# Remediation Statement
# Appendix J

# Phosphate Contributions from the Rhodia Site to the Irish Sea

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## EXECUTIVE SUMMARY

*URS was commissioned by Rhodia UK to undertaken an assessment of the potential risk to controlled waters posed by residual phosphate within shallow soils and porewater at the Rhodia facility, in Whitehaven, Cumbria.*

*The site has been designated by Copeland Borough Council as statutory "Contaminated Land" under Part 2A of the Environmental Protection Act 1990. Copeland Borough Council determined the site as contaminated land on the basis of sixteen pollutant linkages. Fifteen of the sixteen have already been assessed as part of the Phase II Investigation conducted by URS in 2005 and the "Plot" investigations conducted in 2006 and 2007, which considered risks to controlled waters from individual pockets of contamination found on the site.*

*The remaining potential pollutant linkage from phosphate was considered separately; given the extensive use of phosphate across the site, URS considered a site wide source a more conservative approach to evaluating potential risks posed by phosphate. Only phosphate has been used on this site and there is not documented evidence of the use of elemental phosphorus*[1]*. No published Marine Environmental Quality Standards exist for phosphate, however URS engaged the assistance of the Environment Agency, who were able to provide an appropriate standard based on the Urban Wastewater Treatment Directive, and associated Comprehensive Studies Task Team (CSTT).*

*URS conducted groundwater modelling to assess the potential migration of phosphate from the site to the Irish Sea utilising their dilution modelling developed during the Phase II and "Plot" investigations. The predicted concentration considered to be entering the Irish Sea was then further diluted by seawater dispersion. With the permission of Rhodia, URS utilised a study undertaken by Westlakes Scientific Consulting (January 2006), which provided typical dispersion rates of effluent emerging from the Whitehaven site, as effluent passed towards Tom Hurd Rock (the designated compliance point) approximately 2.25km along the coast to the north of the site. URS were able to adopt these dispersion values and apply them to the modelled site derived groundwater discharge emerging at the coastline. Values generated were then compared to the CSTT standard. URS concluded that the remnant phosphate within shallow soils and porewater underlying the Whitehaven site are unlikely to result in exceedence of the chosen water quality standard, at Tom Hurd Rock.*

*It is concluded that there is unlikely to be a significant environmental impact from the remnant phosphate observed on the site. URS considers that this shows to an appropriate level of confidence that the phosphate pollutant linkage is not significant.*

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[1] Where phosphorus is referred in to this text it is an a component of phosphate.

# 1. INTRODUCTION

This report details the desk based study performed by URS to evaluate the potential impact of the remnant phosphate levels in the shallow strata beneath the Whitehaven Site on the Irish Sea. This work was conducted so as to complete the evaluation of each of the pollutant linkages identified by Copeland Borough Council as posing a potential risk to controlled waters receptors.

This work was authorised by an email sent by Tom Dutton to Frank Wigley on 22nd May 2007.

# 2. BACKGROUND

The Rhodia site has been designated by Copeland Borough Council as statutory "Contaminated Land" under Part 2A of the Environmental Protection Act 1990. Copeland Borough Council determined the site as contaminated land on the basis of several pollutant linkages, which they considered likely to be present on the site as a result of its previous history. These are sumsrised in the following table:

| **Copeland Borough Council Pollutant Linkages:**. | |
|---|---|
| 1. Petroleum Hydrocarbons<br>2. Polycyclic Aromatic Hydrocarbons<br>3. Surfactants<br>4. Phosphates<br>5. Metals (arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc)<br>6. Volatile and Semi Volatile Organic Compounds | *Analytes in soil migrating from soil to groundwater and through drains impacting undefined controlled waters receptor* |

URS has conducted a series of investigations to address the Part 2A liabilities on the site, to evaluate the potential risks posed by the pollutant linkages identified by Copeland Borough Council. (these assessments are provided as Appendix B to I of the remediation statement).

For these evaluations, a soil, soil leachate, and groundwater sampling exercise was conducted on the Rhodia site in a number of different "plots" which targeted areas of former production, or additional samples were taken in areas identified as containing elevated concentrations of individual analytes. If elevated concentrations were identified, then a source (or hotspot) was delineated. Following groundwater modelling, URS evaluated the potential impact of such areas on controlled waters receptors through comparison of modelled concentrations against the respective screening criteria for each analyte. The identified receptor for the majority of the site is the Irish Sea. Consequently, the appropriate screening criteria (in this case Marine Environmental Quality Standards) were adopted, against which predicted concentrations entering the Irish Sea could be evaluated. Where potential risks were determined, additional investigation or remedial actions were presented.

This process addressed fifteen of the sixteen potential pollutant linkages identified by Copeland Borough Council. One remaining analyte, phosphate, was not addressed using this approach. This is because phosphate was used across the entire site, and so it was considered that the shallow soils and porewater across the entire site may be a potential source. Further to this, URS considered that hotspot modelling may not accurately represent the cumulative risk posed by phosphate to controlled waters.

In order to evaluate potential risks posed by phosphate, a screening value was required. There is no published Marine Environmental Quality Standard for phosphate, however the Environment Agency)[2], provided suggested target values for phosphate derived from the Urban Wastewater Treatment Directive[3]. A standard of 6.2µg/L (as elemental phosphorus, P) in the Irish Sea was derived from the Comprehensive Studies Task Team (CSTT). The CSTT standard is used throughout the UK for implementing the Urban Waste Water Treatment Directive that provides guidance on the sewage output to coastal waters.

This standard enabled URS to assess the potential impact of site-derived elemental phosphorus on the Irish Sea, through calculations involving mixing and dilution within the subsurface pathways followed by dispersion of predicted concentrations on entry to the Irish Sea.

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[2] (internal EA memo from Andrew Wither to Roger Green, dated 22nd March 2007 provided to URS Corporation on 30th March 2007provided in Appendix A of this report

[3] Urban waste water treatment, Directive 91/271/EEC

# 3. CONCEPTUAL SITE MODEL

The conceptual site model is presented in Figure 1 and a cross section detailing the flow mechanisms is presented in Figure 2.

## 3.1. Sources

Given the potentially extensive site wide distribution of phosphate, URS has considered the detected concentrations of phosphate reported during previous investigations across the entire site. Phosphate was used for a variety of purposes on the site and is widely present in site soils, including phosphoric acid production and storage, and as a component of the phosphate process.

The “source” was deemed as shallow soils (<5mbgl) and porewater. This included groundwater within the made ground or drift horizons, as well as groundwater already within the evaporite sequence. As discussed in Section 2, the evaluation in this report is focused on Part 2A liabilities of the Rhodia site, and does not consider phosphate within deep groundwater (which includes the water within the flooded mine adits).

Phosphate data has been obtained during several investigations. This data has been utilised for this assessment. The calculated 95th percentile mean concentration (US95, as defined in CLR-7) derived from soil leachate and groundwater analytical results was adopted as the source term concentrations for this assessment.

## 3.2. Pathways

The viable pathways applicable to these sources include the leaching and infiltration of soil contamination within the unsaturated shallow strata (made ground and drift), and entry into the underlying shallow groundwater. For the purposes of this assessment, it has been assumed contamination then migrates downwards and enters solution-enhanced conduits of the generally low permeability St. Bees Evaporites. Once within the evaporites, this water migrates towards the coast via complex subsurface pathways (solution enhanced pipes and fissures) before emerging at the beach at the Byerstead Spring. Tracer testing has provided evidence to suggest that this pathway is rapid, with travel times often less than 10 hours. Such short travel times suggest this migration may be via underground streams.

Such migration will be characterised by limited attenuation factors (such as retardation and degradation) as compared to more standard groundwater migration within porous media. Therefore, it was considered appropriate to assume that infiltrating contaminated water entering this unit from within site would remain at this entry concentration until it reached the site boundary. Beyond this point the only attenuation assumed to occur before the water reached the coast would be through dilution. This dilution was caused by mixing with clean water infiltrating from the overlying geological units (predominantly the St. Bees Sandstone). Following this dilution the groundwater is likely to emerge at the coastline. It is unlikely that this is at one single point of entry (such as the Byerstead Spring, which is known to contain some of the site derived waters), but more likely several points along the stretch of coastline. The positions where the groundwater emerges is likely to be controlled by the occurrence of low permeability horizons (refer to Figure 2) and/or the position of the groundwater/saline interface.

Furthermore, concentrations at the Byerstead Spring have not been considered as there is evidence[4] to suggest that this spring water contains waters from the flooded mine adits, which may contain historic phosphate concentrations, not representative of the current concentrations potentially emanating from the site.

## 3.3. Receptors

The ultimate receptor for this assessment is assumed to be the Irish Sea, with Tom Hurd Rock (Grid Reference NX965 183) specified as the compliance point for assessing potential impacts (refer to Figure 1). This compliance point has previously been accepted by the Environment Agency as a suitable compliance point for monitoring discharges from the Rhodia site

Discharges from the foreshore (including the Byerstead Spring) will mix and be diluted by sea water at the point of entry. Westlakes Scientific Consulting have previously undertaken a detailed assessment of the dispersion mechanisms within the Irish Sea adjacent to the site[5]. This assessment evaluated the potential impacts resulting from chromium levels within effluent emanating from the Rhodia sea outfall pipe (the consented discharge point known as the Barrowmouth Outfall). The study was requested by the Environment Agency to support Rhodia's application for a water resources consent to discharge their landfill leachate to the existing sea outfall pipe. Detailed dispersion modelling within the Irish Sea after discharge was undertaken by this study which utilised Tom Hurd Rock as the compliance point. This report is presented in Appendix C.

The results of the dispersion modelling have been used by URS to define dilution factors within the Irish Sea, which have been applied in the current assessment for phosphate. Details of these dilution factors are presented in Section 4.3.

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[4] Ladysmith and Croft pits were closed and flooded in 1933, at which time the presence of a 'rusty' coloured staining of the water in the vicinity of the unconsented discharge was reportedly observed for several weeks. This staining suggests a component of hydraulic continuity between the mine, the fault and the shore.

[5] Marine Dispersion Modelling and Impact Assessment for Landfill Leachate Chromium Discharges to Saltom Bay from Rhodia, Whitehaven (dated 26th January 2006).

# 4. METHODOLOGY

The risk assessment methodology is outlined as follows:

## 4.1. Step 1: Generation of Site Derived Phosphate Concentrations

In order to gain an understanding of the likely concentrations of phosphate that may leach from the soils, and migrate offsite towards the Irish Sea, measured concentrations in soil leachate and shallow groundwater have been collated. It is likely that the lateral and vertical distribution of these samples may vary across the site, and consequently the calculated US95 (95th percentile mean concentration, CLR-7) for the entire data set has been adopted so as to provide a conservative source term concentration.

## 4.2. Step 2: Application of Stage 3a and Stage 3b models

Stage 3a and 3b models have been described in a number of the main investigation reports. Details of this methodology can be found in Appendix B of this report.

In brief, this modelling approach involves:

- The determination of the potential dilution of the phosphate as it enters the underlying St. Bees Evaporite Formation, followed by;
- potential dilution of this water caused by the mixing with clean groundwater infiltrating through the St. Bees Sandstone, which overlies the St. Bees Evaporite Formation.

This modelling is conservative in nature and will provide a high-end estimate of potential site derived phosphate concentrations at the Byerstead Spring and the foreshore.

## 4.3. Step 3: Dilution as the Site Derived Water enters the Irish Sea

For simplicity, site-derived waters are assumed to enter the Irish Sea from a single point rather than from multiple seepages and streams across the foreshore (which is likely to be the reality). One major stream is known to exist on the coastline, the Byerstead Spring, which has been adopted as the single point of entry. Phosphorus concentrations in this stream have been measured since 2002, and have been showing evidence of decline since the decommissioning of the site in 2002, when recorded concentrations of phosphorus reached approximately 400,000µg/l. The most recent monitoring undertaken by URS (in April 2007) determined a concentration of 7,000µg/l.

Phosphate use on the Rhodia site was at its peak in the 1980s and 1990s and consequently the loss of phosphate to ground (and into the mine adits) was substantial during this period. Historic evidence suggests that the Byerstead Spring contains waters derived from the mine adits[6]. Consequently, the waters emanating at the Byerstead Spring are not thought to be representative of the potential *current* site-derived phosphate contributions alone, but are strongly influenced by the historic legacy associated with the mine shafts. Such discharges from the mine shafts are not considered further in this assessment because they are beyond the scope of Part 2A.

As groundwater enters the Irish Sea and mixes with a substantial volume of seawater, dilution occurs. The modelled discharge rate from site derived waters was calculated as approximately 10m$^3$ hr$^{-1}$(i.e site derived waters have been assumed to enter the sea at one single point, at a rate of 10m$^3$ hr$^{-1}$) and is about an order of magnitude more than appears to come from the Byerstead. In the Westlakes Scientific Consulting (WSC) report, dilutions rates have been provided, which are based on flow rates of 5,6,7,8,9, and 10m$^3$ hr$^{-1}$, as effluent flows through the site discharge pipe and reaches the coastline. URS could therefore directly adopt the rates based on the 10m$^3$ hr$^{-1}$ discharge (refer to Tables 7 and 11 in Appendix C). The dilution factors vary between a minimum of 2.4 during low water conditions during a Spring Tide, to 232 during high water conditions also during a Spring Tide. The methodology for how these dilution factors are derived is presented in the WSC Report (Appendix C). If in reality there are ten discharges of 1m$^3$ per hour each along the coast this will make the real dilution factor much greater as a diffuse source will be more readily dispersed. URS therefore consider this model which assumes a point source to be very pessimistic.

### 4.4. Step 4: Dilution as site-derived waters migrates towards the compliance point at Tom Hurd Rock

The predicted concentration after entry into the Irish Sea then incurs further dilution as it interacts with more seawater as it disperses along the coastline. The Westlakes report details that the specified Environmental Quality Standard (EQS) monitoring point for Rhodia discharges is at Tom Hurd Rock (Grid Reference NX965 183). This is located approximately 2.25km to the north of the section of beach where site derived waters are likely to be discharging into the sea. From the Westlakes report, calculated dilution factors range from 30 at high water during a Neap Tide, to 209 at low water during a Spring Tide. The methodology for how these dilution factors are derived is presented in the Westlakes Report (Appendix C).

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[6] "*Ladysmith and Croft pits were closed and flooded in 1933, at which time the presence of a 'rusty' coloured staining of the water in the vicinity of the unconsented discharge (the Byerstead Spring) was reportedly observed for several weeks. This staining suggests a component of hydraulic continuity between the mine, the fault and the shore*" (REF: A Source Audit at the former Albright and Wilson Facility, Whitehaven, R1131C-01/44557-026-787/JRM, dated 21st March 2002).

## 5. RESULTS

The results of the modelling assessment are presented in Table 1 and are summarised below[7].

| Tidal Occurrence | Tidal State | Predicted Concentration as Phosphorus discharging to the sea (µg/l) | Initial Dilution Factor (following entry to the Sea) | Secondary Dilution Factor (as water disperses 2.25km towards compliance point | Resultant concentration as Phosphorus at compliance point (µg/l) | Required Standard as phosphorus (µg/l) |
|---|---|---|---|---|---|---|
| Neap Tide | LW | 965 | 10 | 55 | 1.75 | 6.2 |
| | HW | 965 | 118 | 30 | 0.27 | 6.2 |
| Spring Tide | LW | 965 | 2.4 | 209 | 1.92 | 6.2 |
| | HW | 965 | 232 | 117 | 0.04 | 6.2 |

**Note:** LW = low water level, HW = high water level

The results of the modelling exercise indicate that site derived phosphate (expressed as total phosphorus) either present in soil (as soil leachate) or shallow groundwater, is unlikely to result in significant impacts to the Irish Sea once the effects of dispersive mixing within the sea are taken into account. All calculated concentrations remain below the chosen standard of 6.2µg/l on reaching the compliance point at Tom Hurd Rock.

## 6. LIMITATIONS

The results of this assessment do not take into consideration potential background concentrations of phosphate in the Irish Sea off Whitehaven. In the Environment Agency memo (Appendix A), it is suggested that the background concentrations in the Irish Sea are controlled by the phosphate loading from the Solway approximately 30km to the north of Whitehaven. The phosphate levels in the Irish Sea are already in excess of the CSTT limit for several months of the year, prior to any input from the Whitehaven site. Furthermore, the report suggests there is no obvious phosphate hotspot off Whitehaven. Therefore, the potential phosphate contribution from the site has not been assessed additively with concentrations already in the seawater. This evidence indicates that discharge from the site does not, in reality, have a significant effect on seawater phosphate concentrations and supports the conclusion that there is no significant risk.

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[7] All phosphate and orthophosphate results and standards have been converted to “total phosphorus” during the modelling process to aid comparison. It should be noted that there is no elemental phosphorus on site.

This assessment has not evaluated the unknown residual phosphate contamination present within the flooded mine adits which is likely to provide a greater loading to the Byerstead Spring and foreshore than shallow soils and groundwater at the site. This groundwater does not fall under this Part 2A assessment. However the evidence provided by the Environment Agency (included in Appendix A) suggests that this is not having a significant effect.

## 7. CONCLUSIONS

Based on the results of this modelling assessment it is considered unlikely that site derived phosphate from either soils (as soil leachate) or shallow groundwater will cause an exceedence of the chosen standard to waters of the Irish Sea at the designated compliance point at Tom Hurd Rock.

URS considers that in terms of Part 2A this is sufficient to demonstrate that the phosphate pollutant linkage is not significant.

The model does not include the contribution of phosphate from water stored in mine workings in the vicinity of the site, which is known to discharge to the Irish Sea. This water is outside the scope of Part 2A.

The Environment Agency's data appear to show that phosphate levels off Whitehaven are no higher than elsewhere along the coast. This indicates that the mine water contribution, whilst probably higher than the site contribution, is also unlikely to be causing significant environmental impact.

# TABLES

# Appendix A - Environment Agency Technical memo

# Appendix B - Stage 3 Modelling Methodology

# Appendix C - Marine Dispersion Modelling Report (Westlakes Scientific Consulting, January 2006)