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ABIDJAN - IVORY COAST
ASSESSMENT FOR POTENTIAL OF RESIDUAL CONTAMINATION FROM THE *PROBO KOALA* SLOPS

EXECUTIVE SUMMARY REPORT

RAMBOLL ENVIRON

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EXECUTIVE SUMMARY

Ramboll Environ UK Limited has been requested by Trafigura Beheer BV ("Trafigura") to prepare an independent study to address the following questions:

1. Are there indications that there is residual contamination associated with waste slops deposited from the *Probo Koala* vessel still present following the passage of time and remediation at locations where they were allegedly deposited in 2006?; and
2. If such residual contamination were assessed to remain present, does it presently have the potential to cause adverse effects to human health?

It has been well documented, by the UNEP, UNDAC and others, that Abidjan has been impacted by a wide range of contaminants prior to or post disposal of waste slops deposited from the *Probo Koala*, notably but not limited to industrial activity and poor waste management practices, including at sites monitored in relation to this review. While these factors will have an on-going environmental impact, this report does not address or take account of the environmental impacts from other sources prior to or post remediation of waste slops deposited from the *Probo Koala* vessel, so as to allow a proper conservative assessment of the potential residual impact of the waste slops ten years after their disposal.

As detailed in this Executive Summary, Ramboll Environ have concluded that, the bulk of the slops and impacted media were removed by the 2006 remediation. In addition, remediated areas were covered with 1 - 2m cover soil and would have been subject to significant degradation processes over the 10 year period since the remediation.

Based on the available sampling data, Ramboll Environ's assessment concludes that in 2016, 10 years after the deposit of the slops and remediation of the sites, there is no residual contamination from the slops present at concentrations that could cause adverse human health effects.

Alleged Deposition of Slops

It is reported in 2006 that 528m^3 of waste slops was unloaded onto sixteen road tankers. However, according to the UNDAC reports, as many as 4 truckloads (possibly as much as 120m^3) may not have been deposited. The remainder was deposited at up to eighteen sites around the City of Abidjan. The locations of the disposal sites were set out in United Nations Disaster Assessment & Coordination's (UNDAC) 2006 report.

These sites ranged from a landfill site and other areas potentially contaminated by industrial activity to rural locations.

Contaminants of Concern (CoC)

The waste slops comprised two phases;

i) an aqueous phase (65%); and

ii) a hydrocarbon phase (35%).

The initial content of the aqueous phase is reported to have comprised primarily sodium hydroxide plus water, sulphur and sulphides, mercaptides, cobalt compounds (used as a catalyst) and dissolved phase hydrocarbons (WSP, 2009a).

The initial content of the hydrocarbon phase is reported to have comprised predominantly low molecular weight short chain hydrocarbons (EC5-EC11) including aliphatic and aromatic hydrocarbons and small amounts of residual sulphur compounds including disulphides and mercaptans (WSP, 2009a).

Through information given in previous reports, the principal contaminants of concern (CoC) contained within the slops have been identified as:

- Sodium hydroxide (NaOH);
- Hydrogen sulphide (H2S);
- Phenols;
- Cresols;
- Hydrocarbons, predominantly EC5 to EC11, including Benzene, Toluene, Ethylbenzene and Xylene (BTEX);
- Thiols and thiol salts (mercaptans and mercaptides); and
- Dimethyl disulphide (indicator for sulphur compounds) and disulphide salts.

The detection of or absence of these CoCs (and their daughter products where relevant) is the primary indicator of whether residual slops remain present.

Remediation Work Carried Out in 2006

Between 19th August 2006 night and 20th August 2006 morning approximately 410m^3 of the offloaded 528m^3 of slops were deposited in Abidjan. Approximately one month after deposition on 17th September 2006 Tredi (commissioned by the Ivorian government) commenced work to remediate the deposit sites by removal of impacted materials (soil and liquid) for off-site disposal and incineration. Tredi completed their excavation work on 12th December 2006. Tredi reported that approximately 9,300 tonnes (between 6,200m^3 – 8,500m^3) of material was excavated and subsequently shipped for incineration to the Tredi facility, Salaise-sur-Sanne, France.

Tredi's work was technically audited by Burgeap. From information given in a technical advice note provided by the Burgeap auditor, it is understood that Tredi excavated material to depths ranging between 2m to 3m from the surface. The 2007 Burgeap Phase 2 report also indicates that Tredi placed a 'clean covering earth' 1m to 2m thick which was added after the impacted soils had been excavated and would have provided a barrier to human contact.

It is noted that parts of some sites were not accessible for remediation, e.g., Maca Route de Anyama (Maca 1 & 2) in the forest. Also, at the Abobo Coco Service (Ravine) deposition site, it is noted by both Tredi and BNETD that residual soils required excavation downstream of the remediated area but that it would require substantial earthworks to access this relatively inaccessible area.

A series of analyses of both liquid and soil samples were undertaken by Tredi prior to shipment and when the materials were received in France:

- The alkalinity, high hydrocarbon and sulphur content of the liquid samples sent to the Tredi facility indicate that at least in part it did correspond to the original liquid slops which had pooled on the surface soils or discharged into gullies and was accessible for removal.
- Data from the impacted soils sent to France by Tredi show that Tredi adopted a precautionary approach and excavated soils until visual and olfactory assessment indicated that they had recovered the impacted materials. The large variation in chloride and sulphur concentrations observed in the Tredi soil samples suggest that soils were over excavated and material which was not contaminated was also removed. Indeed, Burgeap's auditor's technical advice note states that, 'Other analysis on soil sampled from the bottom of trench (T 1-11, sampled from no1 at a depth of 4.8m, and T 3-6 sampled from trench no3 at a depth of 4m) display total hydrocarbon concentrations ranging from 300 to 900mg/kg. These concentrations remain well below the threshold qualifying polluted soils in France (VDSS level which is 2,500mg/kg).'

Burgeap and WSP Post Remediation Contamination Assessments

Two post remediation data sets exist:

i) Burgeap (2007) assessed the risks post remediation based on data collected shortly after the Tredi remediation had been completed; and

ii) WSP (2009) assessed the risks post remediation based on data collected approximately two years after remediation.

Ramboll Environ made an independent assessment of the Burgeap and WSP data and tested the validity of their conclusions against 2016 guideline assessment values.

Burgeap (2007)

With regards to results of the sample analyses, performed on remediated sites, Burgeap stated that, 'Generally speaking, all the concentrations quantified by the laboratory were low and were well below the standards which are applied in France to quantify, by the rules which apply, the impact of pollution has on soil and water.'

Based on Burgeap's data, Ramboll Environ consider that the conclusions made by Burgeap regarding residual contamination at the deposit sites are still valid.

WSP (2009)

Based on the results from the WSP investigation, WSP concluded that there was no risk to human health at the deposit sites from contaminants potentially relating to the slops (i.e., the CoC).

No compounds specifically characteristic of the slops were detected at concentrations exceeding the WSP screening criteria at any of the remediated deposit sites tested and no visual evidence of impact was recorded by WSP in 2009.

Analysis of sediment and water samples taken from the Vridi Canal (a canal running through an industrialised part of the city) and water samples taken from the Akouédo landfill deposit sites identified traces of light hydrocarbons and sulphides. WSP concluded that there was no risk to human health from these identified trace contaminants at these two sites based on their current use.

WSP further opined that these identified light hydrocarbon and sulphide compounds would have been present in a wide range of wastes from a broad variety of processes undertaken in the region or are naturally occurring and therefore could entirely be associated with local waste sources observed in these areas and not related to the slops.

Ramboll Environ reassessed the historic WSP soil and water data against the current 2016 guideline assessment values (Generic Assessment Criteria, GAC). The results of the current screening assessment showed that there were no exceedances of the current 2016 GAC.

Ramboll Environ consider that the conclusions reached by WSP in 2009 regarding residual contamination at the deposit sites are still valid.

Ramboll Current Assessment (2016)

Chemical and Physical Properties of CoC

The physicochemical/fate and transport (natural degradation) properties of the CoC have been assessed and have been used to provide an indication of how concentrations in the ground are expected to have changed over time as a result of migration through surface water courses and/or the subsurface, and also the partitioning between air/water/solid phases.

On deposition, much of the deposited material will have volatilised. Residual vapour phase releases from surface soil or water would have dissipated as a function of time and would no

longer constitute a separate source to consider. Therefore, residual contaminants if present today would be in the subsurface soil or groundwater and not associated with the surface soils.

Some of the slops could have soaked into and adsorbed onto the soils according to the chemical properties of the constituents. Contaminants could have migrated through permeable subsurface soils immediately following deposition.

The degradation potential in the soil, surface water and groundwater has been used to predict how contaminants naturally break down over time. In this instance degradation refers to the naturally occurring physical, chemical and biological processes that act within the soil environment to reduce contaminant mass, concentration, flux or toxicity. The degradation mechanisms include destructive mechanisms, e.g., biodegradation, abiotic oxidation and hydrolysis; and non-destructive mechanisms such as sorption, dispersion and chemical or biological stabilisation, and volatilisation. With regards to the slops, biodegradation, volatilisation and dispersion are the most relevant degradation mechanisms due to the nature of the CoCs and the local environmental conditions of the soil.

Therefore, based on the physicochemical properties of the CoC alone, the high mobility and biodegradation potential of the CoCs implies that the vast majority of residual contamination associated with the slops will have volatised, been diluted and dispersed by rainwater or biodegraded. Hence, these natural degradation mechanisms caused a major reduction in the concentrations of residual CoCs remaining, if any remained present.

Assessment Methodology

In line with best scientific practice, Ramboll Environ have carried out an assessment of the potential risks to human health from residual contamination using a source, pathway, receptor assessment and taking into account the degradation mechanisms that would have reduced any residual CoC concentrations over the 10 year time period since the deposit of the slops and their remediation. This methodology is an industry standard method to evaluate contamination by assessing the linkage between a contaminant and a receptor by means of a pathway. The potential contaminant source will be remaining slops material; following remediation the pathways will be the mechanism by which the contamination would move towards a person; and the receptors will be the local residents.

Air – Inhalation of Volatile Contaminants

The CoCs in the slops that had the potential to cause adverse effects to human health through the inhalation exposure route typically dissipate by volatilisation and biodegrade rapidly. UNDAC concluded that 3 weeks after deposition of the wastes, the concentrations of the relevant compounds in the air were low and no further adverse health effects were expected. In addition, WSP's 2009 air monitoring did not identify any significant CoC concentrations.

Therefore, based on the type of contaminants present within the slops, their natural degradation properties within the air and the results of the air quality data collected, as well as the known remediation activities that have removed large quantities of source material, Ramboll Environ concludes that 10 years on from the deposition and remediation of the slops waste, there is no potential for adverse effects to human health from exposure to air borne residual contamination.

Soil and Sediment Impacts - Direct Contact

A substantial volume of soil was removed by Tredi within three months of the original deposition of the slops waste and a 1-2m soil cover placed over the remediated areas. Through this removal of soils it is considered that the bulk of the mass of CoCs in the surface soils (i.e., those available for direct contact) will have been removed and a barrier established for contact with residual materials, if any, left in place.

Additionally, soil quality data collected by the various groups attending site did not identify residual contamination and indeed in 2007 Burgeap concluded that 'the soils remaining in place thus present low traces of pollutants linked to the slops.'

It is noted that parts of some sites were not completely remediated because of accessibility constraints and thus some residual contamination may have remained in the limited areas post-2006. However, no visual evidence of impact was recorded by WSP in 2009 and these areas were noted to be heavily vegetated and sparsely populated.

Overall, based on these considerations, Ramboll Environ concludes that 10 years on from the deposition and remediation of the slops waste, there is no potential for adverse effects to human health from direct contact with residual surface soil or sediment contamination

Surface Water

The slops waste was mainly deposited as a liquid directly onto the ground surface. Prior to remediation and soil removal, there is a potential that some contaminants may have percolated through the permeable soils and migrated to surface water bodies.

Based on the type of contaminants present within the slops, their natural degradation and their dilution and dispersion properties within surface water as well as the surface water quality data collected, Ramboll Environ concludes that 10 years on from the deposition of the slops that there is no contamination to surface water from the slops.

Groundwater

While there are certain data gaps related to the absence of deeper soil or groundwater sampling, based on the type of contaminants present within the slops, their natural degradation properties within groundwater and the depth to groundwater at 60m, Ramboll Environ concludes that 10 years on from the deposition and remediation of the slops there is unlikely to be contamination of groundwater resources from the slops and consequently no adverse effects to human health via this pathway. This is consistent with the UNDAC 2006 report that deeper groundwater drinking supplies are unlikely to have been impacted due to their relatively great depth and the distance from the deposit sites (nearest well is >1km away).

Concluding Remarks

The bulk of the slops and impacted media were removed by the 2006 remediation. It appears that because the remediation process was based on olfactory and visual indicators of residual contamination, most of the impacted areas were "over-excavated', i.e. more soils were removed than may have been required relative to clean-up objectives based on concentration measurements. In addition, remediated areas were covered with 1 - 2m cover soil and would have been subject to significant degradation processes over the 10 year period since the remediation.

Based on the available sampling data and taking into consideration the CoC natural degradation properties, Ramboll Environ have conducted an evaluation of potential human exposure pathways to residual CoCs, if any, that may be present via inhalation of air, direct contact with soils and sediments, consumption and other uses of surface water and consumption of groundwater. Ramboll Environ's assessment concludes that in 2016, 10 years after the deposit of the slops and remediation of the sites, there is no residual contamination from the slops present at concentrations that could cause adverse human health effects.