the borehole log for BH201 approximately 30m away from the Sub Z area). This boulder clay is consequently thought to provide a confining layer and therefore it is considered unlikely that there is a pathway to deep groundwater and that groundwater from the Sub Z area will migrate to the previously identified controlled waters receptors which is the Irish Sea. For the avoidance of doubt, this is conceptually represented by the post-remediation condition shown in Figure 3.

[4] Remediation Statement Appendix E Plot C Site Investigation: Former Albright and Wilson Facility, Whitehaven, Cumbria. 20 November 2007. 44319943/MARP0002

4.3. Potential Receptors

Based on the environmental site setting and previous conceptual site models developed in the Plot C report, URS considers the following to be the receptors most likely to be at risk from potential contamination within the Sub Z area:

- ***Shallow groundwater and subsequently Sandwith Beck***. The likely receptor requiring further assessment is Sandwith Beck. This is a small stream that runs from the southern edge of the site south through Sandwith village, reaching the Irish Sea a few kilometres to the south. The location of Sandwith Beck in relation to the Sub Z area is presented in Figure 1.

5. QUANTITATIVE RISK ASSESSMENT

5.1. Introduction

In order to assess whether the observed contaminant levels in the soil and groundwater pose a theoretical risk to Sandwith Beck, a detailed risk assessment has been completed.

As the geological conditions at Sub Z were found to be very similar to the rest of Plot C, the same site-specific assessment criteria for controlled waters[6] were considered to be applicable for the purposes of these risk assessments.

5.2. Controlled Waters Risk Assessment

A controlled waters risk assessment was undertaken to assess the significance of the identified potential pollutant linkage between the TPH and PCB contamination at Sub Z and Sandwith Beck. A Stage 2 assessment identified exceedences of generic assessment criteria for TPH (EC> 12-16) aromatic, TPH (EC> 16-21) aromatic and TPH (EC>21-35) aromatic for soil, with maximum concentrations of 6 mg/kg (TP1 at 0.5m bgl), 110 mg/kg (TP6 at 1.2m bgl) and 400 mg/kg (TP4 at 1.2m bgl) respectively. Exceedances were also noted for TPH (EC> 12-16) aliphatic, TPH (EC> 16-21) aliphatic and TPH (EC>21-35) aliphatic for groundwater at 26 µg/l (TP3), 270 µg/l (TP4) and 270 µg/l (TP4) respectively.

A site specific Stage 3 assessment was carried out using CONSIM[7], an analytical tool which has been thoroughly bench-marked by the Environment Agency and is considered suitable for Stage 3 assessments. Full details of the controlled waters risk assessment are included in Appendix A of this report.

The results of this modelling indicated that the concentrations of contaminants in the Sub–Z soils do not represent a significant risk to Sandwith Beck.

[6] Remediation Statement Appendix E Plot C Site Investigation: Former Albright and Wilson Facility, Whitehaven, Cumbria. 20 November 2007. 44319943/MARP0002

[7] CONSIM version 2.02 (2003), Golder Associates and Environment Agency

6. VALIDATION SUMMARY

6.1. Summary of validation investigations

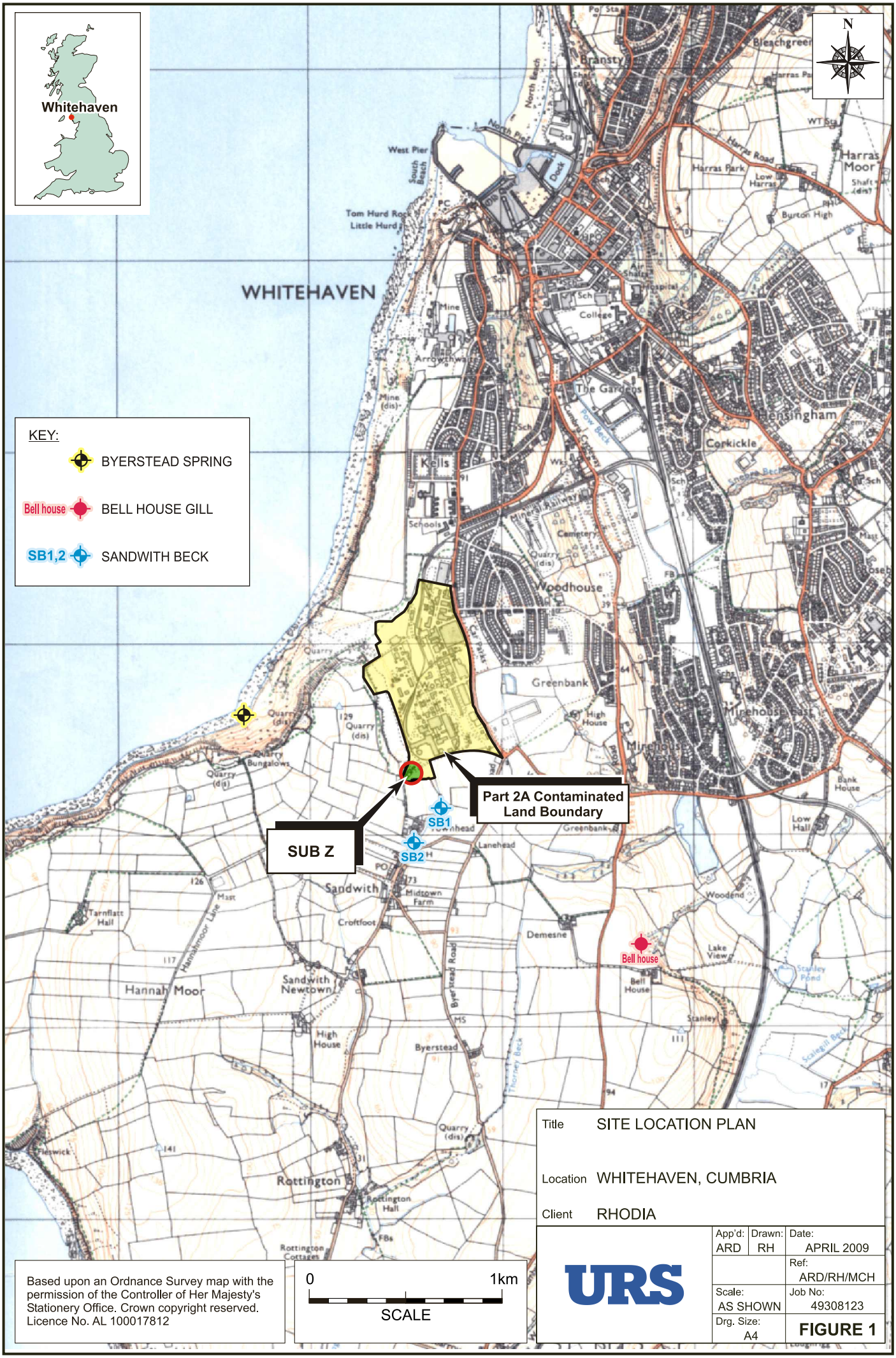
Potential contamination sources were considered to be spillages, leaks and releases to ground of transformer oil from the transformers that used to exist in the Sub Z area. A total of eight trial pits were excavated in a grid pattern in the approximate 30m^2 area of concern. Soil and water samples were obtained for chemical testing.

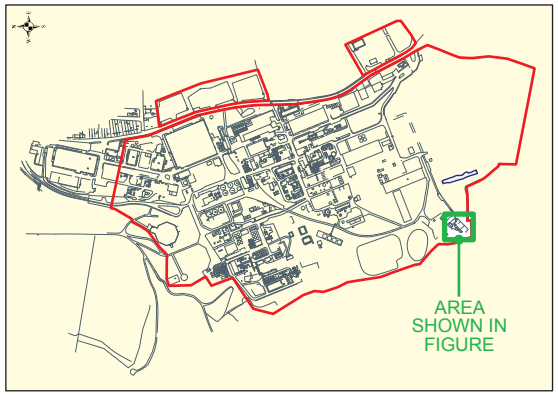
6.2. Summary of validation assessments

A detailed risk assessment was undertaken to evaluate post-remediation impacts on Sandwith Beck, the controlled water body identified as the receptor. This was undertaken as a site-specific Stage 3 assessment using CONSIM.

The risk assessment confirms that contaminant concentrations in the Sub–Z soils do not represent a significant risk to Sandwith Beck, concluding that the remedial actions previously undertaken were successful.

Figures


Whitehaven
N
WHITEHAVEN
KEY:
BYERSTEAD SPRING
Bell house
BELL HOUSE GILL
SB1,2
SANDWITH BECK
Part 2A Contaminated Land Boundary
SUB Z
SB1
SB2
Bell house
Based upon an Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office. Crown copyright reserved. Licence No. AL 100017812
0
1km
SCALE
Title SITE LOCATION PLAN
Location WHITEHAVEN, CUMBRIA
Client RHODIA
URS
App'd: ARD
Drawn: RH
Date: APRIL 2009
Ref: ARD/RH/MCH
Scale: AS SHOWN
Job No: 49308123
Drg. Size: A4
FIGURE 1



KEY:

- BOUNDARY OF SUB Z REMEDIATION AREA
- ENTIRE SITE BOUNDARY
- AREA OF CONCRETE HARDSTANDING
- TRIAL PIT LOCATIONS

Title TRIAL PIT LOCATIONS

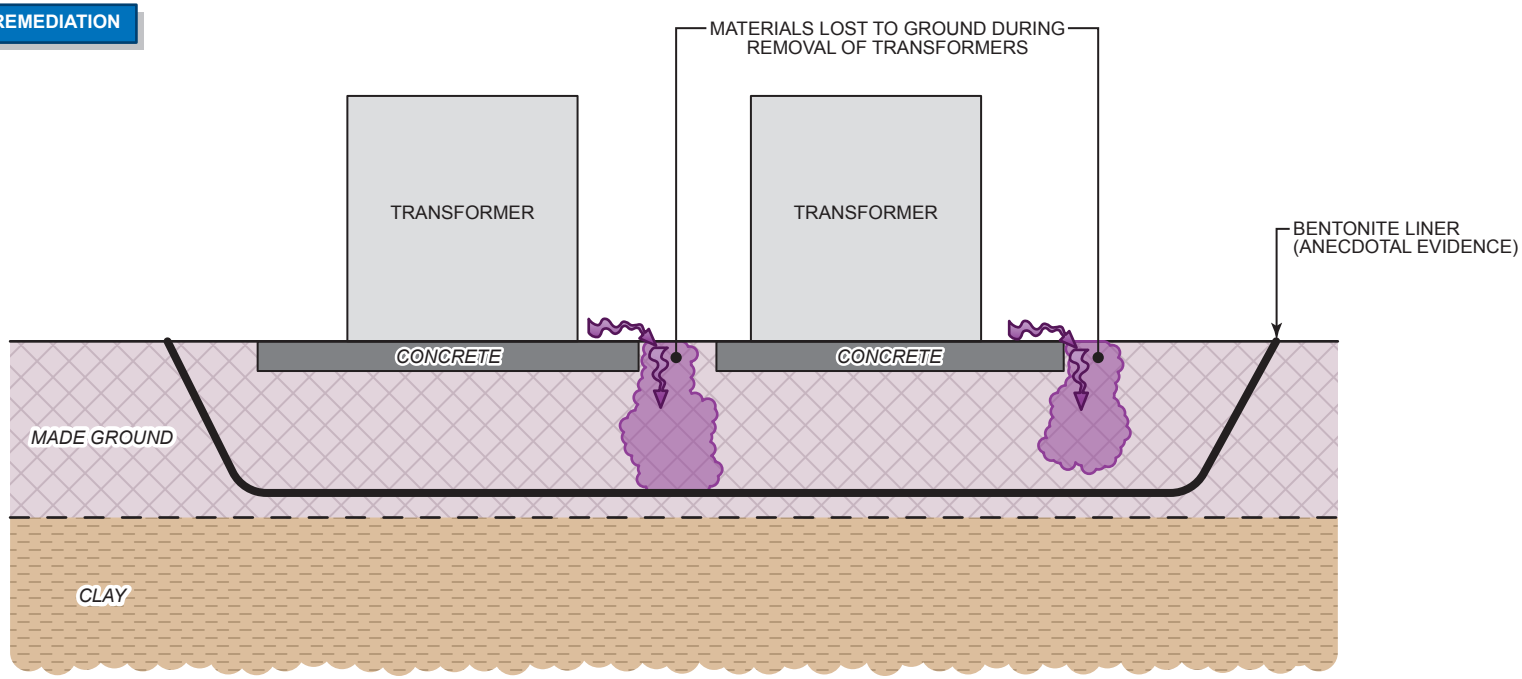
Location WHITEHAVEN - SUB Z

Client RHODIA

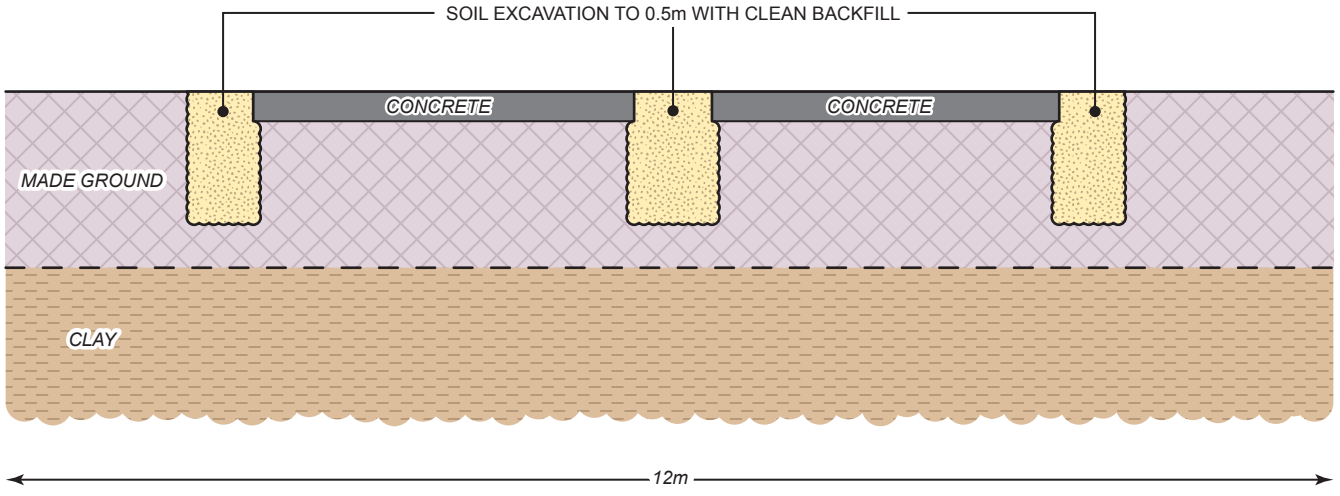
URS

App'd:	Drawn:	Date:
ARD	SQ	DEC 2008
		Ref: ARD/SQ/MCH
Scale: NTS		Job No: 49308123
Drg. Size: A4		**FIGURE 2**

PRE REMEDIATION



POST REMEDIATION



Title	PRE REMEDIATION/POST REMEDIATION CONDITIONS
Location	WHITEHAVEN - SUB Z
Client	RHODIA

URS

App'd:	Drawn:	Date:
ARD	SQ	DEC 2008
		Ref: ARD/SQ/MCH
Scale: NTS		Job No: 49308123
Drg. Size: A4		**FIGURE 3**

Tables

Table 1
Analytical Shedule

Date	Trial Pit	Soil		Grab Sample - Groundwater	
		TPH-CWG	PCBs	TPH-CWG	
Oct-07	TP1	2	1	-	
	TP2	-	-	-	* samples taken but not analyzed
	TP3	2	1	1	
	TP4	2	1	1	
	TP5A	-	-	-	* TP abandoned at 0.3mbgl; no samples taken
	TP5B	2	1	-	
	TP6	2	1	-	
Jun-08	TP7	1	1	-	
	TP8	1	1	-	

TPH CWG: TPH Criteria Working Group
PCB: polychlorinated biphenyl
" - " = not analyzed

Table 2
Soil TPH

Field Identification					TP1	TP1	TP3	TP3	TP4	TP4	TP5B	TP5B	TP6	TP6	TP7	TP8
Sample Depth					0.5	1.2	0.5	0.75	0.5	1	0.5	1	0.5	0.75	0.4	0.7
Date					19-Oct-07	19-Oct-07	19-Oct-07	19-Oct-07	19-Oct-07	19-Oct-07	19-Oct-07	19-Oct-07	19-Oct-07	19-Oct-07	02-Jun-08	02-Jun-08
			SSAC	GAC												
Chemical	Method Detection Limit	Units	Human Health	Controlled Waters												
TPH (>EC6-7) aromatic	0.01	mg/kg	12000	0.06	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
TPH (>EC7-8) aromatic	0.01	mg/kg	12000	0.08	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
TPH (>EC8-10) aromatic	0.01	mg/kg	2400	0.10	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
TPH (>EC10-12) aromatic	0.01	mg/kg	2400	0.15	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
TPH (>EC12-16) aromatic	0.1	mg/kg	2400	0.3	6	5	0.2	1	<mdl	<mdl	1.3	<mdl	4	0.12	-	-
TPH (>EC16-21) aromatic	0.1	mg/kg	1800	1.0	24	110	7	2	<mdl	<mdl	6.0	<mdl	17	4	-	-
TPH (>EC21-35) aromatic	0.1	mg/kg	1800	7.6	110	400	28	14	<mdl	<mdl	38	<mdl	69	21	-	-
Total Aromatics (C6-C35)	0.1	mg/kg	NA	nv	140	510	35	17	<mdl	<mdl	45	<mdl	90	25	-	-
TPH Aliphatics by GC-FID																
TPH (>EC5-6) aliphatic	0.01	mg/kg	299000	0.07	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
TPH (>EC6-8) aliphatic	0.01	mg/kg	299000	0.27	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
TPH (>EC8-10) aliphatic	0.01	mg/kg	5990	2	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
TPH (>EC10-12) aliphatic	0.01	mg/kg	5990	15	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
TPH (>EC12-16) aliphatic	0.1	mg/kg	5990	301	9	53	5	3	3	3	11	4	15	3	-	-
TPH (>EC16-21) aliphatic	0.1	mg/kg	120000	37,861	130	590	62	22	22	19	96	25	230	32	-	-
TPH (EC21-35) aliphatic	0.1	mg/kg	120000	37,861	150	460	57	42	36	24	150	43	270	36	-	-
Total Aliphatics (C5-C35)	0.1	mg/kg	NA	nv	290	1,100	120	67	61	45	250	73	510	70	-	-
TPH-PRO (C4-C12)	0.01	mg/kg	NA	-	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
TPH (C5-C35)	0.1	mg/kg	NA	-	430	1,600	160	84	61	45	300	73	600	96	<mdl	<mdl
BTEXs by GC-FID																
Benzene	0.01	mg/kg	17.40	0.03	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
Ethylbenzene	0.01	mg/kg	NC	0.83	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
Methyl tert butyle ether (MTBE)	0.01	mg/kg	NC	0.002	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
Toluene (Methyl benzene)	0.01	mg/kg	12000	0.04	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
M,P-Xylene	0.01	mg/kg	See Note 1	see note 1	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
O-Xylene	0.01	mg/kg	See Note 1	see note 1	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-
Total Xylene		mg/kg	10,700	0.08	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	<mdl	-	-

NOTES
TP = Trial Pit
" - " = not analyzed
" NA " = no risk anticipated from controlled water SSAC calculations
nv = no value
<mdl = below method detection limit

Note 1: Total Xylene calculated as a total of M,P-Xylene and O-Xylene
Note 2: TP2 sample put on hold as TP6 added to sampling suite

XX	Reported concentration exceeds Stage 2 human health and controlled waters screening criteria
XX	Reported concentration exceeds Stage 2 human health screening criteria
XX	Reported concentration exceeds Stage 2 controlled waters screening criteria

Table 3
Soil PCB

Field Identification					TP1	TP3	TP4	TP5B	TP6	TP7	TP8
Sample Depth					0.5	0.75	1	0.5	0.5	0.4	0.7
Date					19-Oct-07	19-Oct-07	19-Oct-07	19-Oct-07	19-Oct-07	02-Jun-08	02-Jun-08
			SSAC	GAC							
Chemical	Method Detection Limit	Units	Human Health	Controlled Waters							
PCB (TOTAL)	0.02	mg/kg	1.13	0.1	<mdl	<mdl	<mdl	**18**	<mdl	<mdl	<mdl

NOTES
TP = Trial Pit
" - " = not analysed
nv = no value
<mdl = below method detection limit

XX	Reported concentration exceeds Stage 2 human health a<mdl controlled waters screening criteria
XX	Reported concentration exceeds Stage 2 human health screening criteria
XX	Reported concentration exceeds Stage 2 controlled waters screening criteria

Table 4
Groundwater Grab Sample TPH

Field Identification					TP3	TP4
Date					19-Oct-07	19-Oct-07
					Grab sample	Grab sample
Chemical	Method Detection	Units	SSAC Human Health	GAC Controlled Waters		
TPH (>EC6-7) aromatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC7-8) aromatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC8-10) aromatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC10-12) aromatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC12-16) aromatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC16-21) aromatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC21-35) aromatic	10	µg/l	>vap	10	<mdl	<mdl
Total Aromatics (C6-C35)	10	µg/l	NA	NA	<mdl	<mdl
TPH Aliphatics by GC-FID						
TPH (>EC5-6) aliphatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC6-8) aliphatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC8-10) aliphatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC10-12) aliphatic	10	µg/l	>vap	10	<mdl	<mdl
TPH (>EC12-16) aliphatic	10	µg/l	>vap	10	<mdl	26
TPH (>EC16-21) aliphatic	10	µg/l	>vap	10	63	270
TPH (EC21-35) aliphatic	10	µg/l	>vap	10	93	270
Total Aliphatics (C5-C35)	10	µg/l	NA	NA	160	560
TPH-PRO (C4-C12)	10	µg/l	NA	NA	<mdl	<mdl
TPH (C5-C35)	10	µg/l	NA	NA	160	560
BTEXs by GC-FID						
Benzene	10	µg/l	36000.00	10	<mdl	<mdl
Ethylbenzene	10	µg/l	NC	10	<mdl	<mdl
Methyl tert butyle ether (MTBE)	10	µg/l	NC	10	<mdl	<mdl
Toluene (Methyl benzene)	10	µg/l	>vap	10	<mdl	<mdl
M,P-Xylene	10	µg/l	See Note 1	See Note 1	<mdl	<mdl
O-Xylene	10	µg/l	See Note 1	See Note 1	<mdl	<mdl
Total Xylene	10	µg/l	>vap	10	<mdl	<mdl

NOTES
TP = Trial Pit
" - " = not analysed
nv = no value
<mdl = below method detection limit

Note 1: Total Xylene calculated as a total of M,P-Xylene and O-Xylene

XX	Reported concentration exceeds Stage 2 human health and controlled waters screening criteria
XX	Reported concentration exceeds Stage 2 human health screening criteria
XX	Reported concentration exceeds Stage 2 controlled waters screening criteria

Appendix A - Controlled Waters Risk Assessment

APPENDIX A- CONTROLLED WATERS RISK ASSESSMENT, RHODIA SUB Z

1. INTRODUCTION

At the southwestern end of the Rhodia Whitehaven site, a substation (known as "Sub Z") was recently dismantled and removed by a contractor acting on behalf of United Utilities. URS understands that during the removal of this substation, hydrocarbons were accidentally released onto the ground surface and that these subsequently infiltrated into shallow soils surrounding the site of the former substation. At the request of the Environment Agency remedial works were undertaken in order to remove contaminated soil by excavation of visual contamination to a maximum depth of 0.5 m bgl. URS understands arisings from the excavation were removed off site to suitably licensed landfill facilities and the excavation subsequently backfilled with gravel.

URS was commissioned to obtain validation samples from the sidewalls and base of this trench. Soil samples were analysed, and returned elevated concentrations of a number of hydrocarbon fractions and a single Polychlorinated Byphenol (PCB Aroclor-1254). A number of these samples were from below the base of the remedial trench.

In order to understand the potential risk to controlled waters posed by the residual contamination in the vicinity of Sub Z, a quantitative risk assessment was required. The closest identified controlled waters receptor was a surface water stream at the southern end of the site, called Sandwith Beck.

2. METHODOLOGY

The Controlled Waters Quantitative Risk Assessment (CW QRA) is based upon the UK Department of the Environment, Food and Rural Affairs (DEFRA) and Environment Agency (EA) "best practice" in regard to the assessment of contaminated land. More specifically, this approach follows the "*Source - Pathway - Receptor*" methodology as defined in Part IIa of the Environmental Protection Act (1990) [as inserted by Section 57 of the Environment Act (1995)] and detailed in the following UK Environment Agency's published guidance:

- Environment Agency R&D Publication 20 (1999) *Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Water Resources* (referred to as R&D P-20);
- Environment Agency R&D Publication CLR11 (2004) *Model Procedures for the Management of Land Contamination* (referred to as CLR11).

The approach involves the identification of sources, pathways and receptors as derived from the conceptual understanding of the site and the surrounding environment's geology, hydrogeology, observed contamination (and its distribution), and potential receptors. From this conceptual understanding, potential pollutant linkages (*source-pathway-receptor* relationships) are identified whose significance is evaluation using a tiered risk-based approach, in accordance with the Environment Agency's "Integrated Methodology".

Several models have previously been generated for the site to assess the potential risks to controlled waters posed by analytes found within the shallow strata. One such model was applicable for this assessment, and was adopted accordingly. The model used was the CONSIM assessment from the Plot C investigation; Sub Z is situated immediately to the west of Plot C, it is underlain by a similar geological profile, and has the same controlled waters receptor (Sandwith Beck). The methodology for the CONSIM assessment is presented in the Plot C Report[1].

3. CONCEPTUAL MODEL

3.1. Sources

For the purposes of this risk assessment, given that only a targeted number of analytes were scheduled for analysis (7 analytes in total), the most elevated concentrations of each of the analytes was entered into the model. The following table presents the analytes, and associated concentrations.

Compound	Maximum recorded soil concentration (mg/kg)
PCB Aroclor-1254	18
TPH (>EC12-16) aromatic	5.5
TPH (>EC16-21) aromatic	110
TPH (>EC21-35) aromatic	400
TPH (>EC12-16) aliphatic	53
TPH (>EC16-21) aliphatic	590
TPH (>EC21-35) aliphatic	460

3.2. Potential Pathways

The geological and hydrogeological conditions encountered during this site investigation, and the Plot C investigation (along with an understanding of the geological profile across the entire Whitehaven site), have been utilised to formulate the conceptual site model. These findings have been summarised below.

Made Ground:

- Remnant concrete plinths are visible at the ground surface within the Sub Z area.
- Surrounding the concrete plinths is grey purple medium gravel, thought to be the material backfilled into the trench following the removal of the contaminated soils. The thickness of the gravel backfill varies from 0.1m to 0.5m. Concrete was also found to be underlying some of the gravel backfill in the central area of Sub Z.

[1] Remediation Statement Appendix E Plot C Site Investigation. Former Albright and Wilson Facility, Whitehaven, Cumbria.20 November 2007Final Issue. Issue No 244319943/MARP0002

- Underlying the gravel backfill is black brown sandy reworked silt, brick and concrete fragments.
- Water ingress was noted in four of the seven trial pits, at approximately 0.35-0.45m depth.

Unconsolidated Drift Deposits (based on Plot C Investigation Results):

- Boulder clay/till – red-brown generally firm to stiff (occasionally soft) clay with varying amounts of inter-bedded silt and occasional fine to medium sand horizons. The silt or fine sand lenses that were present were typically less than 0.3m thick. The boulder clay was present to up to approximately 8.0m in Plot C. A discontinuous groundwater table was encountered in the locations investigated as part of the Plot C investigation. Groundwater, where present, was associated with silt and sand lenses within the boulder clay. Measured groundwater elevations and interpreted discontinuous groundwater contours are presented as Figure 2 of the Plot C report. In areas within Plot C where some form of groundwater body was encountered, a generally convergent groundwater flow towards Sandwith Beck was inferred.
- A single deep borehole was drilled by URS in 2003 (REF: Further Soil and Groundwater Investigation, 44557-033, dated 8th August 2003) that is approximately 30m to the north east of Sub Z. This was logged as drift deposits (very silty clay) to at least 21m, which was typically dry throughout with no continuous groundwater encountered until 49mbgl.

Consolidated Deposits:

- URS did not encounter bedrock was not encountered during either the Sub Z or Plot C investigations. However, the borehole log for BH201 determined St.Bees Shale at 34mbgl (with weathered shale horizons between 21mbgl and 34mbgl). BH201 is screened within this shale unit, and measured rest-water levels are approximately 49mbgl (35mAOD).

3.3. Controlled Waters Receptors

The likely receptor requiring further assessment is Sandwith Beck. This is a small stream that runs from the southern edge of the site south through Sandwith village, reaching the sea a few kilometres to the south. The conceptual model is presented in Figure 1 below.

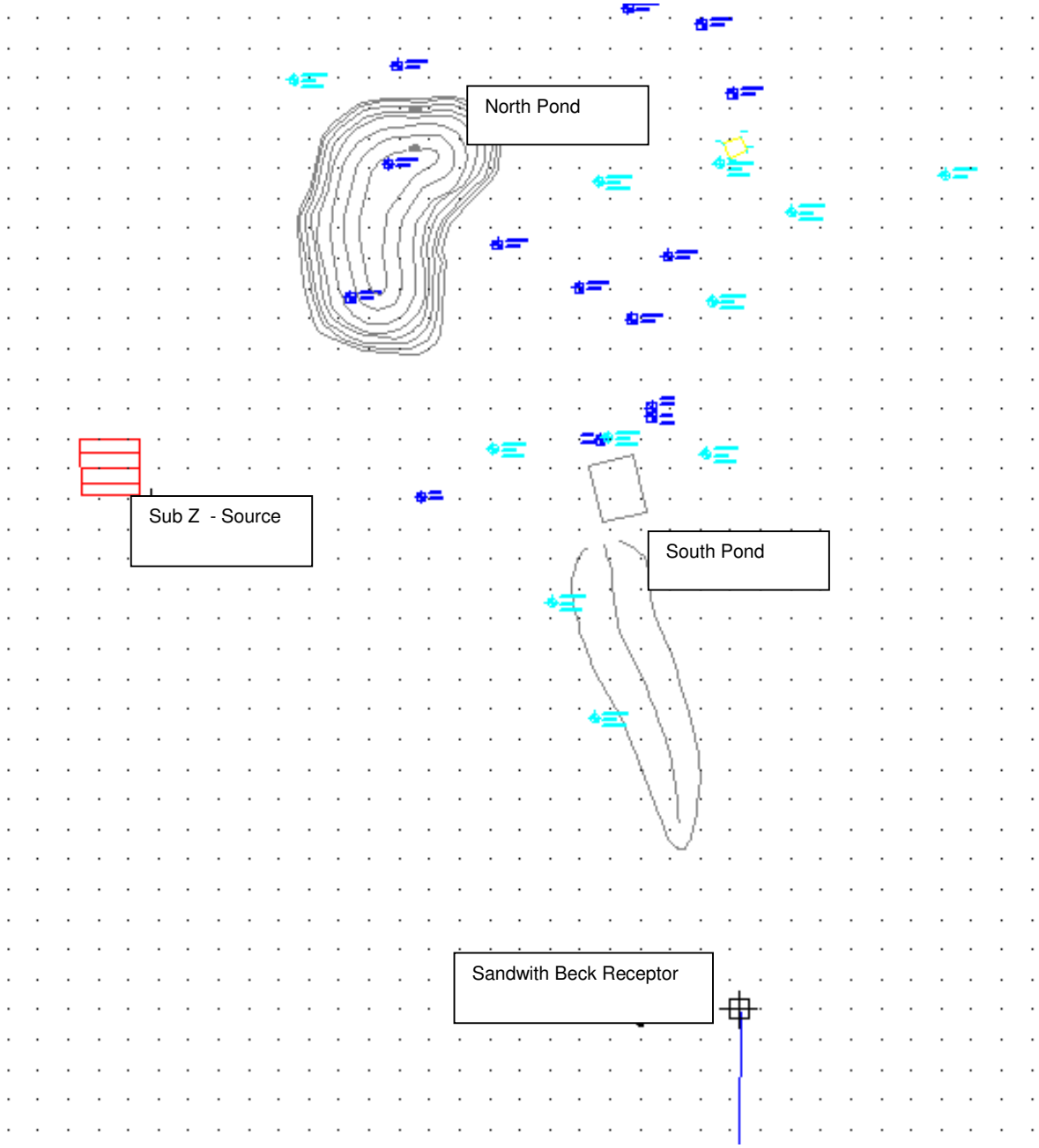


Figure 1- Conceptual Model created in CONSIM

4. MODEL INPUTS SUMMARY

The model parameters (including contaminant physio-chemical parameters such as the partition coefficients) are presented in Tables 5, 6, and 7 at the end of this report. Justification for a number of the model inputs relating to the conceptual model is presented below.

Source Area

The source area was conservatively assumed to be the size of investigation area, which was approximately 20 meters long by 20 meters wide. This is larger than the footprint of Sub Z and reflects the potential for some migration of contamination within shallow soils.

Underlying the backfilled gravel horizons (which extend to up to 0.5mbgl), it has been conservatively assumed that residual contamination extends for 1m (0.5-1.5mbgl), justification for this is provided in Table 5C.

It has been assumed that a saturated silt horizon directly underlies the source area (again conservative, but considered necessary in the absence of deep trial pit or borehole log), and consequently, that no unsaturated zone is present between the source and the groundwater within the silt horizon.

Pathways

The viable pathway applicable to this source involves the leaching of soil contamination downwards into the shallow water table, followed by mixing in shallow groundwater and subsequent *horizontal* migration of shallow groundwater within the silt horizon, which has been conservatively assumed to extend to the receptor.

Receptor

The single receptor modelled in the assessment is the closest surface water to the site, Sandwith Beck, located 250m to the south east of Sub Z. Vertical migration is considered unlikely given the substantial thickness of likely to be in this area of the site.

5. MODEL RESULTS- RISKS FROM SOIL CONTAMINATION TO SANDWITH BECK

The model results are presented in Table 8. Based on the data obtained from the Sub Z site investigation, no risks to Sandwith Beck were simulated for TPH fractions or PCB (aroclor 1254) at the 50^{th} or 95^{th} percentile confidence limit.

6. LIMITATIONS OF CONTROLLED WATERS QUANTITATIVE RISK ASSESSMENT

The risk assessment conclusions are based on the risks to Controlled Waters, under the requirements of Part 2A (ENVIRONMENTAL PROTECTION ACT 1990, SECTION 78H(7)).

The additional assessment, that evaluated risks to human health, assumed a future "right to roam" end use without any continued industrial operations and no significant changes to the site layout, or off-site changes. As such, if such changes occur it will be necessary to reassess the risk assessment results and conclusions; a change of use of the site will be regulated by Planning Legislation.

It is acknowledged that there are uncertainties inherent in all risk assessment methodologies, particularly in relation to the assignment of assumed values for difficult to measure site specific variables, such as infiltration rate. However, a reasonable body of research exists such that these variables can be estimated with reasonable accuracy, and in a manner that is known to be conservative. It is therefore likely that risks are, if anything, overestimated, as a result of these assumptions (constant source terms, use of 95th percentile concentrations), and so the results of the Controlled Waters risk assessment should be viewed in this context.

The assessment can only be undertaken on the data set available from site investigations, thus it is possible that higher concentrations of ground contaminants than observed during the recent site assessment works may exist.

Assessment of Uncertainty

A degree of uncertainty is associated with the adopted parameters characterising the various geological strata encountered at the site that make up the source and pathways. As such, a probabilistic 'Monte Carlo' assessment has been adopted encompassing distributions in the likely range in parameters that could be considered appropriate for the strata encountered at the site. In addition, the undertaking of probabilistic modelling and simulating concentrations at the 50th & 95th percentile level of confidence presents an assessment of the effects of the variability in parameters, be they poorly or well understood. Simulated 50th and 95th percentile concentrations can be interpreted as follows:

- Simulated concentrations at the 50th percentile confidence limit represent 'on the balance of probabilities' the most likely simulated concentrations given the range of parameters applied.
- Simulated concentrations at the 95th percentile confidence limit represent a worse case or extreme condition, resulting from a worse case combination of parameters (e.g. high permeability, high source concentrations, low degradation rate etc).

The simulation of 95th percentile concentrations already takes into account a worse case scenario resulting from the combination of worse case parameters such as high permeability etc. In addition, calibration exercises typically result in the predicted concentrations at the 50th percentile confidence level matching observed data (*Pers. Comm*. Hugh Potter of Environment Agency, Groundwater Modelling Seminar, Birmingham, 8 May 2006).

7. REFERENCES

CLR-7 (2002) Assessment of Risks to Human Health from Land Contamination: An overview of the Development of Soil Guideline Values and Related Research. Department for the Environment, Food and Rural Affairs (DEFRA) and Environment Agency (EA), Appendix A.

CLR-11 (2004) Model Procedures for the Management of Land Contamination" (Environment Agency, 2004).

Environment Agency (1999) Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Water Resources. Authors Marsland, P.A. and Carey, M.A. Environment Agency R&D Publication 20, 89pp.

Tables

Tables 5a-5c
Source Zone Concentrations for Chemicals of Potential Concern (CoPC) and Source Zone Dimensions

TABLE 5a - SOURCE CONCENTRATIONS					
MODELLED RECEPTOR	**Compound**	**Media**	**Measured Concentration in Soil (mg/kg)**	**Distribution used in model**	**Comments**
Sandwith Beck	PCB Aroclor-1254	Soil	18	single	Maximum measured concentrations in soil were input directly into the model.
	TPH (>EC12-16) aromatic		5.5		
	TPH (>EC16-21) aromatic		110		
	TPH (>EC21-35) aromatic		400		
	TPH (>EC12-16) aliphatic		53		
	TPH (>EC16-21) aliphatic		590		
	TPH (>EC21-35) aliphatic		460		

TABLE 1b - SOURCE AREA					
MODELLED RECEPTOR	**Compound**	**Length of source area (m)**	**Width of source area (m)**	**Distribution used in model**	**Comments**
Sandwith Beck	PCB Aroclor-1254	20	20	single	A conservative assumption was included in the model, that each of the measured analytes was at the measured concentration across the entire source area (I.e the entire footprint of Sub Z was considered to be the source area). The defined source area was 20meters long by 20meters wide (giving a 400m^2 source area).
	TPH (>EC12-16) aromatic				
	TPH (>EC16-21) aromatic				
	TPH (>EC21-35) aromatic				
	TPH (>EC12-16) aliphatic				
	TPH (>EC16-21) aliphatic				
	TPH (>EC21-35) aliphatic				

TABLE 1C - SOURCE THICKNESS				
MODELLED RECEPTOR	**Compound**	**Thickness of source area (m)**	**Distribution used in model**	**Comments**
Sandwith Beck	PCB Aroclor-1254	1	single	Remediation of the uppermost 0.5m removed what was expected to be the most impacted area of contamination (given the source infiltrated from the surface). At each location, soil samples were taken at the base of the remediation zone (between 0.1m and 0.5mbgl) and also from the deeper strata (to a maximum depth of 1.2mbgl). In three of the four deep samples, limited detections of TPH were recorded, with the one remaining deep sample (TP1 at 1.2mbgl) returning a relatively elevated concentration of 510mg/kg (Total TPH). It was conservatively assumed in the model that contamination extended to 1.5mbgl, and was therefore 1 meter thick. Only one sample for PCB was taken, so it was conservatively assumed that this analyte was also present between 0.5 and 1.5mbgl. URS understands that the spillage occured in August 2007 and was remediated in September 2007, and so it was considered conservative to assume the contamination had infiltrated through one meter of strata, especially as the Plot C investigation found this strata was generally found to be dry and of low permeability.
	TPH (>EC12-16) aromatic			
	TPH (>EC16-21) aromatic			
	TPH (>EC21-35) aromatic			
	TPH (>EC12-16) aliphatic			
	TPH (>EC16-21) aliphatic			
	TPH (>EC21-35) aliphatic			

Table 6a-b
Aquifer and Pathway Characteristics

Table 6a: Soil and groundwater pathway model parameters						
Parameters		**Parameter Value**			**Distribution Used**	**Comment**
		Most Likely	**Min**	**Max**		
Aquifer Characteristics	Hydraulic conductivity (m/s)	2.00E-05	-	-	Single	Conservatively assumed that a continuous horizon of silt exists between the source and the receptor. Furthermore, the highest hydraulic conductivity for the range for silt in the CONSIM manual has been adopted (this will generate the worst case scenario as it will transport the analyte to the receptor in the shortest time)
	Hydraulic gradient	0.014286	-	-	Single	Based on hydraulic gradient calculation used in the Plot C model.
	Effective porosity (fraction)	-	0.05	0.25	Uniform	Adopted range of porosities for silt and more granular zones of Glacial Boulder Clay. Within range of parameters defined in CONSIM manual.
	Aquifer Bulk Density (g/cm^3)	-	1.7	2.45	Uniform	Adopted range for weathered and unweathered Glacial Till from CONSIM manual.
	Groundwater flow direction (degrees)	135	-	-	Single	Interpreted from the on-site groundwater contour plot for Plot C which suggests a convergent flow towards Sandwith Beck
	Saturated Aquifer Thickness (m)	2	-	-	Single	A silt horizon has been conservatively assumed to be present, with a thickness of 2 meters. The closest borehole log to sub Z is BH201 (approximately 30m to the north east). This was logged as containing drift deposits (very silty clay) to at least 21m depth in this area, with no continuous groundwater encountered until 49mbgl. Therefore it is conservative to assume that a silt horizon of 2 meters in thickness is present beneath Sub Z (at a depth of 1.5m to 3.5m below ground level), that is saturated, and extends to the receptor 250m away.
Active Processes	Retarded Travel in UZ	NO			It is considered likely that retardation will occur in the aquifer, however it has been assumed no unsaturated zone is present and that the source area extends to the water table.	
	Retarded Travel in Aquifer	YES				
	Biodegredation in UZ	NO			It is considered likely that biodegradation will occur, however it has been assumed no unsaturated zone is present and that the source area extends to the water table.	
	Blodegredation in Aquifer	YES				

Table 2b: Soil and groundwater pathway model parameters					
Parameters		**Distance to Receptor (m)***	**Longitudinal Dispersivity (m)****	**Lateral Dispersivity (m)*****	**Comment**
Pathway to Sandwith Beck	PCB Aroclor-1254	*250*	*25*	*8.3*	*Distance to receptor (m): This is the distance from the closest point of the source area to the receptor **Longitudinal Dispersivity (m): Assumed 1/10th travel distance to receptor (this is the minimum distance between closest part of contaminant source and identified receptor) as defined in ConSim manual. This is different for each individual contaminant. ***Lateral Dispersivity (m):Assumed 1/3rd longitudinal dispersivity: defined in ConSim manual. 1/3 of each individual compounds longitudinal dispersivity.
	TPH (>EC12-16) aromatic				
	TPH (>EC16-21) aromatic				
	TPH (>EC21-35) aromatic				
	TPH (>EC12-16) aliphatic				
	TPH (>EC16-21) aliphatic				
	TPH (>EC21-35) aliphatic				

Table 7
Physical-Chemical and Half Life Parameters

Analytical Suite	Contaminant	Partition Coefficient, K_{oc} or K_d (ml/g)	Ref.	Maximum Solubility (mg/l)	Ref.	Henry's Law Constant, H (unitless)	Ref.	Half-life (years)			
								Most Likely	Minimum	Maximum	Ref.
PCB	PCB Aroclor-1254	2.75E+05	a	0.01-0.3	a	0.0081-0.105	a	1000	-	-	c
TPH	TPH (>EC12-16) aromatic	5.01E+03	b	5.80E+00	b	5.30E-02	b	19.0	9.5	28.5	c
	TPH (>EC16-21) aromatic	1.58E+04	b	6.50E-01	b	1.30E-02	b	38.1	19.0	57.1	c
	TPH (>EC21-35) aromatic	1.26E+05	b	6.60E-04	b	6.70E-04	b	75.0	37.5	112.5	c
	TPH (>EC12-16) aliphatic	5.01E+06	b	7.60E-04	b	5.20E+02	b	1.9	1.0	2.8	c
	TPH (>EC16-21) aliphatic	6.31E+08	b	2.50E-06	b	4.90E+03	b	3.8	1.9	5.7	c
	TPH (>EC21-35) aliphatic	7.59E+09	b	8.91E-08	b	2.00E+04	b	19.0	9.5	28.5	c

Literature Sources:

a Mackay, D.,Wan-Ying, S., Kuo-Ching, M. 1997. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. CRC Press LLC, Florida.

b TPH Criteria Working Group, Fate and Transport Technical Action Group. 1997. Selection of Representative TPH Fractions Based on Fate and Transport Considerations.

c URS derived conservative degradtion rates (References below)

References:

Environment Agency (2002) The effects of Contaminant Concentration on the Potential for Natural Attenuation. (Authored by Noble, P. & Morgan, P.) Environment Agency R&D Technical Report P2-228/TR, Environment Agency, Bristol.

Aronson, D., & Howard, P.H. (1997) Anaerobic Biodegradation of Organic Chemicals in Groundwater: A Summary of Field and Laboratory Studies, Final Report. Prepared for the American Petroleum Institute, Chemical Manufacturer's Association, National Council of the Paper Industry for Air and Stream Improvement, Edison Electric Institute, American Forest and Paper Association, Washington DC, USA.

Howard, P.H., Boethling, R.S. , Jarvis, W.F., Meylan, W.M. & Michalenko, E.M. (1991) Handbook of Environmental Degradation Rates. Lewis Publishers Inc., Chelsea, MI, USA.

Wild, S.R., Waterhouse, K.S., McGrath, S., & Jones, K. (1990) Organic contaminants in an agricultural soil with a known history of sewage sludge amendments: polynuclear aromatic hydrocarbons. Environ. Sci. Technol., 24:1706-1711.

Wild, S.R. & Jones, K.C. (1995) Polynuclear aromatic hydrocarbons in the United Kingdom environment: a preliminary source inventory and budget. Environ. Pollut., 88: 91-108.

Table 8
Approximate Time for Simulated Contaminant Concentration to Exceed Controlled Waters EQS at Receptor From Source at Sub Z

MODELLED RECEPTOR	Individual Compounds	Stage 2 Controlled Waters Screening Criteria (ug/l)	Source	SIMULATED TIME TO EXCEED DWS	Maximum Simulated Concentrations at Receptor (ug/l)	
					50th PERCENTILE (Years)	95th PERCENTILE (Years)
Sandwith Beck	PCB Aroclor-1254	0.1	UK DWS (2000)	IR	IR	IR
	TPH (>EC12-16) aromatic	10	UK DWS (2000)	IR	IR	IR
	TPH (>EC16-21) aromatic	10	UK DWS (2000)	IR	IR	IR
	TPH (>EC21-35) aromatic	10	UK DWS (2000)	IR	IR	IR
	TPH (>EC12-16) aliphatic	10	UK DWS (2000)	IR	IR	IR
	TPH (>EC16-21) aliphatic	10	UK DWS (2000)	IR	IR	IR
	TPH (>EC21-35) aliphatic	10	UK DWS (2000)	IR	IR	IR

Key
UK DWS - UK Drinking Water Standards

Appendix B - Borehole Logs

BOREHOLE NUMBER: TP1

PAGE **1 of 1**

DRILLING DATES: 19/10/07	DRILLING METHODS : Trial Pit
DRILLER : JOY PLANT	BOREHOLE DIAMETER : n/a
LOGGED BY : LMB	SCREEN TYPE & DIAM: n/a
CHECKED BY : FW	SCREEN SLOT SIZE: n/a

BOREHOLE CONSTRUCTION	SAMPLE NUMBER	INSITU TESTING	GROUNDWATER	DEPTH (m)	GEOLOGY	DESCRIPTION	COMMENTS
				0.0		MADE GROUND. Medium to coarse grey - purple gravel.	
		0.0ppm					
				0.5		MADE GROUND. Dark brown gravelly silt with frequent fragments of brick and metal pieces.	Water ingress
	0.5m TPH, PCB	0.0ppm					Slight HC odour
						Redundant electric cables at 1m bgl	
		0.4ppm					
				1.0			NVO
	1.2m TPH	0.2ppm				MADE GROUND. Brown - beige silty sand with occassional fine to medium gravel.	
						Becoming more clayey from 1.3m bgl	
				1.5			
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			
				4.5			
				5.0			

LOCATION / NOTES:

NVO = No visual or olfactory evidence of contamination

Trial pit backfilled with spoil

LEGEND

- Disturbed Sample
- Undisturbed Sample
- Headspace Analysis
- Down Borehole Analysis
- Groundwater Table
- Perched Water Table

BOREHOLE LOG

Job Title: Rhodia Sub Z

Location: Whitehaven

Client: Rhodia

URS

App'd:	Date: 22/10/07
Drawn : LMB	Ref: Rhodia
Scale: as shown	Job No: 49308123
Drg. Size: A4	BOREHOLE LOG TP1

BOREHOLE NUMBER: TP2

PAGE **1 of 1**

DRILLING DATES: 19/10/07

DRILLING METHODS : Trial Pit

DRILLER : JOY PLANT

BOREHOLE DIAMETER : n/a

LOGGED BY : LMB

SCREEN TYPE & DIAM: n/a

CHECKED BY : FW

SCREEN SLOT SIZE: n/a

BOREHOLE CONSTRUCTION	SAMPLE NUMBER	INSITU TESTING	GROUNDWATER	DEPTH (m)	GEOLOGY	DESCRIPTION	COMMENTS
				0.0		MADE GROUND. Grey - purple medium to coarse gravel.	NVO
		0.0ppm				MADE GROUND. Brown very gravelly silt with occassional cobbles of concrete, brick fragments and a redundant electric cable.	NVO
	0.5m TPH	0.0ppm		0.5			Water ingress at 0.35, water is red/brown with foam
	0.75 TPH, PCB	0.0ppm				MADE GROUND. Brown -red gravelly very sandy clay. Gravel is fine to medium.	
		0.0ppm		1.0			NVO
				1.5			
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			
				4.5			
				5.0			

LOCATION / NOTES:

NVO = No visual or olfactory evidence of contamination

Trial pit backfilled with spoil

LEGEND

- Disturbed Sample
- Undisturbed Sample
- Headspace Analysis
- Down Borehole Analysis
- Groundwater Table
- Perched Water Table

BOREHOLE LOG

Job Title: Rhodia Sub Z

Location: Whitehaven

Client: Rhodia

URS

App'd:	Date: 22/10/07
Drawn : LMB	Ref: Rhodia
Scale: as shown	Job No: 49308123
Drg. Size: A4	BOREHOLE LOG TP1

BOREHOLE NUMBER: TP3

PAGE **1 of 1**

DRILLING DATES: 19/10/07	DRILLING METHODS : Trial Pit
DRILLER : JOY PLANT	BOREHOLE DIAMETER : n/a
LOGGED BY : LMB	SCREEN TYPE & DIAM: n/a
CHECKED BY : FW	SCREEN SLOT SIZE: n/a

BOREHOLE CONSTRUCTION	SAMPLE NUMBER	INSITU TESTING	GROUNDWATER	DEPTH (m)	GEOLOGY	DESCRIPTION	COMMENTS
				0.0		MADE GROUND. Grey - purple gravel.	Dry ,NVO
		0.0ppm				MADE GROUND.Black - brown very gravelly silt. Gravel is medium to coarse. Pocket of sand at 0.2m bgl	Dry, NVO
	0.5m TPH	0.0ppm		0.5			Water ingress at 0.4m, water is light brown with an oily sheen
		0.0ppm				Grey slag in southern corner of trial pit from 0.5m bgl.	
	0.75m TPH, PCB	0.0ppm		1.0			Wet, NVO
				1.5			
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			
				4.5			
				5.0			

LOCATION / NOTES:

NVO = No visual or olfactory evidence of contamination

Trial pit backfilled with spoil

LEGEND

- Disturbed Sample
- Undisturbed Sample
- Headspace Analysis
- Down Borehole Analysis
- Groundwater Table
- Perched Water Table

BOREHOLE LOG

Job Title: Rhodia Sub Z

Location: Whitehaven

Client: Rhodia

URS

App'd:	Date: 22/10/07
Drawn : LMB	Ref: Rhodia
Scale: as shown	Job No: 49308123
Drg. Size: A4	BOREHOLE LOG TP1

BOREHOLE NUMBER: TP4

PAGE **1 of 1**

DRILLING DATES: 19/10/07	DRILLING METHODS : Trial Pit
DRILLER : JOY PLANT	BOREHOLE DIAMETER : n/a
LOGGED BY : LMB	SCREEN TYPE & DIAM: n/a
CHECKED BY : FW	SCREEN SLOT SIZE: n/a

BOREHOLE CONSTRUCTION	SAMPLE NUMBER	INSITU TESTING	GROUNDWATER	DEPTH (m)	GEOLOGY	DESCRIPTION	COMMENTS
		0.0ppm		0.0		MADE GROUND. Medium to coarse grey - purple gravel with a concrete cobble at 0.4m.	NVO
	0.5m TPH	0.0ppm		0.5		MADE GROUND. Red - brown medium to coarse gravel in a sand and clay matrix.	Water ingress at 0.35m, water is light brown with an oily sheen
		0.0ppm				Black sand at 0.75m bgl	Clay had an oily sheen due to ingress of water from 0.75m bgl
	1m TPH, PCB	0.0ppm		1.0			
				1.5			
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			
				4.5			
				5.0			

LOCATION / NOTES:

NVO = No visual or olfactory evidence of contamination

Trial pit backfilled with spoil

LEGEND

- Disturbed Sample
- Undisturbed Sample
- Headspace Analysis
- Down Borehole Analysis
- Groundwater Table
- Perched Water Table

BOREHOLE LOG

Job Title: Rhodia Sub Z

Location: Whitehaven

Client: Rhodia

URS

App'd:	Date: 22/10/07
Drawn : LMB	Ref: Rhodia
Scale: as shown	Job No: 49308123
Drg. Size: A4	BOREHOLE LOG TP4

BOREHOLE NUMBER: TP5A

PAGE 1 of 1

DRILLING DATES: 19/10/07

DRILLING METHODS : Trial Pit

DRILLER : JOY PLANT

BOREHOLE DIAMETER : n/a

LOGGED BY : LMB

SCREEN TYPE & DIAM: n/a

CHECKED BY : FW

SCREEN SLOT SIZE: n/a

BOREHOLE CONSTRUCTION	SAMPLE NUMBER	INSITU TESTING	GROUNDWATER	DEPTH (m)	GEOLOGY	DESCRIPTION	COMMENTS
		0.0ppm		0.0		MADE GROUND. Grey - purple gravel with frequent brick fragments and cobbles of concrete.	HC odour
						Trial Pit terminated on concrete hardstanding.	

0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

LOCATION / NOTES:

NVO = No visual or olfactory evidence of contamination

Trial pit backfilled with spoil

LEGEND

- Disturbed Sample
- Undisturbed Sample
- Headspace Analysis
- Down Borehole Analysis
- Groundwater Table
- Perched Water Table

BOREHOLE LOG

Job Title: Rhodia Sub Z

Location: Whitehaven

Client: Rhodia

URS

App'd:	Date: 22/10/07
Drawn : LMB	Ref: Rhodia
Scale: as shown	Job No: 49308123
Drg. Size: A4	BOREHOLE LOG TP

BOREHOLE NUMBER: TP5B

PAGE **1 of 1**

DRILLING DATES: 19/10/07	DRILLING METHODS : Trial Pit
DRILLER : JOY PLANT	BOREHOLE DIAMETER : n/a
LOGGED BY : LMB	SCREEN TYPE & DIAM: n/a
CHECKED BY : FW	SCREEN SLOT SIZE: n/a

BOREHOLE CONSTRUCTION	SAMPLE NUMBER	INSITU TESTING	GROUNDWATER	DEPTH (m)	GEOLOGY	DESCRIPTION	COMMENTS
				0.0		MADE GROUND. Grey - purple gravel.	NVO
		0.0ppm					NVO
	0.5m TPH, PCB	0.0ppm		0.5		MADE GROUND. Soft to firm red-brown clay with frequent medium to coarse gravel. Occassional brick fragments, concrete cobbles and an electric cable.	
		0.0ppm					
	1m TPH	0.0ppm		1.0			
				1.5			
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			
				4.5			
				5.0			

LOCATION / NOTES:

NVO = No visual or olfactory evidence of contamination

Trial pit backfilled with spoil

LEGEND

- Disturbed Sample
- Undisturbed Sample
- Headspace Analysis
- Down Borehole Analysis
- Groundwater Table
- Perched Water Table

BOREHOLE LOG

Job Title: Rhodia Sub Z

Location: Whitehaven

Client: Rhodia

URS

App'd:	Date: 22/10/07
Drawn : LMB	Ref: Rhodia
Scale: as shown	Job No: 49308123
Drg. Size: A4	BOREHOLE LOG TP1

BOREHOLE NUMBER: TP6

PAGE **1 of 1**

DRILLING DATES: 19/10/07	DRILLING METHODS : Trial Pit
DRILLER : JOY PLANT	BOREHOLE DIAMETER : n/a
LOGGED BY : LMB	SCREEN TYPE & DIAM: n/a
CHECKED BY : FW	SCREEN SLOT SIZE: n/a

BOREHOLE CONSTRUCTION	SAMPLE NUMBER	INSITU TESTING	GROUNDWATER	DEPTH (m)	GEOLOGY	DESCRIPTION	COMMENTS
				0.0		MADE GROUND. Medium to coarse grey - purple gravel.	NVO
		0.8ppm				MADE GROUND.Brown - black sandy silt with frequent gravel and brick fragments.	NVO
	0.5m TPH, PCB	1.1ppm		0.5		Becoming more sandy from 0.5m bgl	
	0.75m TPH	1.5ppm				Cable marker at 0.7m bgl	
				1.0		Terminated at 0.75m bgl due to insitu electric cable	
				1.5			
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			
				4.5			
				5.0			

LOCATION / NOTES:

NVO = No visual or olfactory evidence of contamination

Trial pit backfilled with spoil

LEGEND

- Disturbed Sample
- Undisturbed Sample
- Headspace Analysis
- Down Borehole Analysis
- Groundwater Table
- Perched Water Table

BOREHOLE LOG

Job Title: Rhodia Sub Z

Location: Whitehaven

Client: Rhodia

URS

App'd:	Date: 22/10/07
Drawn : LMB	Ref: Rhodia
Scale: as shown	Job No: 49308123
Drg. Size: A4	BOREHOLE LOG TP1

BOREHOLE NUMBER: TP7

PAGE **1 of 1**

DRILLING DATES: 2/6/2008	DRILLING METHODS : Trial Pit
DRILLER : Lawsons	BOREHOLE DIAMETER : n/a
LOGGED BY : NJL	SCREEN TYPE & DIAM: n/a
CHECKED BY : PJM	SCREEN SLOT SIZE: n/a

BOREHOLE CONSTRUCTION	SAMPLE NUMBER	INSITU TESTING	GROUNDWATER	DEPTH (m)	GEOLOGY	DESCRIPTION	COMMENTS
	Sample collected			0.0		MADE GROUND: angular, medium to coarse grey - purple gravel.	
				0.5		MADE GROUND: black, silty sandy gravel with abundant ash and occasional bricks	Small amount of water ingress
						Very stiff, reddish brown, CLAY with occasional rounded fine to medium gravel and very weak weathered mudstone.	
				1.0		Trial Pit Terminated at 0.8m	
				1.5			
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			
				4.5			
				5.0			

LOCATION / NOTES:

NVO = No visual or olfactory evidence of contamination

Trial pit backfilled with spoil

LEGEND

- Disturbed Sample
- Undisturbed Sample
- Headspace Analysis
- Down Borehole Analysis
- Groundwater Table
- Perched Water Table

BOREHOLE LOG

Job Title: Rhodia Sub Z

Location: Whitehaven

Client: Rhodia

URS

App'd:	Date: 23/6/2008
Drawn : NJL	Ref: Rhodia
Scale: as shown	Job No: 49308123
Drg. Size: A4	BOREHOLE LOG TP601Z

BOREHOLE NUMBER: TP8

PAGE **1 of 1**

DRILLING DATES: 2/6/2008

DRILLING METHODS : Trial Pit

DRILLER : Lawsons

BOREHOLE DIAMETER : n/a

LOGGED BY : NJL

SCREEN TYPE & DIAM: n/a

CHECKED BY : PJM

SCREEN SLOT SIZE: n/a

BOREHOLE CONSTRUCTION	SAMPLE NUMBER	INSITU TESTING	GROUNDWATER	DEPTH (m)	GEOLOGY	DESCRIPTION	COMMENTS
				0.0		MADE GROUND: angular, coarse grey gravel.	
						MADE GROUND: black, silty sandy gravel with abundant ash and occasional bricks. Gravel is angular and medium to coarse.	
				0.5		MADE GROUND: stiff, brown, CLAY with occasional rounded to subrounded fine gravel and rare cobbles.	
	Sample collected						Wet
				1.0		Very stiff, reddish brown CLAY with occasional rounded fine to medium gravel and rare subrounded medium gravel.	
						0.7-0.85m Light brown and grey sand with redundant electric cable running in it on western side of the pit	
				1.5			
				2.0			
				2.5			
				3.0			
				3.5			
				4.0			
				4.5			
				5.0			

LOCATION / NOTES:

NVO = No visual or olfactory evidence of contamination

Trial pit backfilled with spoil

LEGEND

- Disturbed Sample
- Undisturbed Sample
- Headspace Analysis
- Down Borehole Analysis
- Groundwater Table
- Perched Water Table

BOREHOLE LOG

Job Title: Rhodia Sub Z

Location: Whitehaven

Client: Rhodia

URS

App'd:	Date: 23/6/2008
Drawn : NJL	Ref: Rhodia
Scale: as shown	Job No: 49308123
Drg. Size: A4	BOREHOLE LOG TP602Z