Remediation Statement Appendix F

Plot D Soil and Groundwater Investigation at the Former Albright and Wilson Works, Whitehaven, Cumbria

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Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the services. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in using this Report.

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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 the former Albright & Wilson site in Whitehaven, Cumbria. The work comprised investigation of soil and groundwater conditions associated with an area of land identified as "Plot D" - one of a sequence of plots on the Whitehaven site identified as requiring further assessment in a Site Remediation Statement document. The report aimed to specifically address the potential significance of controlled waters pollutant linkages identified by Copeland Borough Council following their determination of the site as Contaminated Land.

Plot D lies in the northwest corner of the Rhodia site and comprises part of the former alabaster works, the fatty alcohol plant, and part of the MMO, MOS, MO and UFEX Plants. The outfall discharge point for the former Cathedral Smoothing Chamber also lies within Plot D. All above ground structures have been demolished and the area is now open ground.

A trial pitting exercise was undertaken which also allowed detailed visual assessment of the subsurface. A total of 15no. trial pits were excavated. Additionally, three groundwater monitoring wells were installed using the window sampling technique. Soil and groundwater samples were collected and scheduled for a suite of analyses.

Ground conditions observed comprised Made Ground, overlying natural clay deposits subsequently underlain by rock head. Ground cover over the majority of the site comprised concrete slab hardstanding. Made Ground generally comprised a heterogeneous mix of building rubble, ash and clinker. The depth to these horizons varied across the site, which was further complicated by the presence of subsurface structures. The natural clay deposits were observed continuously beneath the site. Bedrock was encountered at a number of locations as a limestone or sandstone and interpreted as the St Bees Evaporite Formation. Small amounts of perched groundwater were identified in boreholes WS715D and WS717D.

A Stage 2 controlled waters generic screening exercise was completed on all data collected from within the Plot D to date (this included data from previous investigations). The key receptor identified for the controlled waters assessment was the Irish Sea, located approximately 1.3km south west of the site. The screening exercise of the site data against the controlled waters generic criteria (Marine Environmental Quality Standards) identified exceedances in soil, leachate, and groundwater. The screening exercise identified exceedances in soil of chloroform, trichloroethene, toluene and tetrachloroethane. In leachate, exceedances were identified for arsenic, copper, fluoranthene, phenanthrene, lead, selenium and Total Petroleum Hydrocarbon (TPH). In groundwater exceedances were identified for copper, naphthalene, benzo(a) anthracene, nickel, selenium and zinc.

A Stage 3 Controlled Waters Risk Assessment was then performed on contaminants exceeding stage 2 criteria. This site specific assessment modelled groundwater flow towards the coastline through an onsite dilution model (Stage 3A) and a further offsite dilution model (Stage 3B). The Stage 3 Risk Assessment identified potential risks associated with fluoranthene, chloroform, naphthalene, zinc and nickel.

The following outline scope of works is recommended to assess the necessity for remedial action.

Area 1- The area in the vicinity of TP708D: Further investigation for chloroform.

Area 2- The area in the vicinity of TP706D: Further investigation for fluoranthene.

Area 3- The area in the vicinity of WS123, WS416 and WS717D: Further investigation for naphthalene, zinc and nickel.

Following completion of this additional investigation, the Stage 3 risk assessment will be updated and the pollutant linkages refined accordingly.

A Human Health DQRA was also completed considering the proposed 'right-to-roam' end use. No risks were identified.

URS has addressed the specific controlled waters pollutant linkages identified by Copeland Borough Council in their determination of the site as Contaminated Land. URS has also addressed additional COPC and potential pollutant linkages identified during the course of the works at the site.

URS concludes that there are no significant pollutant linkages with respect to Human Health, either in the current site use or for the proposed 'right to roam' use.

For Controlled Waters, limited additional investigation is required to investigate possible significant pollutant linkages for fluoranthene, chloroform, naphthalene, zinc and nickel.

The significant pollutant linkages declared by Copeland Borough Council with respect to surfactants, phosphates, arsenic, boron, cadmium, chromium, copper, lead, mercury, and selenium have been shown to not exist within Plot D.

1. INTRODUCTION

1.1. General Introduction

URS was commissioned by Rhodia on 16th February 2007 to undertake an intrusive soil and groundwater investigation at the former Albright & Wilson site in Whitehaven, Cumbria as detailed in URS Proposal 1941NG1111 (dated 12th February 2007). This work was requested by Rhodia UK Limited (Rhodia) at a meeting with URS Corporation Ltd (URS) on 5th February 2007.

This project focuses on the soil and groundwater conditions within an area of land identified as "Plot D" within the boundary of the Rhodia site. Plot D is one of a sequence of plots on the Whitehaven site identified as requiring further investigation in a Site Remediation Statement[1] document. This report formalises the scope, context, and timescales of investigations required on the Rhodia site.

The Rhodia site (including Plot D) has been designated by Copeland Borough Council as statutory "Contaminated Land" under Part IIA of the Environmental Protection Act 1990. The entire site has subsequently been declared a "Special Site" and is now regulated by the Environment Agency.

The location of the former Albright and Wilson Works is presented on Figure 1. The site layout and the boundary of Plot D are presented on Figure 2.

1.2. Project Background

URS has undertaken a variety of investigations on the Rhodia site (formerly Albright & Wilson), dating back to 1995. During this period, Rhodia's operations on the site have diminished, the phosphate business has been closed down and over the past 2 years the remaining production operations have ceased. It is understood that at the time of issue of this report, decommissioning of above ground structures relating to former Rhodia operations at the site has now been completed. URS also understands that the only remaining structure relates to a small surfactants production facility (previously operated by Huntsman), located towards the north-eastern corner of the site and is scheduled for demolition during the latter part of 2007.

Following demolition and remediation of the site, it is understood by URS (at the time of reporting) that the proposed use of the site is as a public open space with a minimum of site preparation expected (such as the removal of protruding trip hazards).

The scope of previous investigations across the Rhodia site were developed in relation to phosphate and surfactant manufacturing processes and other historic activities comprising: coal and anhydrite mining; coke production: tar distillation; and firelighter manufacture. A

[1] Former Albright and Wilson Works: Site Remediation Statement. 23 June 2006. URS Corporation. (Ref 44319877/R2234.B01)

site wide investigation was undertaken in 2005 and the resulting report (ref; 44319623. Phase II Investigations and Environmental Assessments at the Former Albright & Wilson Works, Whitehaven, 23 June 2005) contains full details of the site's history and the environmental investigations previously undertaken. The report is presented in the Site Remediation Statement (and it is hereafter referred to as the "Phase II report").

The Site Remediation Statement document included a requirement for additional investigation in key areas of the Rhodia site to address the significant pollutant linkages identified – one of those areas identified was Plot D. Further to this requirement, URS have reported the findings of the Plot D investigation herein in accordance with the Site Remediation Statement. It should be noted that the Site Remediation Statement has yet to be approved by the Environment Agency.

The proposal that defines the scope for the Plot D investigation (REF: 1941NG1111/MARP0001 (dated 19th February 2007) is included in Appendix A. The proposal comprises background information, project objectives, scope, approach and rationale on which the investigation has been based.

This proposal was submitted to the Environment Agency on 2nd March 2007 for comment. To date, URS has not received a response.

1.3. Site Investigation Area – Plot D

Plot D lies in the northwest corner of the Rhodia site and comprises part of the former alabaster works, the fatty alcohol, and part of the MMO, MOS, MO and UFEX Plants. The outfall discharge point for the former Cathedral Smoothing Chamber also lies within Plot D. Operations in these areas have now ceased, and all above ground structures associated with these historical activities have subsequently been decommissioned and removed.

The area of interest has been identified as Plot D (Figure 2). The former layout of the site is presented on Figure 3. The plot is approximately rectangular in shape and is located adjacent to the north-west site boundary. The estimated area of the plot is approximately 1.52 hectares.

1.4. Existing Site Investigation Information

1.4.1. Introduction

The findings of previous investigations have indicated the potential presence of contamination within the soils and shallow groundwater. However, due to operational constraints during these investigations it was not possible to fully characterise the soil and groundwater quality with respect to risk to human health and controlled waters receptors. The investigations that have previously been undertaken within the identified boundary, of Plot D, are as follows:

- URS investigation on behalf of Rhodia, ref; 44557-021, February 2002;

- URS investigation on behalf of Rhodia, ref; 44319623, during 2005; and,

- URS investigation on behalf of Rhodia, ref; 44319904, during 2006. Continued ongoing monitoring of 6 deep groundwater wells (on the Rhodia site, but not within the boundary of Plot D), and four offsite surface water locations. Quarterly groundwater monitoring has been conducted since February 2004; previous report references are 44319646 and 44557-045.

1.4.2. Key Findings

Phase II Soil and Groundwater Investigation Interpretive Report the Former Albright & Wilson Works, Whitehaven (ref;44557-021, 4 February 2002)

URS was commissioned by Rhodia during 2001 to undertake a Phase II Soil and Groundwater Baseline Contamination Investigation at the site. The investigation was designed primarily to provide a baseline assessment of soil and groundwater conditions with regard to current and historical contamination. The site investigation comprised the drilling of 65 shallow boreholes with 35 installed as shallow groundwater monitoring wells across the site. Soil and groundwater samples were subsequently submitted for laboratory analysis.

Two shallow soil borings (WS402 and WS416) were advanced in Plot D as part of site wide assessment. The laboratory analytical suite in soils comprised metals, TPH, VOCs, SVOCs, asbestos, phosphates, and pH.

In WS121 no visual or olfactory evidence was noted in the soil arisings. Analytical results detected a strongly alkaline pH of pH 10.5 and trace SVOC concentrations in soils. In WS122 no visual or olfactory evidence was noted in the soil. Soil analytical results detected metals and phosphorus at concentrations above the laboratory method detection limit.

Following a generic screening exercise and human health Detailed Quantitative Risk Assessment (DQRA) based on a scenario of a continued industrial land use, it was considered that the concentrations reported did not represent a potentially significant risk to the identified human health receptors in Plot D.

No assessment was made for controlled waters. It was considered that further work was required to determine the extent of impact to receptors, although leachability results on soils indicated a limited potential for soil impacts.

The data obtained during this investigation has been considered in the Human Health and Controlled Waters risk assessments produced in this report.

Phase II Investigations and Environmental Assessments at the Former Albright & Wilson Works, Whitehaven (ref: 44319623, 23 June 2005)

The principal aim of this investigation was to develop a comprehensive understanding of the contaminated land liabilities associated with the site and future licensing requirements for Rhodia's proposed forthcoming divestiture. It was identified that Rhodia were proposing to divest the site to potential purchasers for a recreational 'right to roam' end use. However,

also that Rhodia required an understanding of the corrective action and costs associated with leaving the site as "derelict" land, with no public access allowed. As such, the assessments carried out by URS for the study were based upon both these proposed end uses. Following a collation of all historic and the recent analytical data, Detailed Quantitative Risk Assessments (DQRA) were performed to assess potentially significant risks to Human Health and Controlled Waters receptors, based on the future end use for the site.

Two shallow soil borings (WS402 and WS416) were advanced in Plot D as part of site wide assessment. One of these soil borings was installed as a groundwater monitoring well (WS416). The laboratory suite of analysis in soils comprised: surfactants; metals; major cations and anions; VOCs; SVOCs; PAHs; TPH; and PCBs. Analysis of groundwater included surfactants, metals, major cations and anions, VOC, SVOC, PAH, TPH and PCB.

No visual or olfactory evidence of contamination was noted in WS402 and WS416. Soil analytical results reported elevated concentrations of arsenic and naphthalene in both WS402 and WS416, which, exceeded the Controlled waters Risk Assessment. However, only trace concentrations of naphthalene were recorded in the groundwater at WS416.

Following a generic screening exercise and human health Detailed Quantitative Risk Assessment (DQRA) based on a continued industrial land use, it was considered that no concentrations represented a potentially significant risk to the identified human health receptors in Plot D.

The data obtained during this investigation has been considered in the Human Health and Controlled Waters risk assessments produced in this report.

Groundwater Monitoring at the Former Albright & Wilson Works, Whitehaven (ref: 44557-045, 44319646, 44319904, February 2004 to date)

The aim of this project has been to provide long term monitoring of the geochemistry of the deep groundwater underlying the Whitehaven site and local surface waters. The aim of this project has been to determine trends in the chemistry of the analytes found in the groundwater, some of which are known to be derived from site processes. The locations assessed are considered to be representative of the potential receptors in the underling geological formations and surface water features fed either by site runoff of issue from the local geology. These include: The Byerstead Spring; groundwater in the Whitehaven Sandstone; groundwater in the St Bees Evaporites, Groundwater in the St Bees Shales; Groundwater in the Middle Coal Measures; Sandwith Beck; and Bellhouse Gill.

Assessment of the condition of the water emanating from the Byerstead Spring has been undertaken sporadically since 2002. Surfactant concentrations have decreased since 2002, and have been below 1200μg/l in the past four monitoring rounds. It is thought that once surfactant production ceases completely on the site (a small surfactants business, operated by Huntsman, still operates onsite, but is due to close), a further decrease is likely to be seen in concentrations of surfactant detected at the Byerstead Spring.

Concentrations of dissolved phosphorus at the Byerstead have shown a substantial decline since monitoring began. This is thought to coincide with the cessation of the Phosphate works in December 2001.

The concentration of the analytes at the Byerstead Spring can be affected (diluted) by an increased volume of water emerging at the spring. For example, the low concentration of MBAS detected in the Byerstead sample in November 2005 (950μg/l), was taken during a prolonged period of heavy rainfall (over a period of days before), and it was noted that the discharge from the spring appeared greater than normal. It is thought that there are several sources for the analytes detected at the Byerstead Spring, the two most prevalent of which are the site itself and the flooded mine systems in the area.

The geological and geochemical data obtained during the monitoring regime has been considered in this report.

1.5. Report Format

For ease of reference, the remainder of this report has been structured as follows:

- Section 2 details the objectives of this study
- Section 3 includes a review of the current site conditions and environmental setting, derived from pre-existing information
- Section 4 describes the site-specific ground conditions encountered and observations made during the Study.
- Section 5 describes the Conceptual Site Model
- Section 6 summarises the assessment of risk to human health.
- Section 7 summarises the assessment of risk to water resources
- Section 8 presents a complete list of the pollutant linkages potentially present on site, updated to include the findings of this investigation
- Section 9 presents the remediation strategy, in which the actions to address the significant pollutant linkages are explained.

In addition, the following Appendices are attached to the report:

Appendix A	Proposal for Site Works (Plot D) and correspondence
Appendix B	Field Methodology
Appendix C	Borehole & Trial Pit logs
Appendix D	Analytical Schedules, Tabulated Results, Laboratory Certificates, and Historic Data
Appendix E	Human Health Detailed Quantitative Risk Assessment
Appendix F	URS GAC Advice Note
Appendix G	Controlled Water Detailed Quantitative Risk Assessment
Appendix H	Model Inputs

2. OBJECTIVES

The project objectives listed below are in line with the *Assessment Actions* detailed in the Site Remediation Statement where the area is referred to as "Plot D".

The key objectives of the investigation were therefore to undertake the following;

- To assess the potential extent and significance of contamination in shallow soil and groundwater in the specified area of interest;
- To provide additional data on potential further compounds not previously detected but which may be considered to be present;
- To provide comprehensive and robust data to allow conceptualisation and characterisation of the site area as far as possible;
- To revisit existing data and to supplement this with additional information from the proposed investigation;
- To revise and develop the current Conceptual Site Model;
- To review the data gathered from the assessments undertaken in the area of interest and to review this against the existing controlled waters and human health site specific risk based screening levels;
- To provide a preliminary evaluation of the need for, and scope of, potential remedial options (if considered appropriate) together with an estimation of potential remedial methodologies and costs.

2.1. Site Investigation Design

The site investigation design was submitted to the Environment Agency for comment prior to start of works. Details of the investigation design and rationale are presented in the proposal. To date URS has not received a response from the Environment Agency.

3. SITE DESCRIPTION AND ENVIRONMENTAL SITE SETTING

3.1. Introduction

The Former Albright and Wilson Works (the site) is located in a coastal setting, on the hill approximately 2 km south of Whitehaven Town Centre. To the north east are residential estates (Woodhouse and Kells) and to the south is the village of Sandwith. The remainder of the site is surrounded by agricultural land. Plot D occupies an area of approximately 15,200m^2 (1.52 hectares) and is located towards the northern end of the site.

The eastern half of Plot D slopes gently from east to west. The western half of Plot D is relatively flat lying. Beyond the western boundary, topography rises to the site boundary, followed by farmland, which is positioned topographically higher than the site, beyond which lie steep cliffs which form the coastline to the Irish Sea.

3.2. Plot D Current and Historical Operations

The area formerly contained part of the fatty alcohol plant, part of the MMO, MOS, MO and UFEX Plants, the former alabaster works and the outfall discharge point for the former Cathedral Smoothing Chamber were located in Plot D. The buildings have been demolished to ground level, though some stockpiles of demolition rubble remain at the time of reporting. Much of the ground remains coved by concrete hardstanding, relating to, roadways, floor slabs from the former buildings, and foundations and cover from former process areas.

3.3. Environmental Setting

The environmental setting for the site has been previously established during URS's Phase II investigation, a summary of the setting, specific to Plot D, is presented in the sections below. The full Phase II investigation is available as an Appendix to the Remediation Statement.

3.3.1. Geology and Hydrogeology

The geology and hydrogeology of the Rhodia site is complex and is described in full in Section 2.3 of the Phase II Investigation. In summary, the main formations comprise:

- Made Ground: the made ground (the man made or disturbed ground formed when the chemical works was built), overlying
- Glacial Till (Boulder Clay) (the "drift"): present across the area in limited thickness, although absent in some other parts of the site, overlying
- St Bees Evaporite Formation (late Permian): present as either pink grey crystalline limestone or as yellow sandstone at a number of locations across Plot D. This

formation is classified as a non aquifer by the Environment Agency. These lithologies are known to have suffered dissolution through historical losses of acid to ground in certain locations within the vicinity of Plot D. Two voids are known to exist to beyond the southern boundary of Plot D, these are in the vicinity of the Ethoxylation Plant.

- The Brockram Formation (early Permian): comprising coarse, well cemented, clast supported breccias, typically only 1 – 2m in thickness is understood to underlie the St Bees Evaporite Formation although it was not encountered in the exploratory holes advanced during this or any previous investigation. This formation unconformably overlies the Whitehaven Sandstone Formation. This formation is classified as a minor aquifer by the Environment Agency.

- The Whitehaven Sandstone Formation (Westphalian C to D, Carboniferous) comprises medium to coarse grained purple to purple-brown sandstones which are cross bedded throughout with thin interbeds of mudstones and siltstones bedded with sandstones and siltstone. This sandstone is classified as a minor aquifer by the Environment Agency.

3.3.2. Surface Waters

No surface water bodies are present in the boundaries of Plot D or within its immediate vicinity. However, the Plot D area is serviced by a storm water drainage system which was designed to drain the water within Plot D northwards towards the coast.

Plot D also contains the main drain that takes effluent derived from across the site to the outfall discharge point (Barrowmouth outfall). As such, this drain may have been damaged by low pH waters. Site effluent also contained surfactants, which tend to keep drains grease free. This increases their tendency to leak because it prevents grease blocking holes and cracks.

It is currently proposed that the drains on the whole of the Rhoda site will be blocked and allowed to silt up and that the groundcover within Plot D will be left in its current state.

Once the drains are no longer able to remove storm water runoff it is assumed that there will be a greater component of overland flow corresponding to the natural watershed which drains the Plot D Area to the North. In addition, it is considered that infiltration of surface water may also increase, potentially adding to the volume of water entering either perched ground water or the aquifers present in the geological sequence.

3.4. Potential Receptors

Based on the environmental site setting and previous conceptual site models developed in the Phase II assessment, URS considers the following to be the receptors likely to be at risk from potential contamination within the Plot D area:

- *Human beings*: Given that the proposed end-use for the Plot D area and the site as a whole is to be a recreational area for open access to the public it is considered by URS that members of the public represent a potential receptor.

- *Deep groundwater and subsequently Coastal Waters*: The groundwater within the St Bees Evaporites is likely to receive infiltrating rainwater in Plot D. Once into the St Bees Evaporite Formation, it has been demonstrated by dye testing experiments that the groundwater migrates rapidly towards the coastline (and is likely to emerge at the Byerstead Spring), which is situated approximately 1.3km to the southwest of Plot D.

3.5. Potential Current and Historical Sources of Contamination

Based on observations and review work undertaken during the Phase II investigation a number of potential current and historical sources of contamination have been identified. These are shown on Figure 3 and are described below.

Historic on-site sources of potential soil and groundwater contamination

- Fatty Alcohol Plant: Spillages, leaks and releases to ground of raw and finished products from above ground storage tanks (AST), reactors and various other site processes. Potential contaminants are considered to include Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons and Nitrates;

- MO and MOS Plants: Spillages, leaks and releases to ground of raw and finished products. Likely contaminants are considered to include Surfactants, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons and Nitrates;

- Alabaster works: Spillages, leaks and releases to ground of raw and finished products. Contaminants of concern are considered to include Heavy Metals, Petroleum Hydrocarbons, Phosphates and Sulphates;

- Outfall discharge point for the former Cathedral Smoothing Chamber (Former smoothing Chambers and pH balancing area). Potential contaminants are likely to be those associated with the operation of the “smoothing chamber” and most likely to include surfactants.

- Made Ground: Concentrations of contaminants within imported materials used for ground raising and reclamation (e.g. ash and clinker fill) which may contain VOCs, SVOCs, heavy metals, petroleum hydrocarbons, ammonium, nitrates, cyanide and sulphates.

- The main drainage system onsite ran through Plot D, this drain will have contained process effluent derived from production areas across the entire Whitehaven site. The integrity of this drain within Plot D is unknown.

4. FIELD OBSERVATIONS AND GROUND CONDITIONS ENCOUNTERED

4.1. Introduction

This section reviews the soil and groundwater 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. Interpretations are based on observations noted during the excavation of the fifteen trial pits and three boreholes (installed as monitoring wells) advanced across Plot D during this investigation.

The northern part of the fatty alcohol plant lies within Plot D, and also parts of the MMO, MOS, MO and UFEX Plants, the former alabaster works, and the outfall discharge point for the former Cathedral Smoothing Chamber were located in Plot D. However, no patterns of ground conditions have emerged to facilitate the discussion of Plot D by dividing it into sub-areas, and as such, it is described as a whole area.

4.2. Soil Conditions

The ground conditions underlying the Plot D area are derived from the inspection of the arisings resulting from excavations and soil borings advanced during the investigation. A summary of the ground conditions encountered is provided in Table 4.1 below.

The rationale for the sampling regime is presented in Appendix A and the field techniques employed during this investigation are detailed in Appendix B. Exploratory logs are presented in Appendix C. Exploratory locations are shown on Figure 4.

Table 4.1 – Summary of Typical Geological Profile Encountered

Unit	Description	Depth Encountered (m)	Maximum Thickness (m)
Made Ground	Reinforced concrete hardstanding	0 – 0.3	0.35
	Hardcore	0 .1– 0.5	0.8
	Brown sand and gravel with many man made components (fill material)	0 – 0.8	0.5
	Orange red or black brown silt and clay with occasional gravel and cobbles	0.2 – 1.2	1
	White or blue cement clinker	0.4 - 0.6	0.3
	Black silt layers with clinker, or pockets or lenses of black clinker. Occasional cobbles of white – blue cement clinker. Frequent coal, ash, slag and brick.	0.4 – 3	3.3
Natural Ground	Glacial Till Deposits typically comprising red brown silt or dark brown clay with occasional gravel, cobbles and lenses of sand. Occasionally contains layers of yellow brown silty, sand and gravel	2.5 – 4	2.8

Unit	Description	Depth Encountered (m)	Maximum Thickness (m)
Bedrock	St Bees Evaporite Formation: typically comprising grey – pink, weathered, Limestone.	5	Not proven

Geological field observations are presented in Figure 5. A geological map is presented as Figure 6 and a geological cross section in Figure 7. The geological sequence observed is summarised below.

4.2.1. Made Ground

The Made Ground varied in thickness from 0.6m at TP716D to 3.8m at TP706D. The Made Ground is typically thicker on the north side of Plot D (approximately 3m thick) and becomes progressively thinner towards the southern edge of the plot (approximately 1m thick).

Reinforced concrete hardstanding (0m – 0.3m thick) was encountered in the areas of former production / foundations: the alabaster works area (TP703D), the fatty alcohol plant (TP710D, TP711D, TP714D, TP716D) and the MMO, MOS, MO and UFEX Plants (TP718D, TP719D). This concrete hardstanding was occasionally underlain by hardcore. Surrounding these former plant areas, the land appears not to have been recently used for industrial works, and the surface layer comprises grass and topsoil or hardcore.

Beneath the surface layer the Made Ground typically compromised one or more of the following:

- Fill material: Typically brown sand and gravel with occasional brick and/or concrete;
- Reworked drift: Typically soft, brown gravelly clay or black, silty, gravelly fine sand;
- Cement clinker: White and blue cement clinker; and
- Ash: Typically black, sandy gravel of coal, ash and clinker. Man made components such as wood, glass and brick are common. This horizon appears to be localised in the vicinity of the former alabaster works. This is thought to be associated with the backfilling and levelling operations in the area.

4.2.2. Natural Ground

Glacial Till (Drift/ Boulder Clay)

Drift deposits were encountered over most of Plot D with a maximum proven thickness of 2.8m observed in TP710D. Drift was not observed in TP708D due to difficulties in the excavation of the trial pit, with a refusal on concrete at 1m. Drift was observed at all remaining locations in Plot D.

Where encountered, the drift typically comprised Glacial Till deposits, which included:

- Soft, orange and brown slightly sandy clay, with occasional gravel. This is found below the Made Ground in the majority of locations.

- Firm, red brown mottled grey and orange, slightly sandy clay with occasional gravel and cobbles.

- Firm, black, slightly sandy clay, with occasional gravel. This horizon is observed in locations TP703D and TP710D only.

Natural Ground (Bedrock)

Bedrock was encountered at nine locations in Plot D between 1 bgl and 7.4m bgl. The lithology observed was as follows:

- Pale grey pink and yellow pink fine grained limestone with occasional dissolution voids, encountered in TP701D (3.5m bgl), TP702D (3.5m bgl) and TP704D (4m bgl).

- Siltstone was encountered at 4.8m bgl in TP705D.

- Grey limestone with red and brown veins, encountered in TP718D (1m bgl), WS712D (4.5m bgl) and WS717D (4.1m bgl).

- Yellow fine sandstone, encountered in TP719D at 4.5m bgl.

This unit is considered to represent the St Bees Evaporites / St Bees Evaporite Formation. The vertical and lateral extent of this unit is illustrated on Figures 6 and 7.

4.3. Groundwater Conditions

Groundwater strikes were observed during the excavation of trial pits in TP708D, TP709D, TP710D, TP711D, TP716D and TP719. Groundwater strike was also observed during the installation of a groundwater monitoring well at WS717D and in WS715D during groundwater monitoring on 7th March 2007. Based on the spatial correlation of groundwater strikes it is not considered likely that a continuous shallow groundwater body is present within the drift deposits. Considering all URS investigations to date, two of the five wells that have been installed in Plot D have been dry (WS401 in April 2005, and WS712D in March 2007). The remaining three wells (WS416 sampled in April 2005, and WS715D and WS717D sampled in March 2007) contained a limited volume of water, with slow recharge. It is likely that these boreholes contain localised pockets of perched groundwater (unconnected underground ponds of water).

The St. Bees Evaporites have undergone dissolution in the vicinity of Plot D due to the loss of acids directly to ground in areas of former acid storage. This has potentially resulted in the creation of solution features/voids which may be present beneath Plot D. It is considered that these voids where streams may be flowing, would form the dominant groundwater transport mechanism within this unit (in parts of Plot D). It is known that at

least one void exists to the south of Plot D (immediately to the north of the ethyoxylation plant), where a large void was created by the loss of acid to ground through leakage from the MO/MOS Plant area.

It is considered groundwater flow direction is likely to follow dip and topography to the west/south west. As groundwater migrates out of Plot D, it will encounter a north-south trending fault. At the fault, the geological sequence has been downthrown on the western side and consequently it is considered that groundwater is likely to migrate downwards into the fault plane, before continuing to migrate laterally following the path of least resistance/highest permeability towards the coastline; this may be within old mine adits or continue to be within the partially dissolved St Bees Evaporite Formation strata.

At the coastline, the groundwater is thought likely to be forced to the surface when it meets the saline water interface. One point known to contain site-derived waters is a spring which emerges on Saltom Beach, known as the Byerstead Spring. Dye tracing experiments have shown that site derived water can reach the Byerstead Spring in less than 10 hours.

4.4. 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 4.2, which summarises areas of potential contamination and likely sources and is shown on Figure 8.

Table 4.2 Field Observations of Contamination

Location	Made Ground	Drift	Bedrock
TP701D	NVO	NVO	NVO
TP702D	NVO	NVO	NVO
TP703D	NVO	NVO	-
TP704D	Sulphur odour	NVO	NVO
TP705D	NVO	NVO	NVO
TP706D	Sulphurous and kerosene odour	NVO	-
TP708D	NVO	NVO	-
TP709D	NVO	NVO	-
TP710D	PID at 65.1 at 0.4m bgl	PID at 30.2 at 4m Water with a black oily sheen	-
TP711D	HC odour and black water	Sulphur odour	-
TP713D	NVO	NVO	-
TP714D	NVO	NVO	-
TP716D	NVO	NVO	-
TP718D	NVO	NVO	NVO
TP719D	NVO	NVO	NVO
WS712D	NVO	NVO	NVO

Location	Made Ground	Drift	Bedrock
WS715D	black staining at 3.6m bgl	NVO	-
WS717D	NVO	NVO	NVO

HC (hydrocarbon); NVO (no visual or olfactory evidence of contamination); PID (photo ionisation detector); - (not observed)

Contamination associated with the composition of the Made Ground

Potential contamination was observed in the Made Ground, the majority of which is considered likely to be associated with the constituents of the made ground, as opposed to chemical impact sourced from site derived activity.

As to be expected from the long industrial history of the site, identified contamination is irregularly distributed over Plot D and can be grouped into:

- Ash, clinker, coal and slag were observed in TP701D, TP702D, TP703D, TP704D, TP705D, TP706D and TP713D. This covers a large proportion of Plot D where the former alabaster works was located; and

- Elevated PID readings were noted in the Made Ground in TP710D located by the former Compressor House and hydrogen tanks.

Contamination potentially derived from Site Processes

At some locations, the nature of the contamination suggests the source of the potential contamination is not associated with the Made Ground present, and is instead likely to have been derived from site activity:

- A hydrocarbon odour was noted in the Made Ground and a sulphur odour were noted in the drift at TP711D located by the Fatty Alcohol Plant and the Compressor House.

- Water with a black oily sheen was noted in both TP710D and TP711D located by the Fatty Alcohol and the Compressor House.

- sulphuric and kerosene odour was noted in the Made Ground in TP706D located on the site of the former Alabaster Works

Unidentified sources of contamination

In WS715D black staining was noted below a large wooden stake at 3.5m. This soil bore is located by the former MOS and MO plants and the former hydrogen tanks; No staining or distinctive layer of contamination was observed nor was olfactory evidence present.

No visual or olfactory evidence of contamination

Trial pits with no visual or olfactory evidence of contamination include: TP701D, TP702D, TP703D, TP705D, TP708D, TP709D, TP713D, TP714D, TP716D, TP718D, TP719D, WS712D and WS717D. The majority of these are located in the area of the former Alabaster works and the MOS, MO and UFEX Plants.

4.5. Geochemical Results

The analytical schedules and results of laboratory chemical analyses are provided in detail in Table 1 and Tables 3 to 20, and included in Appendix D to this report (enclosed as a CD). The laboratory certificates are also included in Appendix D.

This section introduces an initial understanding of the distribution of key analytes detected in the soil, leachate and groundwater on the site. The term 'elevated' refers to the comparison between a reported analyte concentration compared to an average concentration for that compound calculated from all data across the investigation area. An assessment of whether the analyte concentration represents a "significant risk" to either controlled waters or human health receptors is made within Sections 6 and 7 in this report.

Volatile Organic Compounds (VOCs)

25 soil samples were scheduled for VOC analysis. Of the samples analysed, 6 had reported concentrations greater than the laboratory method detection limit (MDL). Elevated concentrations of VOCs are summarised in the Table 4.3 below:

Table 4.3 – Elevated Concentrations of VOCs (soil)

VOC in soil	Minimum reported concentration (mg/kg)	Maximum reported concentration (mg/kg)	Number of samples with elevated concentrations	Strata elevated concentrations located in
Chloroform	0.008	0.079	1	Made Ground
M,P, Xylene	0.014	0.086	1	Made Ground
O Xylene	0.01	0.05	1	Made Ground
Tetrachloroethene	0.005	0.009	1	Made Ground
Toluene	0.005	0.018	5	Made Ground
Trichloroethene	0.009	0.025	1	Made Ground

Concentrations of toluene above the method detection limit appear to be location in the centre of Plot D. No obvious spatial correlation of the remaining VOCs in soil exists over Plot D.

VOC analysis was not carried out on soil leachates as the leaching methodology is unsuitable for VOCs, i.e. it allows VOCs to escape during the leaching process and thus results obtained would be unrealistically low.

Two samples were taken for VOC analysis of groundwater in Plot D. WS715D showed no elevated concentrations over the laboratory method detection limited (MDL). Elevated concentrations of M, P xylene, naphthalene and toluene were observed in WS717D.

Metals

Ten soil samples and one groundwater sample were scheduled for metals analysis. In addition, 20 samples were scheduled for NRA leachate preparation and analysis. Elevated concentrations are summarised in the Tables 4.4, 4.5 and 4.6 below:

Table 4.4 – Elevated Concentrations of Metals (Soils)

Metal in soil	Minimum reported concentration (mg/kg)	Maximum reported concentration (mg/kg)	Number of samples with elevated concentrations	Strata elevated concentrations located in
Arsenic	3	44	5	Made Ground (4) Drift (1)
Cadmium	0.4	3	3	Made Ground
Boron	3.5	4.9	3	Made Ground (3)
Chromium	4.5	110	2	Made Ground (2)
Copper	6	380	2	Made Ground
Lead	2	190	2	Made Ground
Mercury	0.6	6.9	1	Made Ground
Nickel	0.9	130	3	Made Ground (2), Drift (1)
Selenium	3	5	1	Drift
Zinc	2.5	380	4	Made Ground

Elevated concentrations of metals in soil are observed continuously across Plot D, with no obvious spatial pattern.

Table 4.5 – Elevated Concentrations of Metals (Soil Leachate)

Leachable Metal	Minimum reported concentration (µg/l)	Maximum reported concentration (µg/l)	Number of samples with elevated concentrations	Strata elevated concentrations located in
Arsenic	1	55	5	Made Ground (4), Drift (1)
Boron	10	160	8	Made Ground (7), Drift (1)
Chromium	1	13	1	Made Ground
Copper	1	73	4	Made Ground (3), Drift (1)
Lead	1	38	1	Drift
Nickel	1	17	7	Made Ground (5), Drift (2)
Selenium	1	26	5	Made Ground (3), Drift (2)

Leachable Metal	Minimum reported concentration (µg/l)	Maximum reported concentration (µg/l)	Number of samples with elevated concentrations	Strata elevated concentrations located in
Zinc	3	28	8	Made Ground (5), Drift (3)

Concentrations of leachable arsenic and leachable boron above their respective average concentrations for Plot D are located in the southern area of Plot D. Elevated concentrations of leachable copper are located in the centre of Plot D. No obvious spatial correlation of the remaining metals in leachate exists in Plot D.

Table 4.6– Elevated Concentrations of Metals (Water)

Metal in water	Minimum reported concentration (µg/l)	Maximum reported concentration (µg/l)	Number of samples with elevated concentrations	Strata elevated concentrations located in
Arsenic	1	14	1	Groundwater
Boron	10	110	1	Groundwater
Nickel	1	11	1	Groundwater
Selenium	1	20	1	Groundwater
Zinc	3	8	1	Groundwater

Elevated concentrations of metals in groundwater were only observed in WS715D.

The majority of elevated concentrations of metals were reported in soil and leachate samples collected from within the Made Ground. As is typical with any historic industrial facility, ash and clinker were used as fill during levelling ground works on the site and these are typically considered to be a likely source for the increase of concentrations of metals in shallow horizons. Elevated concentrations of metals in soil and leachate were also observed in drift.

Anionic Surfactants

Concentrations of surfactants above the MDL were reported in four of the 14 samples submitted for NRA leachate preparation and analysis. The minimum reported concentration was 50µg/l and the maximum concentration was 53000µg/l in Made Ground from 2m at TP705A. The elevated concentrations of anionic surfactant are located centrally in Plot D.

Semi Volatile Organic Compounds (SVOCs)

20 soil samples were scheduled for SVOC analysis and 31 samples were scheduled for leachate preparation and analysis. Elevated concentrations are summarised in Tables 4.7 and 4.8 below.

Table 4.7– Elevated Concentrations of SVOCs (Soils)

SVOC in soil	Minimum reported concentration (mg/kg)	Maximum reported concentration (mg/kg)	Number of samples with elevated concentrations	Strata elevated concentrations located in
2 Methylnaphthalene	0.1	6	6	Made Ground
Acenaphthene	0.1	0.72	3	Made Ground
Acenaphthylene	0.1	0.28	1	Made Ground
Anthracene	0.1	2	3	Made Ground
Benzo (a) Anthracene	0.1	5.1	4	Made Ground
Benzo (a) Pyrene	0.1	4.5	3	Made Ground
Benzo (b) Fluoranthene	0.1	5.5	3	Made Ground
Benzo (g,h,i) perylene	0.1	2.3	3	Made Ground
Benzo (k) fluoranthene	0.1	2.3	3	Made Ground
Bis (2-Ethylhexyl) phthalate	0.1	4.8	1	Made Ground
Butylbenzylphalate	0.1	0.89	1	Made Ground
Carbazole	0.1	1.4	2	Made Ground
Chyrsene	0.1	5.2	3	Made Ground
Dibenz (a,h) anthracene	0.1	0.74	3	Made Ground
Dibenofuran	0.1	1.2	7	Made Ground
Di-N-Butylphthalate	0.1	0.42	1	Made Ground
Fluoranthene	0.1	11	4	Made Ground
Fluorene	0.1	0.71	7	Made Ground
Indeno (1,2,3 – cd) pyrene	0.1	1.9	2	Made Ground
Naphthalene	0.1	2.6	7	Made Ground
Phenanthrene	0.1	10	6	Made Ground
Pyrene	0.1	9.4	3	Made Ground

The majority of elevated concentrations of SVOCs in soil are located in the north of Plot D. and are collected from the Made Ground.

Table 4.8 Elevated concentrations of SVOC (leachate)

SVOC in leachate	Minimum reported concentration (µg /l)	Maximum reported concentration (µg /l)	Number of samples with elevated concentrations	Strata elevated concentrations located in
Acenaphthene	1	15	1	Made Ground
Acenaphthylene	1	5	1	Made Ground
Anthracene	1	9	1	Made Ground
Bis (2-ethyhexyl) phthalate	1	2	1	Made Ground
Dibenzofuran	1	9	1	Made Ground
Di-N-Butylphthalate	1	3	1	Made Ground
Fluoranthene	1	5	2	Made Ground (1), Drift (1)
Fluorene	1	24	1	Made Ground
Phenanthrene	1	28	1	Drift
Pyrene	1	3	2	Made Ground

The majority of elevated concentrations of SVOCs in leachate were observed in TP706D at 2m. One groundwater sample was taken for SVOC analysis (WS715D) within which no concentrations exceeded the laboratory method detection limit (MDL).

Total Petroleum Hydrocarbons (TPH)

21 samples were submitted for TPH analysis, 10 for risk based evaluation (RBE) analysis, and 11 for criteria working group (CWG) analysis. Elevated concentrations for CWG analysis are summarised in table 4.9 below. Elevated concentrations were reported for the risk based evaluation (RBE) analysis. Total Aliphatics (C6-C40) illustrated an elevated concentration of 55 mg/kg in TP713D at 0.5m; Total Aromatics (C6-C40) showed an elevated concentration of 91 mg/kg in TP706D at 4.2m and Total Hydrocarbons demonstrated four exceedances above the area average, with a maximum concentration of 850 mg/kg.

Table 4.9 Elevated concentrations of TPH CWG in soil

TPH in soil	Minimum reported concentration (mg/kg)	Maximum reported concentration (mg/kg)	Number of samples with elevated concentrations	Strata elevated concentrations located in
TPH (EC12-16) Aromatic	0.1	160	4	Made Ground
TPH (EC16-21) Aromatic	0.1	1200	3	Made Ground

TPH in soil	Minimum reported concentration (mg/kg)	Maximum reported concentration (mg/kg)	Number of samples with elevated concentrations	Strata elevated concentrations located in
TPH (EC21-35) Aromatic	0.1	4100	3	Made Ground
Total Aromatic	0.1	5800	4	Made Ground
TPH (EC12-16) Aliphatic	0.1	23	5	Made Ground (4), Drift (1)
TPH (EC16-21) Aliphatic	0.1	40	4	Made Ground
TPH (EC21-35) Aliphatic	0.1	1600	3	Made Ground (2), Drift (1)
Total Aliphatic	0.1	1600	4	Made Ground (3), Drift (1)
TPH (C5-C35)	0.1	5800	6	Made Ground (5), Drift (1)
Toluene	0.01	0.041	1	Made Ground
M,P - xylene	0.01	0.03	1	Made Ground

Elevated concentrations of TPH CWG in soils are mainly confined to TP703D at 0.5m, TP705D at 1.5m, TP706D at 2m and TP711D at 0.4m and 2.4m.

One of the thirty samples submitted for NRA leachate analysis and preparation reported concentrations of TPH above the MDL. Elevated concentrations were reported for TPH in TP706D at 2m, this included TPH (EC12-16) Aromatics at 37 μg/l; TPH (EC16-21) Aromatics at 100 μg/l; Total Aromatics at 140 μg/l and TPH (C5-C35) at 140 μg/l. One groundwater sample was taken for TPH analysis (WS715D) within which no concentrations exceeded the laboratory method detection limit (MDL).

Additional Analytes

Eleven samples were scheduled for Polychlorinated Biphenyls (PCB) soil analysis. None of the samples reported concentrations of leachable PCBs above the MDL.

Further additional analytes include: ammoniacal nitrogen (15 soil, 1 groundwater analyses), cyanide (10 soil, 19 leachate, 1 groundwater), sum of cyanides (10 soil), nitrogen as N (15 soil, 1 groundwater), phosphate as ortho (17 soil, 28 leachate, 1 groundwater), total sulphate (15 soil, 14 leachate 1 groundwater), pH (15 soil, 37 leachate, 1 groundwater), total organic carbon (2 soil), chloride (1 groundwater), electrical conductivity (1 soil) and phosphorous (1 soil). Tables 4.10, 4.11 and 4.12 summarises the elevated concentrations reported for these analytes.

Table 4.10 – Elevated Concentrations of Additional Analytes (Soils)

Additional analytes in soil	Minimum reported concentration (mg/kg)	Maximum reported concentration (mg/kg)	Number of samples with elevated concentrations	Strata elevated concentrations located in
Nitrate as N	1	9	8	Made Ground (6), Drift (2)-
Phosphate (as ortho)	1	26	2	Drift
Cyanide	1	350	1	Made Ground
Total Sulphate	100	70000	3	Made Ground

Table 4.11 – Elevated Concentrations of Additional Analytes (leachate)

Additional analytes in leachate	Minimum reported concentration (μg/l)	Maximum reported concentration (μg/l)	Number of samples with elevated concentrations	Strata elevated concentrations located in
Phosphate (as ortho)	80	49000	2	Made Ground (1), Drift (1)-
Sulphate	3000	1400000	5	Made Ground

No obvious spatial correlation of elevated additional analytes in soils or leachable metal concentrations exists over Plot D. The majority of elevated concentrations of metals were reported in samples collected from within the Made Ground. One groundwater sample was taken for additional analyte analysis (WS715D) within which chloride (51,000ug/l), Nitrate as N (2,200 ug/l), phosphate (51,000 ug/l) and sulphate (160,0000 ug/l) exceeded the laboratory method detection limit (MDL).

Summary

Based on the analytical results of this site investigation, it is considered that the majority of samples with elevated concentrations are located within the Made Ground forming small pockets across Plot D.

5. CONCEPTUAL SITE MODEL

5.1. Introduction

The objective of the conceptual site model is to place the environmental, geological and hydrogeological information obtained to date in the context of a risk-based setting, and produce a conceptual model of the site. The conceptual model of the site will highlight the primary sources of site contamination and the sources of exposure to potential receptors. The conceptual model assumes the site use is public open space.

The findings of this preliminary qualitative assessment will be used to define the extent and nature of the quantitative risk assessment.

Copeland Borough Council determined the site as contaminated land on the basis of the pollutant linkages listed below. These pollutant linkages are of a very general nature, and in order to present a meaningful assessment, URS has carried out a more detailed analysis, presented in the sections below.

Copeland Borough Council Pollutant Linkages
Petroleum Hydrocarbons in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Poly Aromatic Hydrocarbons in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Surfactants in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Phosphates in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Arsenic in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Boron in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Cadmium in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Chromium in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Copper in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Lead in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.

Copeland Borough Council Pollutant Linkages
Mercury in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Nickel in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Selenium in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
Zinc in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.
VOC's/SVOCs in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.

5.1.1. Potential Sources

Potential contaminant sources on site associated with current and historical uses, as outlined previously in Section 3.5 and detailed in the Site Remediation Statement (23 June 2006 ref 44319877/R2234.B01), and the proposal and EA correspondence in Appendix A. These comprise the following**;**

Table 5.1a – Summary of potential Sources

Potential Sources	Contaminants of Concern
Fatty Alcohol Plant	Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons, and Nitrates
The MO and MOS Plants	Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons and Nitrates
Alabaster Works	Heavy Metals, Petroleum Hydrocarbons, Phosphates and Sulphates
Outfall from the Cathedral (Former Smoothing Chambers and pH balancing area).	Surfactant and potentially other analytes within process effluent
Made Ground	VOCs, SVOCs, Heavy Metals, Petroleum Hydrocarbons, Ammonium, Nitrates, Cyanide and Sulphates

In their determination of the site as "contaminated land", Copeland Borough Council listed a number of contaminants which they considered likely to be present on the site as a result of its previous history. These contaminants were included in Assessment Action to ensure that the possibility of there being Contaminants of Concern is fully evaluated.

5.2. Potential Pathways

Copeland Borough Council's determination of the land as contaminated land refers to only two pathways – the movement of contaminants from soil to groundwater, and the migration of contaminants to controlled waters through drains. In the generation of the Remediation Statement, URS refined the understanding of the pathways. The pathways that are relevant to the land to which this report relates are listed below in Table 5.2a.

Table 5.2a Pathway details

Pathway	Pathway characteristics
Controlled Water 1 (CW1)	a) Infiltration of rainwater through contaminated soil and subsequent leaching and vertical movement to shallow groundwater. b) Migration of rainwater through the drainage system, possibly resulting in dissolution of contaminants and/or the mobilisation of contaminants within the drains, leading to discharge into shallow groundwater at point where the integrity of the drainage lines has been compromised by exposure to acid.
Controlled Water 2 (CW2)	Vertical movement of dissolved or liquid contaminants from shallow groundwater to groundwater within the St. Bees Evaporite Formation. Movement from shallow groundwater to groundwater in the St. Bees Evaporite Formation may be enhanced by engineering earthwork which is likely to have been undertaken in the development of the site (removal of drift, build up of made ground) and by faulting in certain areas or may also be retarded by the presence of concrete foundations and cellars.
Controlled Water 3 (CW3)	The potentially rapid flow of groundwater within the St. Bees Evaporite Formation via complex pathways in a west/southwest direction towards the coast and the Irish Sea. This occurs through flow in solution features in the St. Bees Evaporite Formation, interaction with faults, and through mine adits).

Pathway	Pathway characteristics
Human Health 1 (HH1)	Dermal contact/ingestion of contaminated soil.
Human Health 2 (HH2)	Inhalation of vapours from soil and/or groundwater.
Human Health 3 (HH3)	Inhalation of dust from contaminated soil.

5.3. Potential Receptors

Table 5.3a Receptor characteristics

Receptor	Receptor characteristics
Humans: Public using the open space	Mainly local residents, likely to use the site for dog walking and other recreation. The critical receptor (person most likely to come to harm) in the risk assessment was a female child aged 6 or under, visiting the site to play for an estimated average 119 days per year. Other, more probable users, would be at lower risk.
Controlled waters: The Irish Sea.	Groundwater migrates via complex underground pathways towards the Irish Sea. It is likely to discharge via the Byerstead Fault Spring on Saltom Beach, located 1.3km away.

5.4. Pollutant Linkages

For a significant 'pollutant linkage' to exist, a *source* of contamination (e.g. a leaking storage tank) must be connected to via a *pathway* (e.g. surface water) to a receptor (e.g. a nearby stream). Pollutant linkages apply to Controlled Waters and Human Health Receptors.

5.4.1. Controlled Waters

The analytes that were considered to present a potentially significant risk to controlled waters were identified in Section 4.0 of the Site Remediation Statement document. Various pollutant linkages are thought to exist from these contaminant sources. Table 5.4a below shows the significant pollutant linkages considered to exist from the identified potential contaminants of concern to the identified controlled waters receptor (please note that the pathway codes refer to the pathways detailed in Table 5.2a).

Table 5.4a Particulars of Substances and Significant Harm/Pollution of Controlled Waters

Pollutant Linkage Identifier	Pollutant	Plot D Source location	Pathway	Main Receptor	Subsequent Receptors	Description of Harm/Pollution of Controlled Waters
C1	Likely substances from the Fatty Alcohol Plant Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons, and Nitrates	The Fatty Alcohol Plant	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St Bees Evaporite Formation before rapidly migrating to the Irish Sea.
C2	Likely sources of contamination include Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons and Nitrates	The MO and MOS Plants.	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St Bees Evaporite Formation before rapidly migrating to the Irish Sea.
C3	Likely substances from the Alabaster Works include Heavy Metals, Petroleum Hydrocarbons, Phosphates and Sulphates	Alabaster Works	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St Bees Evaporite Formation before rapidly migrating to the Irish Sea.
C4	Likely sources of contamination include VOCs, SVOCs and PAHs	The Catalyst Preparation Plant and Fatty Alcohol Plant.	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St Bees Evaporite Formation before rapidly migrating to the Irish Sea.
C5	Substances associated with fill material VOCs, SVOCs, Heavy Metals, Petroleum Hydrocarbons, Ammonium, Nitrates, Cyanide and Sulphates	Made Ground comprising ash and clinker and other diffuse sources	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St Bees Evaporite Formation before rapidly migrating to the Irish Sea.

5.4.2. Human Health

Copeland Borough Council determined the site as contaminated land on the basis of the pollutant linkages with regard to controlled waters receptors. However, based on the additional data provided from the most recent investigation it was considered prudent to revise and update the existing site-wide human health risk assessment to a area-specific

assessment for Plot D. Therefore Table 5.4b below shows the significant pollutant linkages considered to exist from the identified potential contaminants of concern to the identified human health receptors (please note that the pathway codes refer to the pathways detailed in Table 5.2a).

Table 5.4b Particulars of Substances and Significant Harm/Pollution of Human Health

Pollutant Linkage Identifier	Pollutant	Plot D Source location	Pathway	Main Receptor	Additional Receptors	Description of Harm/Pollution of Controlled Waters
H1	Likely substances from the Fatty Alcohol Plant Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons, and Nitrates	The Fatty Alcohol Plant	HH1, HH2, HH3	0-6 yr old female child	Other site users	Incidental ingestion, dust inhalation and dermal contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater
H2	Likely sources of contamination include Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons and Nitrates	The MO and MOS Plants.	HH1, HH2, HH3	0-6 yr old female child	Other site users	Incidental ingestion, dust inhalation and dermal contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater
H3	Likely substances from the Alabaster Works include Heavy Metals, Petroleum Hydrocarbons, Phosphates and Sulphates	Alabaster Works	HH1, HH2, HH3	0-6 yr old female child	Other site users	Incidental ingestion, dust inhalation and dermal contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater
H4	Likely sources of contamination include VOCs, SVOCs and PAHs	The Catalyst Preparation Plant and Fatty Alcohol Plant.	HH1, HH2, HH3	0-6 yr old female child	Other site users	Incidental ingestion, dust inhalation and dermal contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater

Pollutant Linkage Identifier	Pollutant	Plot D Source location	Pathway	Main Receptor	Additional Receptors	Description of Harm/Pollution of Controlled Waters
H5	Substances associated with fill material VOCs, SVOCs, Heavy Metals, Petroleum Hydrocarbons, Ammonium, Nitrates, Cyanide and Sulphates	Made Ground comprising ash and clinker and other diffuse sources	HH1, HH2, HH3	0-6 yr old female child	Other site users	Incidental ingestion, dust inhalation and dermal contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater

6. HUMAN HEALTH RISK ASSESSMENT

6.1. Introduction

Details of the rationale, methodology and results of the modelling undertaken for the human health quantitative risk assessment are presented in full in Appendix E and are summarised below.

The primary objective was to assess the potential risk to human health assuming the site is opened to the general public for a right-to-roam open space usage. The screening assessment is based on the current condition of the subsurface soil and groundwater beneath Plot D as detected by investigations undertaken at the site.

6.2. Stage 2 Assessment

A Stage 2 generic screening risk assessment was undertaken using a residential without garden scenario. A number of substances were identified which exceeded their respective generic screening criteria:

Soil

- **Metals, metalloids and inorganic** – arsenic, nickel, cyanide;
- **PAH** –benzo(a)pyrene, dibenzo[a,h]anthracene; and
- **TPH** – assessed via TPH Criteria Working Group (TPHCWG) fractions.

6.3. Stage 2 Risk Evaluation

Prior to assessing the exceedances at Stage 3 (DQRA) further review has been made with regard to the significance of the contamination in the context of the proposed public open space end use of the site. This has comprised further assessment of the plausibility of the identified pollutant linkages and has taken into consideration factors such as the nature, extent and location of the detected contamination (i.e. the size of the source), the likely pathways for receptor exposure, receptor behaviour, condition and circumstances of the land and other factors which may prevent or enhance potential exposure.

Therefore for the exceedances identified at Stage 2 further assessment has been completed and the significance for potential harm identified. Where appropriate, assessment has also included the use of simple statistical tests in accordance with CLR7 to derive averaging concentrations for the area to which a receptor could potentially be exposed while occupying the site. Data relating to the adjacent Plot A has also been reviewed in addition to the data for Plot D in completing the risk evaluation process.

It should also be noted that the generic assessment criteria for the Stage 2 assessment are based upon a conceptual exposure model[2] which is highly conservative for the 'right to roam' end use and is designed to be suitably protective of future site users.

The evaluation of each of the Stage 2 potential sources is presented in Tables E4 and E5 in Appendix E.

6.4. Summary of Risks to Human Health

In summary, it is considered that there are no contaminant concentrations detected in this area of the site which are considered to represent a significant possibility of significant harm to the identified receptors based on the proposed end-use of the site.

Therefore, should the current condition and layout of Plot D be maintained, it is considered that potentially significant risks to human health would be unlikely for a public open space scenario. Plot D is considered suitable for use as public open space without the requirement for further action, with the exception of addressing Health and Safety issues (such as the removal of protruding trip hazards etc).

The risks to potential future maintenance, remediation or redevelopment workers who may be involved in subsurface working are not specifically assessed as part of this report. URS advises that separate activity related risk assessments should be carried out as required to comply with the necessary legislation and guidance, which identifies the need for any preventative measures (such as the use of PPE) to be completed prior to such activities being carried out. The results of this human health assessment however could be used to inform decision-making on this issue.

[2] Residential without gardens

7. CONTROLLED WATERS QUANTITATIVE RISK ASSESSMENT

7.1. Introduction

Details of the rationale, methodology and results of the modelling undertaken for the Controlled Waters Quantitative Risk Assessment are presented in full in Appendix G and are summarised below.

7.2. Stage 2 Assessment

A Stage 2 generic quantitative screening risk assessment was undertaken that incorporated the new March 2007 data, and compared measured concentrations to the generic screening values for the protection of Controlled Waters (in this case, Marine EQS values).

The results are summarised in Table 7.1.

Table 7.1 – Controlled Waters Stage 2 Summary of Screening Criteria Exceedances

Soil	Soil Leachate	Shallow Groundwater
chloroform	arsenic	copper
trichloroethene	copper	selenium
toluene (2)	lead	nickel
tetrachloroethane	selenium (1)	zinc
	fluoranthene (2)	naphthalene
	phenanthrene	benzo(a)anthracene
	TPH C12-C16 Aromatic	
	TPH C16-C21 Aromatic	

Each of the determinands whose concentrations exceeded their respective Stage 2 criterion were then assessed to determine whether the potential risk they posed was realistic. As such, the geochemical profile, geological horizons, water strikes, and field observations of contamination were all considered. For example, if the exceedance was from a sample taken in the made ground, it was not necessarily a risk. If the underlying geology was several meters of dry low permeability clay, and a deep sample from within or below this clay did not detect this analyte, then this risk may have not be deemed significant, given the pathway into the underlying evaporites (which forms part of the pollutant linkage) was not realistic. Therefore this analyte may have been discounted and not taken to Stage 3. Conversely, if contamination was found in granular wet made ground, that sat directly onto bedrock, this will have been considered significant.

If a pollutant linkage was deemed potentially significant or could not be discounted (due to insufficient geochemical and geological evidence) they were taken forward to Stage 3, the detailed quantitative risk assessment.

The evaluation of each of the Stage 2 potential sources is presented in Section 3.5 in Appendix G.

7.3. Stage 3A Assessment

The hydrogeological sequence onsite is complex. It has been further compounded by historic site activities, the most prevalent of which has been the deposition of acids into the ground, resulting in voids and channels being created in certain locations, some of which are likely to be in Plot D.

Given the complexity of the geology in Plot D and the rapid travel times for migration sourced from Plot D, no standard model (e.g. CONSIM, which was used in Plots B and C) was considered to be appropriate. Instead, a mass balance approach was adopted in order to assess potential risks. This approach is described in detail, with examples, in Appendix G, a brief overview is given here.

Stage 3a calculates the concentrations of contaminants entering the underlying geology based on contaminated groundwater from the source zone mixing with surrounding clean groundwater prior to entry into the St. Bees Evaporite sequence. This mixing results in dilution of the contaminant concentrations. The diluted concentrations are then compared directly against their respective screening criteria. If the contaminant concentrations have been diluted below their respective Marine EQS values, they are no longer considered to represent a significant risk to controlled waters. However, if they are still in exceedance, they will be entered into the Stage 3B model discussed in Section 7.4.

The following contaminants identified in Stage 2 were still found to be in exceedance of their respective Stage 2 screening values.

Table 7.2 – Controlled Waters Stage 3a Summary of Screening Criteria Exceedances

Soil	Soil Leachate	Shallow Groundwater
chloroform	fluoranthene (2)	nickel
trichloroethene	TPH C16-C21 Aromatic	naphthalene
		selenium
		zinc

7.4. Stage 3B Assessment

The current model builds upon the previous modelling. Specifically, it recognises the potential for an *offsite* dilution of site derived waters. This is due to the infiltration of clean water through the St. Bees Sandstone (located down hydraulic gradient), and its subsequent vertical movement into the underlying units, which includes the St. Bees Evaporites, where the conduits containing the site derived waters are thought to exist. As the clean waters enter the conduits, they dilute the site derived waters.

The model takes the Stage 3a assessment to the next step (through generating a second dilution), by considering rainfall, surface area of infiltration into the St. Bees Sandstone, likely infiltration rates through the geological strata, and combines this with a mass of contamination (a concentration).

As the concentration reduces after this second dilution, the resultant analyte concentrations are then compared to their respective screening criteria.

The results of the Stage 3b assessment are summarised in Table 7.3. Further details regarding the methodology, limitations and assumptions are included in Appendix G.

Table 7.3 – Controlled Waters Stage 3b - Summary of Screening Criteria Exceedances

Soil	Soil Leachate	Shallow Groundwater
chloroform	fluoranthene	zinc
		naphthalene
		nickel

7.5. Summary of Risks to Controlled Waters

The results of the modelling have indicated that potentially significant risks may be present with regard to controlled waters. Three areas of the site: an area around TP708D; the area around TP706D; and the area around WS123, WS416 and WS717D will require further investigation and assessment to determine whether or not remedial action may be required. These areas are shown on Figure 9.

8. REFINED POLLUTANT LINKAGE ASSESSMENT

The human health risk assessment for Plot D has indicated that there are no potentially significant risks with regard to a proposed end use of public open space. The controlled waters risk assessment has identified some analytes that pose a theoretical potential risk to the identified receptors. The following section provides a review on the plausibility of the modelled potential pollutant linkages (Section 5.4) as detailed in the Site Remediation Statement.

The controlled waters risk assessment has used a worst case assessment where by each hotspot identified is assessed against meeting the respective EQS on entry into the Irish Sea via theoretical solution features located immediately beneath each hotspot within the St Bees Evaporite Formation. The assessment assumes rapid flow within the St Bees Evaporite Formation to the Irish Sea, based on the travel times of dye tracing from the vicinity of Plot D to the Byerstead Spring being in the order of 10 hours. The assessment at Stage 3a makes no allowance for dilution or lateral/vertical attenuation within the unsaturated zone above the St Bees Evaporite Formation. Dilution is considered at Stage 3B, but this only accounts for dilution of site derived waters once they have entered into the St. Bees Evaporites.

This model considers the complex hydrogeological regime at the site, and specifically within Plot D, where a number of solution features are thought to exist (solution features are known to exist beyond the plot boundary). However, whilst every effort has been made to develop a reasonably realistic model, there is insufficient detailed information on the precise location and nature of solution features within Plot D, resulting in there being an element of conservatism in the model.

It is considered highly likely that solution features are present within the site, however, it is unlikely that there are as extensive as considered by the model. The model has also assumed that the contaminants are present immediately above the solution features. Physical evidence from the site suggests that an unsaturated zone is present in most areas between the contaminated soils and the theoretical receptor. Consideration has been given to modelling a variety of situations to take this into account, but given the complexity of the geological, and hydrogeological conditions, coupled with the spatial distribution of the modelled hotspots, each model would have its own inherent conservative elements and to remove these would require an enormous amount of additional data gathering. It is doubtful whether such an exercise would add any benefit to the assessment given that the overall picture of the site that has emerged from the investigation is that there is no evidence of widespread contamination.

Whilst the assessment has identified a number of potential risks, we have considered the field and laboratory data in conjunction with the results of the modelling. This has provided a balanced view on the plausibility of pollutant linkages for each identified hotspot.

Table 8.1 – Refined Pollutant Linkage Assessment

Pollutant Linkage Identifier	Pollutant	Plot D Source location	Pathway	Main Receptor	Subsequent Receptors	Description of Harm/Pollution of Controlled Waters	Does the linkage still exist, and is it still significant based on the recent site investigation and risk assessment? (Y/N)
C1	Likely substances from the Fatty Alcohol Plant Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons, and Nitrates	The Fatty Alcohol Plant	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St. Bees Evaporites before rapidly migrating to the Irish Sea.	No. Source not identified
C2	Likely sources of contamination include Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons and Nitrates	The MO and MOS Plants.	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St. Bees Evaporites before rapidly migrating to the Irish Sea.	1) VOCs. No. Tetrachloroethene (PCE). A soil concentration of 0.15mg/kg in WS416 at a depth of 0.45m. Sample from granular Made Ground with a shallow groundwater table present 1.2m below ground level. Therefore, it is considered likely that mobile contamination would have impacted the shallow groundwater by now. PCE not detected in water samples from WS416 or the other water samples analysed. Therefore pathway not considered significant. 2) No. Surfactants, Phosphates, Sulphates, Petroleum Hydrocarbons. Source not identified. 3) SVOCs. Yes. A potential risk has been identified from naphthalene. Potential risks associated with naphthalene in vicinity of WS123, WS416 and WS717D are considered to require further assessment. Additional data is required to delineate the extent of naphthalene contamination and its potential significance in this area. Refer to Section 9. 4) Benzo(a)anthracene. No. This analyte was detected in groundwater at WS416 (0.11μg/l, screening criteria is 0.09μg/l). Subsequent dilution would result in a benzo(a)anthracene concentration less than the screening criteria. Therefore, source not considered significant. 5) Zinc. Yes. Potential risks associated with zinc in perched groundwater in vicinity of WS123, WS416 and are considered to require further assessment. These areas require further delineation and assessment. Refer to Section 9.

Pollutant Linkage Identifier	Pollutant	Plot D Source location	Pathway	Main Receptor	Subsequent Receptors	Description of Harm/Pollution of Controlled Waters	Does the linkage still exist, and is it still significant based on the recent site investigation and risk assessment? (Y/N)
C3	Likely substances from the Alabaster Works include Heavy Metals, Petroleum Hydrocarbons, Phosphates and Sulphates	Alabaster Works	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St. Bees Evaporites before rapidly migrating to the Irish Sea.	1) Copper. No. Source Considered to be related to the nature of the backfilled made ground in this area (Refer to Section 3.5 of Appendix G).
C4	Substances associated with fill material VOCs	The Catalyst Preparation Plant and Fatty Alcohol Plant.	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St. Bees Evaporites before rapidly migrating to the Irish Sea.	No. Source not identified
C5	Substances associated with fill material VOCs, SVOCs, Heavy Metals, Petroleum Hydrocarbons, Ammonium, Nitrates, Cyanide and Sulphates	Made Ground comprising ash and clinker and other diffuse sources	CW1, CW2, CW3	The Irish Sea	-	Potential for entry of contaminant into the St. Bees Evaporites before rapidly migrating to the Irish Sea.	1) VOCs. Yes. A potential risk has been identified from chloroform in TP708D. Additional data is required to delineate the extent of Chloroform contamination and its potential significance in this area. Refer to Section 9. 2) Fluoranthene. Yes. Potential risks associated with fluoranthene have been identified at TP706D. These areas require further delineation and assessment. Refer to Section 9. 3) TPH. No. Potential pollutant linkage identified for TPH at TP706D. However, groundwater modelling has determined that these risks are not significant. Therefore source not significant. 4) Copper. No. Potential linkage identified for copper in shallow groundwater at WS416 but not considered significant based on site observations and ground conditions. (Refer to Section 3.5 of Appendix G). 5) Nickel. Yes. A potential risk has been identified from nickel in the vicinity of WS416. Further data gathering and assessment is required to determine whether remedial action is required (included in the Scope in Section 9.1).
H1	Likely substances from the Fatty Alcohol Plant	The Fatty Alcohol	HH1, HH2,	0-6 yr old female	Other site	Incidental ingestion, dust inhalation and dermal	No. Stage 2 Risk Assessment indicates no significant risk.

Pollutant Linkage Identifier	Pollutant	Plot D Source location	Pathway	Main Receptor	Subsequent Receptors	Description of Harm/Pollution of Controlled Waters	Does the linkage still exist, and is it still significant based on the recent site investigation and risk assessment? (Y/N)
	Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons, and Nitrates	Plant	HH3	child	users	contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater	
H2	Likely sources of contamination include Surfactants, VOCs, SVOCs, Heavy Metals, Phosphates, Sulphates, Petroleum Hydrocarbons and Nitrates	The MO and MOS Plants.	HH1, HH2, HH3	0-6 yr old female child	Other site users	Incidental ingestion, dust inhalation and dermal contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater	No. Stage 2 Risk Assessment indicates no significant risk.
H3	Likely substances from the Alabaster Works include Heavy Metals, Petroleum Hydrocarbons, Phosphates and Sulphates	Alabaster Works	HH1, HH2, HH3	0-6 yr old female child	Other site users	Incidental ingestion, dust inhalation and dermal contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater	No. Stage 2 Risk Assessment indicates no significant risk.
H4	Likely sources of contamination include VOCs, SVOCs and PAHs	The Catalyst Preparation Plant and Fatty Alcohol Plant.	HH1, HH2, HH3	0-6 yr old female child	Other site users	Incidental ingestion, dust inhalation and dermal contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater	No. Stage 2 Risk Assessment indicates no significant risk.
H5	Substances associated with fill material VOCs, SVOCs, Heavy Metals, Petroleum Hydrocarbons, Ammonium, Nitrates, Cyanide and Sulphates	Made Ground comprising ash and clinker and other diffuse sources	HH1, HH2, HH3	0-6 yr old female child	Other site users	Incidental ingestion, dust inhalation and dermal contact with contaminated soil. Vapour inhalation of contaminants in soil and groundwater	No. Stage 2 Risk Assessment indicates no significant risk.

9. REMEDIATION ACTIONS

9.1. Summary of remediation actions required relating to Pollutant Linkages Identified specific to Plot D

The majority of potential pollutant linkages have been shown to be not significant, and for these linkages no remediation actions will be necessary. Some potential linkages have been identified which will require additional investigation in order to assess their significance.

The results of the modelling have indicated that potentially significant risks may be present with regard to controlled waters. Three areas of the site: an area around TP708D; the area around TP706D; and the area around WS123, WS416 and WS717D will require further investigation and assessment to determine whether or not remedial action may be required. Refer to Figure 9.

The following outline scope of works is recommended to assess the necessity for remedial action.

The following outline scope of works is recommended to assess the necessity for remdial action.

Area 1- The area in the vicinity of TP708D

It is proposed that up to 4 trial pits are advanced to 5mbgl (or bedrock, if shallower) in the vicinity of TP709D. Soil samples shall be taken at approximately 0.5m intervals for subsequent on site headspace analysis. Up to two samples shall be scheduled for analysis from each location; one shallow sample within the made ground and one deeper sample within the underlying strata, where possible). If a significant presence of contamination is detected, additional samples may be scheduled for analysis. Soil analysis shall include total soil for the presence of VOCs.

Area 2- The area in the vicinity of TP706D

It is proposed that up to 3 trial pits are advanced to 5mbgl (or bedrock, if shallower) and 1 groundwater monitoring well is installed in the vicinity of TP624. Soil samples shall be taken at approximately 0.5m intervals for subsequent on site headspace analysis. Up to two samples shall be scheduled for analysis from each location; one shallow sample within the made ground and one deeper sample within the underlying strata, where possible). If a significant presence of contamination is detected, additional samples may be scheduled for analysis. Soil analysis shall include total soil and soil leachate tests for the presence of SVOCs. Groundwater, where present, shall be scheduled for SVOCs analysis.

Area 3- The area in the vicinity of WS123, WS416 and WS717D

It is proposed that up to 3 trial pits are advanced to 5mbgl (or bedrock, if shallower) and 1 groundwater monitoring well is installed in the vicinity of WS123, WS416 and WS717D. Soil samples shall be taken at approximately 0.5m intervals for subsequent on site headspace

analysis. Up to two samples shall be scheduled for analysis from each location; one shallow sample within the made ground and one deeper sample within the underlying strata, where possible). If a significant presence of contamination is detected, additional samples may be scheduled for analysis. Soil analysis shall include total soil and soil leachate tests for the presence of PAHs, zinc and nickel. Groundwater, where present, shall be scheduled for PAHs, zinc and nickel analysis.

Following completion of the investigation, the Stage 3 risk assessment will be updated and the pollutant linkage assessment refined accordingly.

9.2. Summary of remediation actions required relating to Part IIA Pollutant Linkages for the overall site area

For regulatory purposes it is necessary to explain how each of the pollutant linkages listed by Copeland Borough Council in their determination of the site as statutory Contaminated Land are dealt with. Table 9.1 below summarises the findings of the investigation and the actions applicable to each pollutant linkage.

Table 9.1 – Summary of Remedial Actions

Copeland Borough Council Pollutant Linkage	***Findings and Remediation Actions for Plot D***
Petroleum Hydrocarbons in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*No significant pollutant linkage (source not significant).*
Poly Aromatic Hydrocarbons in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*Yes- A potential risk has been identified from naphthalene in the vicinity of the MOS plant (WS123, WS416 and WS717D) and fluoranthene in the vicinity of TP706D. Further data gathering and assessment is needed to determine whether remedial action is required (included in the Scope in Section 9.1).*
Surfactants in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*No significant pollutant linkage (no source).*
Phosphates in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*Screening criteria for phosphate are currently not available based on UK or other legislation. Therefore, the risk assessment cannot determine if a potential risk exists from phosphate.*
Arsenic in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*No significant pollutant linkage (no source).*
Boron in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*No significant pollutant linkage (no source).*
Cadmium in soil, migrating from soil to groundwater and through drains	*No significant pollutant linkage (no source).*

Copeland Borough Council Pollutant Linkage	***Findings and Remediation Actions for Plot D***
impacting undefined controlled waters receptor.	
Chromium in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*No significant pollutant linkage (no source).*
Copper in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*No significant pollutant linkages identified for copper (potential linkage identified but not considered significant based on site observations, ground conditions, and geochemical results). Refer to Section 3.5 of Appendix G.*
Lead in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*No significant pollutant linkage (no source).*
Mercury in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*No significant pollutant linkage (no source).*
Nickel in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*Yes- A potential risk has been identified from nickel in the vicinity of WS416. Further data gathering and assessment is required to determine whether remedial action is required (included in the Scope in Section 9.1).*
Selenium in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*No significant pollutant linkage (no source).*
Zinc in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*Yes- A potential risk has been identified from zinc in the vicinity of WS416. Further data gathering and assessment is required to determine whether remedial action is required (included in the Scope in Section 9.1).*
VOCs/ SVOCs in soil, migrating from soil to groundwater and through drains impacting undefined controlled waters receptor.	*Yes- A potential risk has been identified from chloroform in the vicinity of TP708D. Further data gathering and assessment is required to determine whether remedial action is required (included in the Scope in Section 9.1).*

TABLES

FIGURES

PLATES

Appendix A - Proposal For Site Works

Appendix B - Field Methodology

Appendix C - Borehole & Trial Pit Logs

Appendix D - Analytical Schedules, Tabulated Analytical Results and Laboratory Certificates

Appendix E - Human Health Detailed Quantitative Risk Assessment

Appendix F - URS GAC Advice Note

Appendix G - Controlled Waters Detailed Quantitative Risk Assessment

Appendix H - Model Inputs