TARAGO LOOP EXTENSION
PRELIMINARY HUMAN HEALTH RISK ASSESSMENT

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Description	**The report presents a preliminary human health risk assessment of lead contamination at the site of Tarago Loop Extension**
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Summary

Ramboll Australia Pty Ltd was commissioned by John Holland Rail to conduct a preliminary human-health risk assessment (HHRA) of lead contaminated ballast material proposed to be disturbed as part of the Tarago Loop Extension. An HHRA was required to determine current and future risks to workers at the site, as exposure scenario for sensitive workers at the site were different from assumptions used in derivation of lead health investigation levels for commercial/industrial scenario in NEPM 2013. The most sensitive worker at the site was a female of reproductive capacity (foetus) and blood lead levels were estimated using US EPA adult lead methodology.

It has been assessed that concentrations of lead present at the site are likely to be presenting an unacceptable level of risk to workers at the site. A clean-up criterion protective of current and future works compliant with the WHS Regulation has been calculated at **2,200 mg/kg**[1]. As concentrations at the site exceed this criterion, any works at the site should implement the recommendations contained within the SLMP, unless there is certainty that work is being carried out in areas where current exposure concentrations are less than the calculated safe level.

[1] Current SafeWork NSW guidelines include definition of lead risk work as work that is likely to result in blood lead levels over 10 μg/dL in females with reproductive capacity. Modelling integrating a blood lead level limit of 10 μg/ limit supports a clean-up criterion of 5300 mg/kg however the WHS Regulation under which SafeWork NSW guidelines are created has been revised reducing the blood lead level in females with reproductive capacity to 5 μg/dL. SafeWork NSW advise guidelines will be amended at completion of a two-year transitional period 30 June 2021. Modelling integrating a blood lead level limit of 10 μg/ limit supports a clean-up criterion of 2200 mg/kg and is recommended by Ramboll.

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1. Introduction

Ramboll Australia Pty Ltd was commissioned by John Holland Rail to conduct a preliminary human-health risk assessment (HHRA) of lead contaminated ballast material proposed to be disturbed as part of the Tarago Loop Extension. The proposed construction footprint is here-in referred to as "the site".

Construction is understood to include excavation of the former Woodlawn Siding, extension of the existing loop, construction of a driver's walkway adjacent the existing loop, removal of tie-ins from the former Woodlawn siding to the existing loop, modification of tie-ins from the loop to the Goulburn – Bombala line (the main line), restoration of drainage between lines and reconditioning of the main line rail formation. For the purpose of this report a total excavation depth of up to 0.95 m was nominated including 0.3 m ballast, 0.15 m capping and 0.5 m structural base/subgrade.

A preliminary site investigation (McMahon, 2015) found lead levels exceeding relevant human-health guideline values within certain parts of the site. Further, intrusive investigations completed by Ramboll in 2019 (Ramboll, 2019a) found ballast at the top of the Woodlawn Siding formation is impacted by lead (CH: 261.980 km to CH: 262.955 km) with a distinct area where much higher lead concentrations observed (CH: 262.090 km and CH: 262.700 km). Surface soils adjacent (west of) the Woodlawn Siding area also have concentrations exceeding the applicable HIL and EIL values.

Materials from the main line are expected to be disturbed as part of the loop extension during excavation and construction of a new turnout and track. Field XRF measurements of lead concentrations showed lead contamination within the main line is spread from approximately CH: 261.950 km to CH: 292.950 km. The highest lead concentrations within the main line occur at three distinct locations, between CH: 262.250 km and CH: 262.350 km, between CH: 262.500 km and CH: 262.650 km (which runs past Tarago Station and the historic ore loading area on the west) and between CH: 262.800 km and CH: 262.900 km. High lead exceedance areas in the main line generally correspond with high lead exceedances in the siding.

Sample locations targeting the proposed construction footprint are presented as **Figure 1**, **Appendix 1**.

Ramboll (2019a) concluded that any work carried out between these chainages, including the section of signalling trench, should be undertaken in accordance with the Short-Term Lead Management Plan (SLMP) (Ramboll, 2019b).

The SLMP prescribes strategies for reducing risks associated with lead exposure which may arise as a result of the excavation of lead impacted materials at the site. The SLMP includes:

- Hazard identification
- Lead management strategies
- Hazard elimination
- Materials tracking requirements
- Stockpile management requirements
- Environmental controls, including the requirement for surface water and air monitoring

The SLMP is to remain in place until a long-term plan is developed and implemented or until the site has been remediated and validated.

There is potential for exposure of the workers to lead contaminated material at the site, either during construction or remediation and therefore this preliminary HHRA assesses the risk to workers during such exposure. The construction/remediation scenario is related to short-term lead exposures only. It is

expected that during site works within areas of contamination, the exposure minimising strategies recommended in the SLMP will be followed. The HHRA does not consider exposure to offsite sensitive receptors or any ecological receptors as these are currently not within the scope of this HHRA.

2. HHRA Objective

The objective of this HHRA is to assess risk to workers exposed to any lead contaminated material at the site by modelling the expected change in blood lead concentration of workers. The HHRA would also derive a site-specific guideline value of lead in soil based on site exposure consideration. A clean-up criterion will also be developed based on future site works scenario.

A HHRA was required for the site as exposure scenarios presented at the site are different from those assumed during the derivation of HIL-D values in NEPC (2013b). The site scenario is for outdoor exposure to lead contaminated material for 100% of the time; however, exposure would be for a short-term duration. HIL-D derivations assume only one hour of outdoor exposure but for chronic (long-term) exposure duration.

The preliminary HHRA was conducted according to relevant national guidelines such as:

- *enHealth (2012) Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards*
- *NEPC (2013a) Assessment of Site Contamination: Schedule B4 – Site-specific Health Risk Assessment Methodology. National Environment Protection Council, Adelaide*
- *US EPA (1989) Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual (Part A)*

3. Site Description

Site details are contained in previous investigation reports:

- Ramboll (2019a) Tarago loop extension: further intrusive assessment and lead management plan. Prepared for John Holland Rail, September 2019. Ramboll Australia Pty Ltd.
- McMahon (2015) Tarago Rail Siding Extension: Preliminary Contaminated Site Assessment, June 2015. DM McMahon Pty Ltd, NSW

4. Data Review and Evaluation

The proposed construction at the site includes works at the Woodlawn siding and the main railway line, and this includes about 1000 lineal meter of the rail corridor from CH: 261.950 to CH: 262.950 km. Previous investigations including intrusive assessments and portable X-ray fluorescence (p-XRF) measurements suggests that lead impacts may be present within this chainage range. The lead impacts are only confined to fines located with the ballast layer (0-0.5 m depth) of the railway line and siding, and to surface soils located adjacent to the Woodlawn siding.

The HHRA has considered data from previous investigations conducted at the site:

- Ramboll (2019a) Tarago loop extension: further intrusive assessment and lead management plan. Prepared for John Holland Rail, September 2019. Ramboll Australia Pty Ltd.
- McMahon (2015) Tarago Rail Siding Extension: Preliminary Contaminated Site Assessment, June 2015. DM McMahon Pty Ltd, NSW

The investigations showed that lead concentrations within the proposed construction area were highly heterogeneous and most concentrated in the Woodlawn Siding ballast layer. The HHRA used soil

concentration data from the Woodlawn Siding ballast layer and from soils collected adjacent and west of the siding. The following data was excluded from the assessment:

- McMahon (2015) Tarago Rail Siding Extension: Preliminary Contaminated Site Assessment, June 2015. DM McMahon Pty Ltd, NSW
- P-XRF data

The McMahon (2015) study was a preliminary investigation and it used a number of composite samples for the analysis, and therefore the results may not reflect actual sample variabilities at the site. p-XRF data was not verified against laboratory measurements and therefore was treated as a semi-quantitative indication of site concentrations in this HHRA.

The Ramboll (2019a) data was taken to be representative of site concentrations, which included tier 1 assessment against NEPC (2013b) health investigation level (HIL-D) of 1500 mg/kg for commercial/industrial applications. The ballast layer concentrations generally exceeded this value and was adopted in this HHRA. Surface soil concentrations that exceeded this tier 1 criterion was also adopted in this HHRA. This is conservative as there were areas were surface soils were well below the tier 1 criterion. Further analysis of the samples was also conducted for the bioavailability measurements. These have also been included in this HHRA assessment and are shown in **Table 4-1** along with data statistics shown in **Table 4-2**.

The 95% upper confidence limit (UCL) of the arithmetic mean contaminant concentration was chosen for use in this HHRA. It provides a 95% confidence level that the true population mean will be less than, or equal to, this value. It accounts for the uncertainty in whether the data set is large enough for the mean to provide reasonable measure of central tendency. The UCL value was calculated using *ProUCL 5.1.002* available from US EPA and the recommended 95% UCL concentration was adopted.

Table 4-1: Site data considered in this HHRA, which were above NEPM HIL D (*n* = 34)

Location	Sampling site (depth m)	Data Source	Lead Conc (mg/kg)
Siding (test pits) ballast layer	TP1 0.1-0.5	Intrusive Assessment Report (Ramboll 2019 a)	4400
	TP2 0.1-0.4	Intrusive Assessment Report (Ramboll 2019 a)	3500
	TP3 0.1-0.5	Intrusive Assessment Report (Ramboll 2019 a)	29000
	TP3a 0.0-0.1	Bioaccessibility study (Appendix 1)	18500
	TP4 0.1-0.3	Intrusive Assessment Report (Ramboll 2019 a)	38000
	TP4a 0.0-0.1	Bioaccessibility study (Appendix 1)	184,000
	TP5 0.1-0.45	Intrusive Assessment Report (Ramboll 2019 a)	3100
	TP5a 0.0-0.1	Bioaccessibility study (Appendix 1)	29000
	TP6 0.1-0.4	Intrusive Assessment Report (Ramboll 2019 a)	6000
	TP7 0.1-0.4	Intrusive Assessment Report (Ramboll 2019 a)	3300
	TP8 0.1-0.3	Intrusive Assessment Report (Ramboll 2019 a)	2800
Surface soils	SS7 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	4100
	SS11 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	2200
	SS12 0.0-0.1*	Bioaccessibility study (Appendix 1)	48000
	SS13 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	2600
	SS16 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	15000
	SS19 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	26000
	SS20 0.0-0.1*	Bioaccessibility study (Appendix 1)	41000
	SS24 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	3000
	SS25 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	11000
	SS27 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	6700
	SS28 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	12000
	SS29 0.0-0.1*	Bioaccessibility study (Appendix 1)	7500
	SS32 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	2800
	SS36 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	2100
	SS37 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	1600
	SS38 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	9900
	SS39 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	2900
	SS40 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	2600
	SS41 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	11000
	SS43 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	31000
	SS45 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	4000
	SS47 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	3900
	SS48 0.0-0.1	Intrusive Assessment Report (Ramboll 2019 a)	1800

*Maximum concentration adopted from Ramboll (2019a) and bioaccessibility study.

Table 4-2: Statistics of data presented in Table 4-1, as calculated by ProUCL 5.1.

Data Statistic	Value (mg/kg unless stated otherwise)
Sample Size	34 (n)
Maximum Concentration	184,000
Minimum Concentration	1600
Mean Concentration	16891
Median	5200
Standard Deviation	32218
95% UCL Concentration	**40975** (95% UCL based on Chebyshev, as recommended by ProUCL 5.1 software)

5. Conceptual Site Model

Conceptual Site Model (CSM) is a site-specific qualitative description of the source(s) of contamination, the pathway(s) by which contaminants may migrate through the environmental media, and the populations (human or ecological) that may potentially be exposed. This relationship is commonly known as a Source-Pathway-Receptor ("SPR") linkage. Where one or more elements of the SPR linkage are missing, the exposure pathway is considered to be incomplete and no further assessment is required. Where this linkage is found to be complete, it does not indicate that health or environmental risk is present, but rather triggers either a more detailed investigation or exposure controls.

The primary source of site lead contamination has been related to historic use for loading out of ore concentrate from the Woodlawn Mine via the Woodlawn siding. Ore was mined for metals including copper, lead, silver, gold and zinc until mine closure in March 1998 (Heron Resources 2019). The main receptors considered in this HHRA are the workers at the site undertaking the proposed construction or remediation activities. These workers can be directly exposed to lead contaminated soil and dust, and lead intake can primarily occur via incidental ingestion and inhalation. Intake via dermal pathway is not considered to be a significant route of intake (ATSDR, 2007). Intake via incidental ingestion and dust inhalation is expected to be much lower if sufficient personal protective equipment is used and dust minimisation protocols are followed. These have been outlined in the SLMP (Ramboll 2019b) provided to John Holland Rail and are expected to be implemented for all works being undertaken within the contaminated areas. A summary of the CSM showing complete SPR linkages are shown in **Table 5-1**. As the proposed activity is targeted construction or remediation, exposures are would only be for short-term.

Table 5-1: Summary of the CSM showing complete SPR linkages.

Pathway	Source-Pathway-Receptor Link?	
	Onsite Workers	Justification/considered in this HHRA?
Lead Contaminated Soil		
Dermal contact with soil/dust	Yes	Pathway not considered as dermal intake is not a significant pathway
Incidental ingestion of soil/dust	Yes	Pathway considered but is expected to be minimal based on recommendations in the SLMP (Ramboll 2019a)
Outdoor inhalation of dust	Yes	Pathway considered but is expected to be minimal based on recommendations in the SLMP (Ramboll 2019a). Consideration based on eventual ingestion via gastrointestinal intake pathway (see exposure assessment)

6. Approach to HHRA

The effects of lead exposure have often been related to the blood lead content, which is generally considered to be the most accurate means of assessing exposure, although other measures of exposure such as bone lead, hair lead and urine lead can be used but are considered less reliable. Physiologically based pharmacokinetic models, such as the US EPA Integrated Exposure Uptake BioKinetic (IEUBK) model, has been used for assessment of lead exposure risks in children. The model simulates multimedia exposures, uptake and kinetics of lead in children ages 0-7 years for predicting pseudo-steady state relationship between lead exposure and blood lead. US EPA also developed a slope factor model called Adult lead methodology (ALM) for assessing lead exposures in adults with foetus in females being the most sensitive receptor. In this model lead biokinetics is represented with a simple linear relationship between blood lead and lead uptake called the biokinetic slope factor. Both these models are lifetime models and cannot be used for short-term kinetics of blood lead (ATSDR 2019). The derivation of NEPM Health screening levels (HILs) used the IEUBK model for calculating HIL-A, HIL-B and HIL-C where children are main receptors and the ALM for calculating HIL-D where adult female of reproductive capacity (foetus) is the most sensitive receptor.

The exposure scenarios presented at the site represent short-term exposures of adults to lead contaminated material. Therefore, the ALM model with chronic assumptions may not be appropriate for assessing risk to workers at the site. Short-term exposures can be simulated by the US EPA All Ages Lead Model (AALM), however its still in draft stage (US EPA 2016) and currently undergoing a review of its theoretical basis (US EPA 2019).

The ALM (and IEUBK) model requires a minimum of 90 days exposure to produce quasi-steady state blood lead concentrations (US EPA 2003a). For short-term exposures the US EPA (2016) recommends adjusting the ALM model exposure scenarios to meet minimum exposure frequency and duration or alternatively using other models such as AALM. Infrequent exposures (i.e., less than 1 day per week) over a minimum duration of 90 days would be expected to produce oscillations in blood lead concentrations associated with the absorption and subsequent clearance of lead from the blood between each exposure event (US EPA 2003a). And therefore, exposure frequency of less than 1 day/week is not

considered suitable for use in the ALM model. Furthermore US EPA (2003b) presents case studies of using the ALM model for assessing short-term adult exposures in non-residential scenario using the ALM model, where minimum averaging time of 91 days and exposure frequency of 65 days (5 days/week exposure over 13 weeks or 91 days) was used. Therefore, in the absence of any robust methodology to assess short-term (<30 days) exposure, the ALM model was used in this HHRA to assess the change in blood lead levels and risks to adult workers at the site based on average exposure over a 13-week period.

7. Adopted Guideline Values

Health effects of lead vary greatly between individuals and can depend on persons age, exposure levels, duration of exposure and presence of any pre-existing conditions. Children and foetuses (via pregnant women) are most at risk. In pregnant women, lead in the bloodstream can cross the placenta into the foetal blood. Health effects from lead in the body is higher for children and babies (including foetuses) than for adults (NHMRC 2016). There is an association between blood lead levels of 5 to 10 micrograms per decilitre (µg/dL) and adverse cognitive effects (reduced Intelligence Quotient (IQ) and academic achievement) and behavioural problems (effects on attention, impulsivity and hyperactivity) in children. It is now recommended that for blood lead levels greater than 5 µg/dL the sources of exposure should be investigated and reduced particularly for children and pregnant women (NHMRC 2016). The main receptors at the site does not include children. Therefore, occupational standards provided by SafeWork Australia has been deemed appropriate for assessing risks related to potential workers at the site.

SafeWork Australia and SafeWork NSW provides guidance for determining if occupational exposure/work is likely to be classified as 'lead risk work'. Regulation 394 states that 'lead risk work' means work carried out in a lead process which is likely to cause the blood lead level of a worker to exceed the thresholds outlined below (Model WHS Regulations 2019):

a) for a female of reproductive capacity—5µg/dL (0.24µmol/L);
   or
b) in any other case—20µg/dL (0.97µmol/L).

There is currently a two-year transitional period from 1 July 2019 to 1 July 2021 to comply with the above changes. SafeWork NSW lead work guidance (2019) currently states the following:

For the period up to and including 30 June 2021 'lead risk work' means blood levels at or exceeding:

- *10 µg/dL (0.48 µmol/L) for a female of reproductive capacity*
- *30 µg/dL (1.45 µmol/L) in other cases.*

From 1 July 2021 'lead risk work' means:

- *5 µg/dL (0.24 µmol/L) for a female of reproductive capacity*
- *20 µg/dL (0.97 µmol/L) in other cases.*

Note that 'female of reproductive capacity' means a female other than a female who provides information stating that she is not of reproductive capacity (SafeWork Australia 2013).

Based on the current occupational guidelines and noting the transitional period for compliance the guideline values adopted in this assessment is shown **Table 7-1**.

Table 7-1: Adopted guideline values used in this HHRA.

Site Receptor	SafeWork Australia Category	Occupation Exposure Standard Blood lead concentration (µg/dL)*
Current onsite Worker	Female of reproductive capacity	10
	Females not of reproductive capacity and males	30
Future onsite worker	Female of reproductive capacity	5
	Females not of reproductive capacity and males	20

*adopted guideline values for 'current onsite worker' are only valid until 30 June 2021 and values are taken to be the target for foetal blood concentrations.

8. Scenarios Assessed

Ramboll had previously provided JHR with a SLMP, which recommends a number of exposure control methods including use of appropriate PPEs and dust minimisation during work in the contaminated areas. This HHRA assumes that the workers at the site are exposed directly to the contaminated material without any exposure controls, as the most conservative worst-case scenario. This is summarised in **Table 8-1**. The main receptor assessed in this HHRA is a 'female of reproductive capacity' and this would also be protective of all other workers onsite.

Table 8-1: Scenario assessed in this HHRA

Scenarios Assessed	Scenario Description	Receptors Assessed
Current onsite worker - short-term	Exposure without any controls	Female of reproductive capacity
		Females not of reproductive capacity and males
Future onsite worker - short-term	Exposure without any controls	Female of reproductive capacity
		Females not of reproductive capacity and males

Greyed out – qualitative assessment only.

9. Exposure Assessment

The proposed site works suggests that workers will have a short-term exposure to contaminated soil and dust at the site. It is expected that on average the workers may spend up to 5 days a week at the site, working 8-hour shifts. However, the workers are expected to be exposed to the contaminated material only for a duration of about 20 to 30 days only. The CSM identified that soil and dust ingestion, and inhalation would be the main routes of exposures. The primary method of assessing exposure to lead contamination will be via blood lead modelling, as discussed in Sections 6 and 12. This model allows for soil and dust intake via ingestion only.

9.1 Intake via Ingestion

Lead concentrations across the site was variable suggesting that lead contamination is heterogeneously located within the top layers of the ballast (within fines) and adjacent surface soils. 95% UCL of the mean concentration was taken to be a conservative representation of the concentrations that would be experienced on average by the workers at the site. It is expected that the ingested amount would be reduced if sufficient personal protective equipment is used and dust minimisation protocols are followed, as recommended in SLMP. The soil ingestion rate for the site was adopted considering the likely soil exposures for worker at the site.

The health impacts of ingested lead depend on the bioavailability of lead in the ingested material. It is the proportion of an ingested chemical substance that is absorbed from the gut into the body and reaches systematic circulation without change (EA 2009). The bioavailability of lead in the material was analysed and is described in Section 10.

9.2 Intake via inhalation

Lead in dust particles would be associated with particles of different sizes and this influence where in the respiratory tract it is deposited. Lead associated with smaller respirable dust particles are predominantly deposited in the pulmonary region of the respiratory tract, where it can either get absorbed directly into general circulation or be transported via phagocytic cells to the gastrointestinal tract. Lead associated with larger particles would be deposited in the upper and large airways, such as nasal and pharyngeal and tracheobronchial regions of the respiratory tract and may be transported via mucociliary transport into oesophagus and swallowed. This would also make its way to the gastrointestinal tract.

The dust lung retention factor describes the percentage of respirable dust that is small enough to be retained in lungs and is associated with health effects. For both indoor and outdoor dust exposures, the respirable fraction is estimated at 37.5% of the inspirable fraction. This fraction is recommended by enHealth (2012) where it was considered that 75% of the inhaled (inspirable) dust will be retained in the respiratory tract (25% exhaled) of which 50% is small enough to reach the pulmonary alveoli, resulting in a respirable fraction of 37.5%. Therefore, a large proportion of the inhaled particles are expected to either be exhaled out or be transported to the gastrointestinal tract where absorption similar to ingested soil fractions would occur.

9.3 Exposure Parameters

The NEPC (2013a) HIL-D values used in the tier 1 risk assessment is not entirely applicable for the short-term exposure scenario for workers at the site and specific reasons are summarised below:

- HIL-D values are derived based on lifetime exposures while site exposure scenarios are for short-term exposure
- HIL-D values assumes that outdoor exposure occurs for only 1 hour, while exposures at the site would mainly be 100% outdoor for the entire duration of the work day, averaging 8 hours.
- Soil ingestion is also expected to be higher at the site if recommendations in the SLMP are not implemented;

Table 9-1 outlines the different exposure parameters used for this HHRA compared to the parameters used in HIL-D derivation.

There are various different soil ingestion rates available for outdoor workers, ranging from 25 mg/day to 330 mg/day (US EPA 2002; US EPA 2017b; NEPC 2013b; Friebel and Nadebaum 2011). The NEPM HIL-D derivation used 25 mg/day, while Friebel and Nadebaum (2011) used 330 mg/day for intrusive works. The 25 mg/day value was adopted as 50% of HIL-A exposure soil intake, which assumes exposure to soil without any intrusive works. The 330 mg/day soil ingestion rate used by Friebel and Nadebaum

(2011) was adopted from US EPA (2002). This high soil intake value was adopted from Stanek et al. (1997) and represented an increased soil intake due to soil-disturbing activities such as excavation or vehicular traffic on contaminated unpaved roads. US EPA's analysis of the impacts of different construction activities on fugitive dust emissions demonstrated that vehicle traffic on contaminated unpaved roads typically accounts for the majority of emissions, with wind erosion, excavation soil dumping, dozing, grading, and filling operations contributing lesser emissions (US EPA 2002). The contamination at the site is mainly present within railway line ballast and not readily present on the surface. Heavy vehicular access to this area is generally restricted, while surface areas where majority of vehicular traffic may occur does not have widespread contamination. Furthermore, the contamination is confined to fines within the ballast layer only, and therefore during any excavation any dusts generated (and hence soil intake) are likely to be from a combination of contaminated and uncontaminated soil/dust. It is therefore assessed that actual soil intake rate is better represented by an outdoor worker value of 100 mg/day, as used in US EPA regional screening levels. An outdoor worker with 100 mg/day soil intake is someone who spends most of the workday conducting maintenance activities outdoors, and activities for this receptor (e.g., moderate digging, landscaping) typically involve on-site exposures to surface and shallow subsurface soils (at depths of zero to two feet; US EPA 2002).

Table 9-1: Exposure parameters used in ALM for modelling blood lead concentrations in workers

Relevant Parameters	Symbol	Units	NEPM HIL-D	Onsite worker – short-term	Comments
Soil and dust ingestion rate	IR_{SA}	mg/day	25	100 mg/day	Outdoor worker (US EPA 2002)
Time spent outdoors	ET_O	hours	1	8	Assumes an 8-hour work day
Time spent indoors	ET_i	hours	8	0	Work related indoor exposures are not expected. Track in of soil to home is considered negligible and part of background blood lead concentration.
Exposure frequency	EF	Days/yr	240	39	Assumes 3 days/week for 13 weeks. 13 weeks (90 days) is the minimum required by ALM model to achieve quasi-steady state blood lead concentration. Actual EF is expected to be about 5 days/week for a month (20 days) and this conservatively averages to about 3 days/week for 13 weeks. This also takes into account that workers are unlikely to be exposed to the contaminated area 100% of their time spent at the site.
Averaging time (non-carcinogenic)	AT_T	days	365 x 30 years	91	13 weeks (90 days) is the minimum required by ALM model to achieve quasi-steady state blood lead concentration. Actual duration of exposure is expected to be about 20-30 days (one month).

10. Bioavailability Measurements

The toxic effect of a contaminant depends upon the uptake or absorbed dose of contaminant, that is, the amount that gets into the bloodstream after being ingested, inhaled or via skin contact. The fraction of a compound that is absorbed into the body (systemic dose) following exposure via all pathways is generically termed the 'bioavailable fraction'.

More specifically:
• absolute bioavailability is the fraction of a compound which is ingested, inhaled or applied to the skin that actually is absorbed and reaches systemic circulation and
• relative bioavailability is referred to the comparative bioavailability of different forms of a chemical or for different exposure media containing the chemical. It is the ratio of the absorbed fraction from the exposure medium in the risk assessment (e.g. soil) to the absorbed fraction from the dosing medium used in the critical toxicity study.

The assessment of contaminant bioaccessibility may also be considered for estimating contaminant uptake. Bioaccessibility is related to the solubility of the contaminant in the gastrointestinal tract. More specifically, in the context of soil contamination, it is defined as the fraction of a contaminant in soil that is soluble in the relevant physiological milieu (usually the gastrointestinal tract) which is potentially available for absorption. If the lead is sourced from the breakdown of car batteries for example then the lead is likely to be readily bioaccessible; however, if the lead is sourced from an ore body (likely source of lead at the site) then the bioaccessibility can be quite different and a site-specific value may be used in the site-specific risk assessment. This can be assessed by validated in vitro test systems.

Relative bioavailability of contaminants in soil is complicated, highly variable and difficult to predict. This is because it depends strongly on the nature of the soil matrix (for example, soil type, age of soil, organic carbon, potential particle size, etc.) and on environmental conditions, particularly redox potential. NEPM HILs for lead are derived using 50% relative bioavailability assumptions however a site-specific assessment can be conducted to further verify or refine this assumption. In vitro assays are appropriate as a surrogate method for estimating relative bioavailability for contaminants such as lead and arsenic (NEPC 2013a). There are a number of in vitro methods that may be considered as a surrogate measure of arsenic and lead relative bioavailability and these may include Relative Bioavailability Leaching Procedure (RBALP) (US EPA 2007), the Solubility Bioavailability Research Consortium (SBRC) (Kelley et al. 2002) or the in vitro gastrointestinal method (IVG).

The bioaccessibility of lead in the material from the site was determined in <250 µm particle size fraction using gastric and intestinal phase of the SBRC assay. The gastric phase of this method (termed RBALP for lead) has been correlated to in vivo lead relative bioavailability when determined using juvenile swine (Juhasz et al., 2007; USEPA 2007). Six samples (3 from ballast and 3 from surface soils) were tested at the Future Industries Institute, based at the Mawson Lakes Campus of the University of South Australia (UniSA). The tests were conducted for several replicates (duplicates and five replicates) and included quality control testing. The reports are provided in **Appendix 2** (which also describes the method used) and gastric phase results are summarised in **Table 10-1**. The results show that the gastric phase bioavailability values are predominantly below 50%, with majority of it below 10%. Results for sample TP5a however shows more than 100% gastric bioavailability and it appears to be an anomaly. Unlike all other samples, the total lead results for this sample (average of 5 replicates) is lower than gastric phase SBRC value. The intestinal phase SBRC is much lower and realistic than the gastric phase value for this sample. Therefore, TP5a gastric phase results are excluded from the average results due to the discrepancy between total lead results and gastric phase results, huge difference

between gastric phase and intestinal phase results, and highly unlikely to be representative of the site conditions. Gastrointestinal absorption of inorganic lead occurs primarily from the duodenum (first part of small intestine) and may involve saturable mechanisms of absorption (ATSDR 2019). The use of gastric phase values, which are generally higher than intestinal phase values, is quite conservative. It is therefore considered that using an average gastric phase value would be appropriate and conservative given that uptake of inorganic lead occurs from the intestine. Furthermore, the various bioaccessibility values of different samples suggests high heterogeneity in-terms of lead bioaccessibility and the average value represents the average exposure to individuals at the site.

Table 10-1: Summary of the lead bioaccessibility results

Soil Sample	Total Lead (mg/kg)	Lead Relative Bioaccessibility (%) SBRC-G
TP3a	18500	3.6
TP4a	184,000	32.4
TP5a	29000	Anomalous data (>100)
SS12	48000	29.2
SS20	41000	1.7
SS29	7500	35.3
Average relative bioaccessibility		20

11. Toxicity Assessment

Lead (Pb) is a naturally occurring element and can exist in three oxidation states, Pb(0) – metallic lead, Pb(II) – most common and Pb(IV). The most common mineral form of lead is galena (PbS), followed by anglesite ($PbSO_4$) and cerussite ($PbCO_3$). Lead is used in a wide range of materials, including storage batteries, metal alloys, radiation shields, ammunition and chemical resistant linings. Lead has also been widely used as a paint pigment and additive in petrol, although its use in these products has been greatly reduced in recent years (ATSDR, 2007).

Natural mobilization of lead occurs via the weathering of mineral deposits and as a result of volcanic activity (ATSDR, 2007). However, these releases are minor compared to emissions from anthropogenic sources, including the mining and smelting of lead-bearing ores, the manufacture of lead-containing products, the combustion of coal and the incineration of lead-based wastes (ATSDR, 2007). The use of lead in products such as petrol, paints, pesticides, ammunition and fishing sinkers has historically resulted in emissions of lead being released to the environment. However, as lead has been phased out as a constituent of these products over the years, their significance as an environmental source of lead has greatly diminished.

Lead is persistent in the environment, the primary sink being soil and sediment (ATSDR, 2007). Atmospheric lead is mainly present in particulate form, with an average residence time of 10 days (ATSDR, 2007). The transport and bioavailability of lead deposited to soil is dependent upon the pH and mineral composition of the soil, as well as the amount and type of organic matter present (WHO, 1995). Lead strongly adsorbs to organic matter and is not readily leached to groundwater or sub-soils (ATSDR, 2007). Lead deposited to water will partition between the sediment and aqueous phase depending upon the salinity, pH and hardness of the water and the amount of humic material present (WHO, 1995)

The exposure scenarios assessed in this HHRA presents risks for potential short-term threshold (non-carcinogenic) health effects for site workers. Short-term exposure (< 1 year) to lead can cause temporary increase in blood lead concentrations with blood lead concentrations between 5 to 39 µg/dL likely to have short-term impacts relating to spontaneous abortion, postnatal developmental delay and reduced birth weight (SafeWork Australia 2013). Short-term effects of blood lead >40 µg/dL can also include neurocognitive deficits, sperm abnormalities, anemia, colic, encephalopathy and other nonspecific symptoms such as headache, fatigue, sleep disturbance, anorexia, constipation, arthralgia and myalgia. As blood lead increases to >30 µg/dL, signs and symptoms of gastrointestinal and neurological toxicity can also occur, with severity increasing with blood lead following short-term exposure (ATSDR 2019). Inorganic lead compounds are classified by the International Agency for Research on Cancer (IARC) as Group 2A agents that are probably carcinogenic to humans. In addition, the exposure scenarios being assessed in this HHRA is short-term for which carcinogenic risks are not of concern.

To quantify exposure in humans, data are expressed in terms of absorbed lead, and not in terms of external exposure levels (e.g., concentration in water) or dose (e.g., mg/kg/day). The most common metric of absorbed dose for lead is the concentration of lead in blood, although other measures of exposure (e.g., concentration of Pb in bone, hair, teeth, or urine) are used; however, measurements of Pb in urine, teeth, and hair are not as reliable. Blood lead mainly reflects exposure history of the previous few months and does not necessarily reflect the larger burden and much slower elimination kinetics of lead in bone. Lead in bone is considered a biomarker of cumulative or long-term exposure because lead accumulates in bone over the lifetime and most of the lead body burden resides in bone. Most of the body burden of Pb (the total amount of Pb in the body) is distributed to the bone, with approximately 94 and 76% of the body burden found in bone in adults and children, respectively (ATSDR 2019). The remainder is distributed to blood and soft tissues. Once absorbed, lead is rapidly taken up in the blood and distributed to soft tissues including the kidney, liver and bone marrow and then redistributed to the bone (WHO, 2011). Lead has a half-life of approximately 40 days in blood and soft tissue, and 20 to 30 years in bone (NHMRC, 2011). Lead is primarily excreted in faeces and urine, with minor excretion via sweat, saliva, hair, nails and breast milk (ATSDR, 2007).

12. Blood Lead Modelling

The Adult Lead Methodology was used for assessing any change in the blood lead levels for the workers under the different scenarios. The algorithms and background information about this methodology is provided elsewhere (NEPC 2013d; US EPA 2003a).

The baseline blood lead concentration input parameter of the model represents the geometric mean blood lead concentration in woman of child-bearing age and the geometric standard deviation (GSD) input parameter is a measure of the inter-individual variability in these concentrations. The default input parameters in the model comes from a survey of US women 17-45 years of age under the National Health and Nutrition Examination Survey (NHANES). The most recent update of the model default parameters was conducted in 2014, with previous updates conducted in 2002, 2007 and 2010 (US EPA 2017a). Consistent with the NEPM derivation of lead HIL-D values, these latest default parameters were used in the model calculations (**Table 12-1**).

Table 12-1: ALM model input parameters

Input Parameter	Description	Value used
PbS	Soil lead concentration	95% UCL
$R_{fetal/maternal}$	Fetal/maternal blood lead ratio	ALM default
BKSF	Biokinetic slope factor relating (quasi-steady state) increase in typical adult blood lead concentration to average daily lead uptake (µg/dL blood lead increase per µg/day lead uptake).	ALM default
GSDi	Geometric standard deviation blood lead	ALM default
PbB_0	Baseline blood lead	ALM default
$AF_{S,D}$	Absorption fraction (same for soil and dust)	Site-specific calculation

The absorption fraction ($AF_{S,D}$) is calculated according to the following equation:

$$AF_{S,D} = AF_{Soluble} \times RBF_{Soil/Soluble}$$

The relative bioavailable fraction (RBF) value was measured in the sample as 20% (average), while $AF_{Soluble}$, which is the absorption of soluble lead from GI tract, was the ALM default value.

The modelling spreadsheets are provided in **Appendix 3** and used the 2014 update of the model parameters (US EPA 2017a).

13. Risk Characterisation

The blood lead estimates calculated from the ALM model is shown in **Table 13-1** along with the exceedance (risk quotient, RQ) of the adopted guideline value.

Table 13-1: Risk characterisation of blood lead estimation of workers at the site.

Scenario	Receptor	ALM Blood Lead Prediction (µg/dL)	Adopted Target (µg/dL)	Exceedance – RQ
Current onsite Worker	Female of reproductive capacity	68	10	7
Future onsite worker	Female of reproductive capacity	68	5	14

Red shading indicates exceedance of adopted guideline value, i.e RQ > 1.

The calculated RQ values are >1, which suggests that an unacceptable level of risk may exist at the site for current and future workers. This level of risk is based on exposure to a concentration of 40975 mg/kg lead having a relative bioavailability of 20%.

Back-calculating a target concentration based on 10 µg/dL blood lead concentration and exposure parameters, a safe level of 5300 mg/kg lead is derived for current works at the site. A criterion for future workers at the site based on 5 µg/dL target blood level is similarly derived to be 2200 mg/kg.

Any clean-up criteria for lead in soil/ballast fines should be based on 5 µg/dL, which is the value that will come into effect from July 2021 as per SafeWork Australia lead risk work guidelines and updated WHS regulations. This clean-up criterion is protective of future intrusive works conducted at the site which would typically be for short-term duration, lasting for 2-3 days at time. This assumption takes into account a likelihood that future works will occur over relatively short periods of time under rail shut-downs and that limited intrusive works are likely to required after the current major works are completed at the site.

Therefore, the calculated criteria for future workers at the site of **2200 mg/kg** should also be used as the site clean up criterion to ensure compliance with updated WHS regulations in the future. It is also recommended that current site exposure controls based on this criterion should also be implemented to ensure protection of site workers. This would be protective of both 'females of reproductive capacity' and all other workers currently working at the site. As concentrations at the site exceed this criterion, then any works at the site should implement the recommendations contained within the SLMP. Unless there is certainty that work is being carried out in areas where current exposure concentrations are less than the calculated safe level.

14. Conclusion

It has been assessed that concentrations of lead present at the site are likely to be presenting an unacceptable level of risk to workers at the site. Based on current SafeWork NSW lead risk work guidelines and the updated relevant WHS Regulations 2019, the following site-specific guideline values are derived:

Table 14-1: Calculated site-specific HILs

Site Receptor	Derived site-specific HIL (mg/kg)*	Target blood lead	Comments
Current onsite Worker	5300	10 µg/dL	This value is safe level for any current site works, valid until 30 June 2021. However, it is recommended to implement exposure controls (as per the SLMP) using site-specific value based on target blood lead of 5 µg/dL (see below)
Future onsite worker	**2200**	5 µg/dL	This value is protective of future workers at the site based on the changed WHS regulations. This value is recommended to be the site clean up criteria to ensure compliance with changed regulations

*Derived values would be protective of 'females not of reproductive capacity and males'.

As concentrations at the site exceed the criteria shown in **Table 14-1** of 2200 mg/kg, any works at the site should implement the recommendations contained within the SLMP, unless there is certainty that work is being carried out in areas where current exposure concentrations are less than the calculated safe level.

15. Limitations

This document is issued in confidence to John Holland Rail for the purposes of assessing risk of contamination associated with the proposed Tarago Loop Extension and associated signal trenching. The guidelines values adopted in this HHRA is only valid till June 30, 2021, however clean-up criteria is based on the impending change in 'lead risk work' definition relating to blood lead concentration of 5 µg/dL. The outcomes of this report is based on the assumptions used for the risk assessment and calculation of the clean-up criteria. Any significant change in this assumption for current or future works would require a re-evaluation of the calculated risks and criteria. The HHRA does not include assessment of risk to off-site receptors, station users or local ecological receptors. Assessment of risks to these receptors may be required if its deemed to be posing any unacceptable risks based on any tier 1 assessments.

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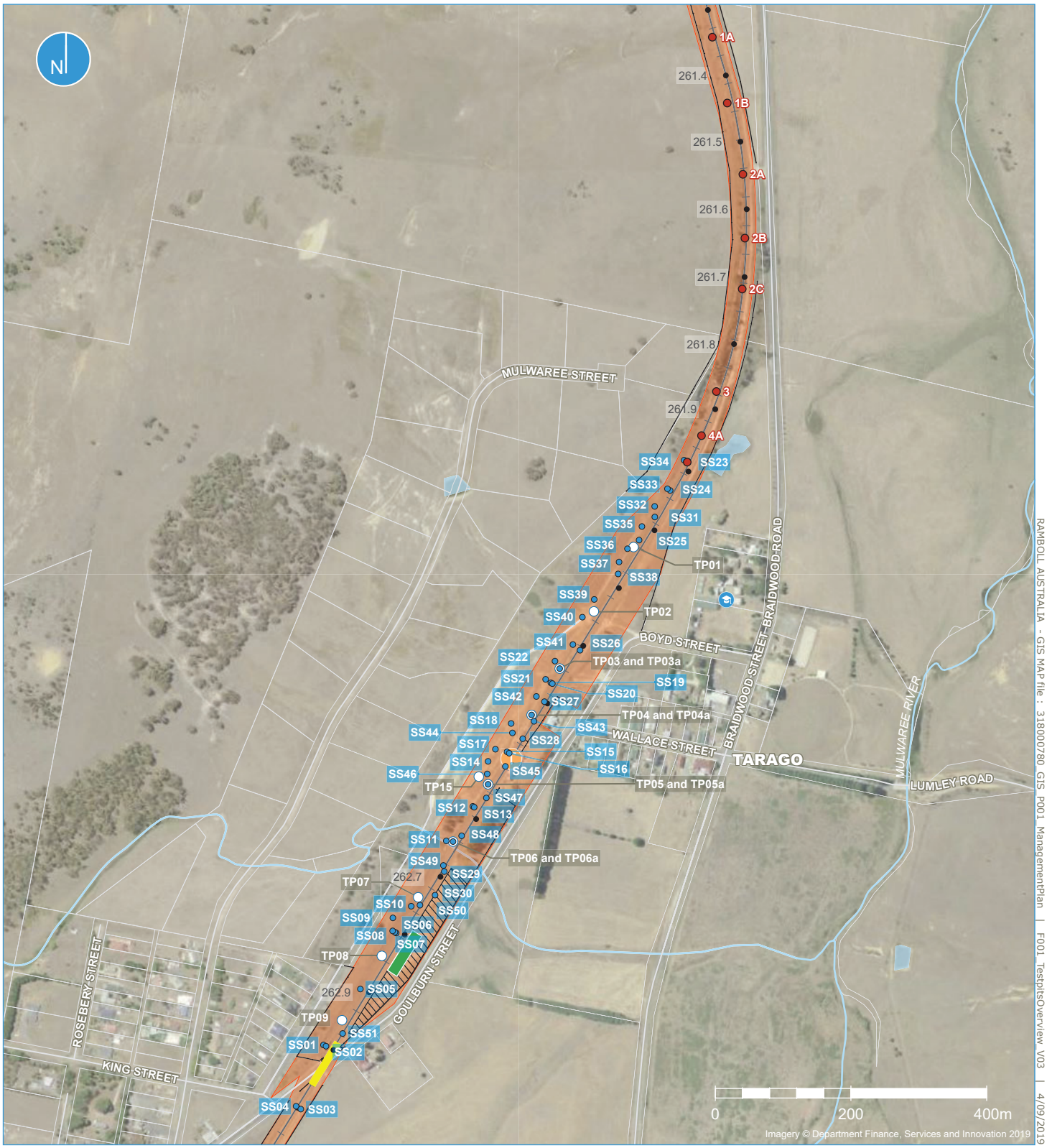
APPENDIX 1: FIGURE



RAMBOLL AUSTRALIA - GIS MAP file : 318000780_GIS_P001_ManagementPlan | F001_TestpitsOverview_V03 | 4/09/2019

A4
1:8,000

Legend

- Rail corridor
- Rail corridor fence
- 0.1km chainage point
- Goulburn Street level crossing
- Construction compound
- Goods shed exclusion zone

Sampling locations (siding works)

- Shallow soil (Ramboll 2019)
- Test pit (Ramboll 2019)
- Previous sample location (McMahon)

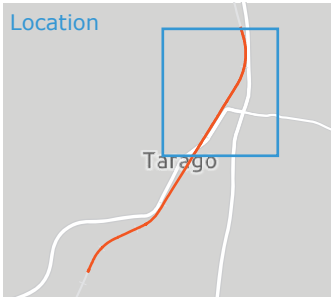


Figure 1 | Overview of siding works sampling locations

APPENDIX 2: BIOACCESSIBILITY RESULTS

University of South Australia

Assessment of Pb Bioaccessibility in Impacted Soil (Eurofins analysis)

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Date of issue: 20 September 2019

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INTRODUCTION

This report was prepared for Ramboll to assess lead bioaccessibility in impacted soil. The bioaccessibility testing was conducted at the Future Industries Institute, based at the Mawson Lakes Campus of the University of South Australia (UniSA). UniSA's Flagship Institute focuses on building knowledge and capacity in core research strengths of physical chemistry and environmental science and management. The Institute has four distinct yet inter-related strands: Minerals and Resources; Energy and Advanced Manufacturing; Environmental Science and Engineering; and Bioengineering and Nanomedicine. The Institute aggregates and builds upon existing expertise and infrastructure from the Ian Wark Research Institute, the Mawson Institute and the Centre for Environmental Risk Assessment and Remediation. The vision for the Future Industries Institute aligns strongly with South Australian and National economic and research priorities by building a critical mass of trans-disciplinary research capacity focused on pressing real-world challenges.

OBJECTIVES

The objective of this assessment was to:

- Assess the concentration of lead in the < 2 mm and < 250 μm soil particle size fractions;
- Assess lead bioaccessibility in the < 250 μm soil particle size fraction using the gastric phase of the SBRC assay;
- Assess lead bioaccessibility in the < 250 μm soil particle size fraction using the intestinal phase of the SBRC assay; and
- Calculate lead relative bioaccessibility in the < 250 μm soil particle size fraction.

OUTCOMES AND DELIVERABLES

The expected outcome from this assessment was:

- A report assessing the bioaccessibility of lead in soil. The report was to include:
    - Assessment of lead concentration in the < 2 mm and < 250 μm soil particle size fractions;
    - Assessment of lead bioaccessibility in the < 250 μm soil particle size fractions using an vitro method;
    - Methodology procedures; and
    - QA/QC protocols

PROJECT BACKGROUND

Soil testing was initiated at the invitation of Ramboll for an assessment of lead bioaccessibility in impacted soil. Human exposure to a contaminant may be through a number of pathways including inhalation, dermal absorption and ingestion. For many metal contaminants, the most significant metal exposure pathway is via soil ingestion. Generally, soil ingestion results from the accidental or, in the case of children less than 5 years old, the incidental ingestion of soil (< 250 µm particle size fraction) via hand-to-mouth contact (Basta et al., 2001). In assessing contaminant exposure, it is often assumed that the contaminant is 100% bioaccessible / bioavailable, however, there is growing evidence to suggest that contaminant bioaccessibility / bioavailability in soil may be less than 100%. Therefore, incorporation of metal bioaccessibility / bioavailability may reduce the uncertainty in estimating exposure associated with the incidental ingestion of contaminated soil.

Contaminant bioaccessibility may be estimated using *in vitro* assays that simulate processes that occur in the human body that lead to the release of contaminants from the soil matrix. A frequently used assay for the determination of contaminant bioaccessibility is the Solubility Bioaccessibility Research Consortium (SBRC) method (Kelly *et al.,* 2002). The gastric phase of this method (termed the Simplified Bioaccessibility Extraction Test [SBET] for arsenic or the Relative Bioavailability Leaching Procedure [RBALP] for lead) has been correlated to *in vivo* arsenic and lead relative bioavailability when determined using juvenile swine (Juhasz *et al*., 2007; USEPA 2007).

FINDINGS

Total lead concentration for each sample is shown in Table 1 while lead bioaccessibility results are shown in Tables 2 (SBRC-G lead bioaccessibility), 3 (SBRC-I lead bioaccessibility) and 4 (summary of data).

- Total lead concentration in the < 250 µm soil particle size fraction ranged from 7500 (SS29) to 184000 mg kg^{-1} (TP4a) (Table 1).
- Lead bioaccessibility determined using gastric phase extraction (SBRC-G) ranged from 3.6% (TP3a) to ~100% (TP5a) (Tables 2 and 4).
- When assays parameters were modified to reflect intestinal phase conditions (SBRC-I), lead bioaccessibility was variable ranging from <0.01% (SS20) to 19.6% (TP4a) (Tables 3 and 4).
- Lead relative bioaccessibility (Rel-SBRC-I) was calculated by adjusting the solubility of lead from contaminated soil by the solubility of lead acetate at the corresponding intestinal phase pH value (Table 4). Lead relative bioaccessibility values ranged from <0.1% (SS20) to 51.9% (TP4a).
- Lead bioaccessibility for QC1 was within an acceptable range for this reference material.

Table 1. Total Pb concentration in the < 2 mm and < 250 µm soil particle size fractions.

Soil	ID #	< 2 mm soil particle size fraction		Sample #	< 250 µm soil particle size fraction	
		Pb (mg kg^{-1})	Mean Pb (mg kg^{-1})		Pb (mg kg^{-1})	Mean Pb (mg kg^{-1})
TP3a	TP3a -2A	17000		TP3a -250A	14000	
	TP3a -2B	25000	21000	TP3a -250B	23000	18500
TP4a	TP4a -2A	180000		TP4a -250A	180000	
	TP4a -2B	150000		TP4a -250B	180000	
	TP4a -2C	150000		TP4a -250C	180000	
	TP4a -2D	160000		TP4a -250D	190000	
	TP4a -2E	150000	158000	TP4a -250E	190000	184000
TP5a	TP5a -2A	37000		TP5a -250A	48000	
	TP5a -2B	40000		TP5a -250B	23000	
	TP5a -2C	42000		TP5a -250C	24000	
	TP5a -2D	39000		TP5a -250D	24000	
	TP5a -2E	40000	39600	TP5a -250E	26000	29000
SS12	-	-		SS12 -250A*	48000	
SS20	-	-		SS20 -250A*	41000	
SS29	-	-		SS29 -250A*	7500	

*Insufficient sample was available for replicate analysis

Table 2. Lead bioaccessibility in contaminated soil determined using gastric phase extraction (SBRC-G).

Soil	Sample #	ICP-AES Pb (mg l^{-1})	Soil:Solution Ratio	Dilution	Gastric Phase Pb Bioaccessibility (mg kg^{-1})	Mean Gastric Phase Pb Bioaccessibility (mg kg^{-1})
TP3a	TP3a-G1	0.63	100	10	630	
	TP3a-G2	0.72	100	10	720	675
TP4a	TP4a-G1	59	100	10	59000	
	TP4a-G2	59	100	10	59000	
	TP4a-G3	59	100	10	59000	
	TP4a-G4	62	100	10	62000	
	TP4a-G5	59	100	10	59000	59600
TP5a	TP5a-G1	35	100	10	35000	
	TP5a-G2	34	100	10	34000	
	TP5a-G3	33	100	10	33000	
	TP5a-G4	35	100	10	35000	
	TP5a-G5	35	100	10	35000	34400
SS12	SS12-G1	14	100	10	14000	
	SS12-G2	14	100	10	14000	14000
SS20	SS20-G1	0.69	100	10	690	
	SS20-G2	0.67	100	10	670	680
SS29	SS29-G1	2.7	100	10	2700	
	SS29-G2	2.6	100	10	2600	2650
QC1†	QC1-G1	5.1	100	10	5100	
	QC1-G2	5.1	100	10	5100	5100
QC2‡	QC2-G1	<0.001	-	10	<0.01	
	QC2-G2	<0.001	-	10	<0.01	<0.01

†QC1 comprised of a lead-contaminated (6400 mg Pb kg^{-1}) reference soil.
‡QC2 comprised of SBRC gastric phase solution without soil addition (assay blank).

Table 3. Lead bioaccessibility in contaminated soil determined using gastro-intestinal phase extraction (SBRC-I).

Soil	Sample #	ICP-AES Pb (mg l^{-1})	Soil:Solution Ratio	Dilution	Intestinal Phase Pb Bioaccessibility (mg kg^{-1})	Mean Intestinal Phase Pb Bioaccessibility (mg kg^{-1})
TP3a	TP3a-I1	0.007	100	10	7.0	
	TP3a-I2	0.13	100	10	13	6.9
TP4a	TP4a-I1	35	100	10	35000	
	TP4a-I2	36	100	10	36000	
	TP4a-I3	37	100	10	37000	
	TP4a-I4	36	100	10	36000	
	TP4a-I5	36	100	10	36000	36000
TP5a	TP5a-I1	10	100	10	10000	
	TP5a-I2	10	100	10	10000	
	TP5a-I3	10	100	10	10000	
	TP5a-I4	10	100	10	10000	
	TP5a-I5	11	100	10	11000	10200
SS12	SS12-I1	3.8	100	10	3800	
	SS12-I2	3.9	100	10	3900	3850
SS20	SS20-I1	<0.001	100	10	<1.0	
	SS20-I2	<0.001	100	10	<1.0	<1.0
SS29	SS29-I1	0.12	100	10	120	
	SS29-I2	0.12	100	10	120	120
QC1[†]	QC1-I1	0.57	100	10	570	
	QC1-I2	0.51	100	10	510	540
QC2[‡]	QC2-I1	<0.001	-	10	<0.01	
	QC2-I2	<0.001	-	10	<0.01	<0.01

[†]QC1 comprised of a lead-contaminated (6400 mg Pb kg^{-1}) reference soil.
[‡]QC2 comprised of SBRC gastrointestinal phase solution without soil addition (assay blank).

Table 4. Total lead concentration and bioaccessible lead in contaminated soil (< 250 µm soil particle size fraction).

Soil	Total Pb (mg kg^{-1})	In vitro Phase	Pb Bioacc. (mg kg^{-1})	Pb Bioacc.‡ (%)
TP3a	18500	SBRC-G	675	3.6
		SBRC-I	6.9	0.04
		Rel-SBRC-I*		0.4
TP4a	184000	SBRC-G	59600	32.4
		SBRC-I	36000	19.6
		Rel-SBRC-I*		51.9
TP5a	29000	SBRC-G	34400	~100
		SBRC-I	1020	3.5
		Rel-SBRC-I*		9.3
SS12	48000	SBRC-G	14000	29.2
		SBRC-I	3850	8.0
		Rel-SBRC-I*		21.3
SS20	41000	SBRC-G	680	1.7
		SBRC-I	<1.0	<0.01
		Rel-SBRC-I*		<0.1
SS29	7500	SBRC-G	2650	35.3
		SBRC-I	120	1.6
		Rel-SBRC-I*		7.7
QC1$^{\Omega}$	6400	SBRC-G	5100	79.7

‡Percentage lead bioaccessibility following gastric or gastrointestinal phase extraction was calculated by dividing the bioaccessible lead (SBRC-G or SBRC-I) by the total lead concentration multiplied by 100.

*Lead relative bioaccessibility was calculated by adjusting the solubility of lead from contaminated soil by the solubility of lead acetate at the corresponding intestinal phase pH value.

$^{\Psi}$Percentage lead bioaccessibility cannot exceed 100%. It was hypothesised that calculated values in excess of 100% may arise from elevated lead bioaccessibility in the intestinal phase as a result of organic-lead complexes.

$^{\Omega}$Lead bioaccessibility for the QC1 soil was within an acceptable range for this reference material.

REFERENCES

Basta, N. T., Rodriguez, R. R., Casteel, S. W. (2001). Bioavailability and risk of arsenic exposure by the soil ingestion pathway. *In* W T Frankenberger Jr (ed): *Environmental Chemistry of Arsenic*. Marcel Dekker, New York, 2001, 117-139.

Kelly, M. E., Brauning, S. E., Schoof, R. A., Ruby, M. V. (2002). Assessing oral bioavailability of metals in soils. Batelle Memorial Institute, Ohio. pp 75-78.

Juhasz, A. L., Smith, E., Weber, J., Rees, M., Rofe, A., Kuchel, T., Sansom, L., Naidu, R. (2007). Comparison of in vivo and in vitro methodologies for the assessment of arsenic bioavailability in contaminated soils. *Chemosphere* **69**: 961-966.

USEPA (2007). *Estimation of relative bioavailability of lead in soil and soil-like material using in vivo and in vitro methods*; OSWER 9285.7-77, EPA: Washington, DC, 2007

CONFIDENTIALITY

We acknowledge the confidential nature of the results of this project and will treat the results and project reports with appropriate confidentiality and security.

APPENDIX 1 - METHODOLOGY

Soil samples

Samples supplied by Ramboll and Eurofins were oven-dried at 105°C for 24 hours and sieved to obtain 2 soil particle size fractions; < 2 mm and < 250 µm. The < 250 µm soil particle size fraction was used to assess lead bioaccessibility.

Assessment of total lead concentration in the < 2 mm and < 250 µm soil fractions

Total lead concentration in the < 2 mm and < 250 µm soil fractions were determined by Eurofins. A copy of the Eurofins analytical report is included in Appendix 3.

Assessment of lead bioaccessibility in the < 250 µm soil particle size fraction

A frequently used assay for the determination of contaminant bioaccessibility is the Solubility Bioaccessibility Research Consortium (SBRC) method (Kelly *et al*., 2002). The gastric phase of this method (termed the Relative Bioavailability Leaching Procedure [RBALP] for lead) has been correlated to *in vivo* lead relative bioavailability when determined using juvenile swine (USEPA 2007). Contaminated soil and gastric solution (30.03 g l^{-1} glycine adjusted to pH 1.5 with concentrated HCl) were combined in polyethylene screw cap flasks at a soil:solution ratio of 1:100. The pH was noted then the flasks were incubated at 37°C, 40 rpm on a Ratek suspension mixer. After 1 hour incubation, the pH was determined and gastric phase samples (10 ml) were collected, filtered through 0.45 µm filters and analysed by ICP-MS by ALS Environmental Laboratories.

Following gastric phase dissolution, the gastric solution was modified to the intestinal phase by adjusting the pH from 1.5 to 6.5-7.0 using 5 or 50% NaOH and by the addition of bovine bile (1750 mg l^{-1}) and porcine pancreatin (500 mg l^{-1}). After a further 4 hours incubation, intestinal phase samples (10 ml) were collected, filtered through 0.45 µm filters and analysed by ICP-MS. Gastric and intestinal phase extractions were performed in triplicate for each soil sample. Lead bioaccessibility was calculated by dividing the gastric or intestinal phase extractable lead by the total soil lead concentration. Lead relative bioaccessibility was determined by adjusting the dissolution of lead from contaminated soils by the solubility of lead acetate at the corresponding pH value. All extracts were analysed by ICP-MS by ALS Environmental Laboratories. A copy of the ALS Environmental Laboratories analytical report is included in Appendix 3.

QA/QC procedures

Eurofins conducted the analysis for total and bioaccessible lead concentrations for all samples. Eurofins is a NATA accredited laboratory for the chemical testing of environmental materials. Quality Control results are reported in Appendix 2. Two additional samples were included in bioaccessibility assays for quality assurance and quality control. The samples consisted of:

a. QC1 – Lead-contaminated (6400 mg Pb kg^{-1}) reference soil.
b. QC2 – SBRC solution without soil addition (assay blank).

APPENDIX 2 – CHAIN OF CUSTODY FORMS

CHAIN OF CUSTODY RECORD

ABN 50 005 085 521

☑ Eurofins | mgt Sydney Lab — Unit F3 Building F, 16 Mars Rd, Lane Cove West, NSW 2066 P +61 2 9900 8400 F: EnviroSampleNSW@eurofins.com.au

☐ Eurofins | mgt Brisbane Lab — Unit 1, 21 Smallwood Place, Murarrie, QLD 4172 P +61 7 3902 4600 E: EnviroSampleQLD@eurofins.com.au

☐ Eurofins | mgt Melbourne Lab — 2 Kingston Town Close, Oakleigh, VIC 3166 P +61 3 8564 5000 F: +61 3 8564 5090 E: EnviroSampleVic@eurofins.com.au

Company	Ramboll	Purchase Order		Project Manager	Stephen Maxwell
Address	Level 2, Suite 18 Eastpoint, 50 Glebe Rd, The Junction, NSW 2291	Eurofins | mgt Quote №		Project №	318000780
Contact Name	Stephen Maxwell				
Contact Phone №	0478 658 194				
Special Direction					
Relinquished by (Signature)	Albert Juhasz				
(Time / Date)	10 : 00 16 / 9 / 19				

Project Name	Pb Bioaccessibility				
Electronic Results Format					
Email for Results	smaxwell@ramboll.com; Albert.Juhasz@unisa.edu.au				
Turn Around Requirements	☑ 1 DAY* ☐ 2 DAY* ☐ 3 DAY* * Surcharges apply ☐ 5 DAY (Std) ☐ Other ( )				

Analysis (Note: Where metals are requested, please specify "Total" or "Filtered")

№	Client Sample ID	Date	Matrix	Total Pb
1	TP4a-2A	16/09/2019	soil	X
2	TP4a-2B	16/09/2019	soil	X
3	TP4a-2C	16/09/2019	soil	X
4	TP4a-2D	16/09/2019	soil	X
5	TP4a-2E	16/09/2019	soil	X
6	TP4a-250A	16/09/2019	soil	X
7	TP4a-250B	16/09/2019	soil	X
8	TP4a-250C	16/09/2019	soil	X
9	TP4a-250D	16/09/2019	soil	X
10	TP4a-250E	16/09/2019	soil	X

1 of 1

Containers: 1L Plastic | 250mL Plastic | 125mL Plastic | 200mL Amber Glass | 40mL vial | 125mL Amber Glass | Jar | Other

Method of Shipment: ☑ Courier ( ) ☐ Hand Delivered ☐ Postal

Sample Comments / DG Hazard Warning

Please refer to email dated 12/9 (5.54pm) regarding [Pb] in these soils. [Pb] may exceed 200,000 mg/kg. May need to increase soil : acid ratio

Laboratory Use Only									
Received By	Packrat	SYD | BNE | MEL | PER (ADL) NEW | DAR	Date	16/9/19	Time	11 am	Signature		Temperature	6.27
Received By	Grace Turkwell	(SYD) | BNE | MEL | PER | ADL | NEW | DAR	Date	17/9/19	Time	9:00	Signature		Report №	677385

US3000_313 Modified by T. Sawyer Approved by T Lakeland Approved on 18 Jun 2015

Submission of samples to the laboratory will be deemed as acceptance of Eurofins | mgt Standard Terms and Condition[illegible] agreed otherwise. A copy of Eurofins | mgt Standard Terms and Conditions is available on request

CHAIN OF CUSTODY RECORD

ABN 50 005 085 521

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☐ Eurofins | mgt Melbourne Lab — 2 Kingston Town Close, Oakleigh, VIC 3166 P +61 3 8564 5000 F +61 3 8564 5090 E: EnviroSampleVic@eurofins.com.au

Company	Ramboll	Purchase Order		Project Manager	Stephen Maxwell
Address	Level 2, Suite 18 Eastpoint, 50 Glebe Rd, The Junction, NSW 2291	Eurofins | mgt Quote №		Project №	318000780
Contact Name	Stephen Maxwell				
Contact Phone №	0478 658 194				
Special Direction					
Relinquished by (Signature)	Albert Juhasz				
(Time / Date)	10 : 00 16 / 9 / 19				

Project Name	Pb Bioaccessibility
Electronic Results Format	
Email for Results	smaxwell@ramboll.com; Albert.Juhasz@unisa.edu.au
Turn Around Requirements	☑ 1 DAY* ☐ 2 DAY* ☐ 3 DAY* (* Surcharges apply) ☐ 5 DAY (Std) ☐ Other ( )

Containers: 1L Plastic | 250mL Plastic | 125mL Plastic | 200mL Amber Glass | 40mLvial | 125mL Amber Glass | Jar | Other

Method of Shipment: ☑ Courier ( ) ☐ Hand Delivered ☐ Postal

№	Client Sample ID	Date	Matrix	Analysis (Note: Where metals are requested, please specify "Total" or "Filtered") — Total Pb	Sample Comments / DG Hazard Warning
11	TP5a-2A	16/09/2019	soil	X	
12	TP5a-2B	16/09/2019	soil	X	
13	TP5a-2C	16/09/2019	soil	X	
14	TP5a-2D	16/09/2019	soil	X	
15	TP5a-2E	16/09/2019	soil	X	
16	TP5a-250A	16/09/2019	soil	X	
17	TP5a-250B	16/09/2019	soil	X	
18	TP5a-250C	16/09/2019	soil	X	
19	TP5a-250D	16/09/2019	soil	X	
20	TP5a-250E	16/09/2019	soil	X	

2 of 7

Laboratory Use Only									
Received By	Parimal	SYD | BNE | MEL | PER | ADL | NEW | DAR	Date	16/9/19	Time	11 am	Signature		Temperature	6-27
Received By	Grace Turnwell	SYD | BNE | MEL | PER | ADL | NEW | DAR	Date	17/9/19	Time	9:00	Signature		Report №	677385

CHAIN OF CUSTODY RECORD

ABN 50 005 085 521

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☐ Eurofins | mgt Melbourne Lab — 2 Kingston Town Close, Oakleigh, VIC 3166 5000 P +61 3 8564 5000 F +61 3 8564 5090 E EnviroSampleVic@eurofins.com.au

Company	Ramboll	Purchase Order		Project Manager	Stephen Maxwell
Address	Level 2, Suite 18 Eastpoint, 50 Glebe Rd, The Junction, NSW 2291	Eurofins | mgt Quote №		Project №	318000780
Contact Name	Stephen Maxwell				
Contact Phone №	0478 658 194				
Special Direction					
Relinquished by (Signature)	Albert Juhasz				
(Time / Date)	10 : 00 16 / 9 / 19				

Project Name	Pb Bioaccessibility
Electronic Results Format	
Email for Results	smaxwell@ramboll.com; Albert.Juhasz@unisa.edu.au
Turn Around Requirements	☑ 1 DAY* ☐ 2 DAY* ☐ 3 DAY* (* Surcharges apply) ☐ 5 DAY (Std) ☐ Other ( )

Containers: 1L Plastic | 250mL Plastic | 125mL Plastic | 200mL Amber Glass | 40mL Vial | 125mL Amber Glass | Jar | Other

Method of Shipment: ☑ Courier ( ) ☐ Hand Delivered ☐ Postal

№	Client Sample ID	Date	Matrix	Analysis (Note: Where metals are requested, please specify "Total" or "Filtered") — Total Pb	Sample Comments / DG Hazard Warning
21	TP3a-2A	16/09/2019	soil	X	
22	TP3a-2B	16/09/2019	soil	X	
23	TP3a-250A	16/09/2019	soil	X	
24	TP3a-250B	16/09/2019	soil	X	
25	SS12-250A	16/09/2019	soil	X	limited sample volume supplied
26	SS20-250A	16/09/2019	soil	X	
27	SS29-250A	16/09/2019	soil	X	

3 of 7

Laboratory Use Only										
	Received By	Pasquale	SYD | BNE | MEL | PER | (ADL) | NEW | DAR	Date	16/9/19	Time	11 am	Signature		Temperature 6.27
	Received By	Grace Turkwell	(SYD) | BNE | MEL | PER | ADL | NEW | DAR	Date	17/9/19	Time	9:00	Signature		Report № 677385

CH3009_R3 Modified by F Nwajiya Approved by F Liesveld Approved on 16 Jan 2015

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ABN 50 005 085 521

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Company	Ramboll	Purchase Order		Project Manager	Stephen Maxwell
Address	Level 2, Suite 18 Eastpoint, 50 Glebe Rd, The Junction, NSW 2291	Eurofins | mgt Quote №		Project №	318000780
Contact Name	Stephen Maxwell				
Contact Phone №	0478 658 194				
Special Direction					
Relinquished by (Signature)	Albert Juhasz				
(Time / Date)	10:00 16/9/19				

Project Name	Pb Bioaccessibility
Electronic Results Format	
Email for Results	smaxwell@ramboll.com; Albert.Juhasz@unisa.edu.au
Turn Around Requirements	☑ 1 DAY* ☐ 2 DAY* ☐ 3 DAY* (* Surcharges apply) ☐ 5 DAY (Std.) ☐ Other ( )

Containers: 1L Plastic | 250mL Plastic | 125mL Plastic | 200mL Amber Glass | 40mLVial | 125mL Amber Glass | Jar | Other

Method of Shipment: ☑ Courier ( ) ☐ Hand Delivered ☐ Postal

№	Client Sample ID	Date	Matrix	Analysis (Note: Where metals are requested, please specify "Total" or "Filtered")	Dissolved Pb	Containers	Sample Comments / DG Hazard Warning
28	TP4a-G1	16/09/2019	water		X	4 of 7	
29	TP4a-G2	16/09/2019	water		X		
30	TP4a-G3	16/09/2019	water		X		
31	TP4a-G4	16/09/2019	water		X		
32	TP4a-G5	16/09/2019	water		X		
33	TP4a-I1	16/09/2019	water		X		
34	TP4a-I2	16/09/2019	water		X		
34	TP4a-I3	16/09/2019	water		X		
36	TP4a-I4	16/09/2019	water		X		
37	TP4a-I5	16/09/2019	water		X		

All water samples are in 0.1M HNO_3 matrix

Laboratory Use Only									
Received By	Parsunal	SYD | BNE | MEL | PER | (ADL) | NEW | DAR	Date	16/9/19	Time	11 am	Signature		Temperature 6.2 °C
Received By	Grace Tunwell	(SYD) | BNE | MEL | PER | ADL | NEW | DAR	Date	17/9/19	Time	9:00	Signature		Report № 677385

DS2008 RC Modified by F Swayne Approved by T Lukaniec Approved on 18 Jun 2015

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☐ Eurofins | mgt Melbourne Lab — 2 Kingston Town Close, Oakleigh, VIC 3166 P: +61 3 8564 5000 F: +61 3 8564 5090 E: EnviroSampleVic@eurofins.com.au

Company	Ramboll	Purchase Order	
Address	Level 2, Suite 18 Eastpoint, 50 Glebe Rd, The Junction, NSW 2291	Eurofins | mgt Quote №	
Contact Name	Stephen Maxwell	Project Manager	Stephen Maxwell
Contact Phone №	0478 658 194	Project №	318000780
Special Direction			
Relinquished by	Albert Juhasz		
(Signature)			
(Time / Date)	10:00 16 / 9 / 19		

Project Name	Pb Bioaccessibility	
Electronic Results Format		
Email for Results	smaxwell@ramboll.com; Albert.Juhasz@unisa.edu.au	
Turn Around Requirements	☑ 1 DAY* ☐ 2 DAY* ☐ 3 DAY* * Surcharges apply ☐ 5 DAY (Std.) ☐ Other ( )	

Analysis (Note: Where metals are requested, please specify "Total" or "Filtered".)

№	Client Sample ID	Date	Matrix	Dissolved Pb	5 of 7	Containers: 1L Plastic	250mL Plastic	125mL Plastic	200mL Amber Glass	40mL Vial	125mL Amber Glass	Jar	Other	Method of Shipment	Sample Comments / DG Hazard Warning
38	TP5a-G1	16/09/2019	water	X										☑ Courier ( ) ☐ Hand Delivered ☐ Postal	
39	TP5a-G2	16/09/2019	water	X											
40	TP5a-G3	16/09/2019	water	X											
41	TP5a-G4	16/09/2019	water	X											
42	TP5a-G5	16/09/2019	water	X											
43	TP5a-I1	16/09/2019	water	X											
44	TP5a-I2	16/09/2019	water	X											
45	TP5a-I3	16/09/2019	water	X											
46	TP5a-I4	16/09/2019	water	X											
47	TP5a-I5	16/09/2019	water	X											

Laboratory Use Only								
Received By	Parmal	SYD | BNE | MEL | PER | (ADL) | NEW | DAR	Date 16/9/19	Time 11 am	Signature		Temperature	6-27
Received By	Grace Turkett	(SYD) | BNE | MEL | PER | ADL | NEW | DAR	Date 17/9/19	Time 9.00	Signature		Report №	677385

Q30009 HQ Modified by F Sequeya Approved by T Leonard Approved on 16 Jan 2015

CHAIN OF CUSTODY RECORD

ABN 50 005 085 521

☑ Eurofins | mgt Sydney Lab — Unit F3 Building F, 16 Mars Rd, Lane Cove West, NSW 2066 P +61 2 9900 8400 E EnviroSampleNSW@eurofins.com.au

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☐ Eurofins | mgt Melbourne Lab — 2 Kingston Town Close, Oakleigh, VIC 3166 P +61 3 8564 5000 F +61 3 8564 5090 E EnviroSampleVic@eurofins.com.au

Company	Ramboll	Purchase Order		Project Manager	Stephen Maxwell	Project Name	Pb Bioaccessibility
Address	Level 2, Suite 18 Eastpoint, 50 Glebe Rd, The Junction, NSW 2291	Eurofins | mgt Quote №		Project №	318000780	Electronic Results Format	
Contact Name	Stephen Maxwell					Email for Results	smaxwell@ramboll.com; Albert.Juhasz@unisa.edu.au
Contact Phone №	0478 658 194					Turn Around Requirements	☑ 1 DAY* ☐ 2 DAY* ☐ 3 DAY* * Surcharges apply ☐ 5 DAY (Std.) ☐ Other ( )
Special Direction						Containers	Method of Shipment
Relinquished by (Signature)	Albert Juhasz						☑ Courier ( ) ☐ Hand Delivered ☐ Postal
(Time / Date)	10:00 16 / 9 / 19						

№	Client Sample ID	Date	Matrix	Analysis (Note: Where metals are requested, please specify "Total" or "Filtered") — Dissolved Pb	1L Plastic	250mL Plastic	125mL Plastic	200mL Amber Glass	40mL Vial	125mL Amber Glass	Jar	Other	Sample Comments / DG Hazard Warning
48	TP3a-G1	16/09/2019	water	X									
49	TP3a-G2	16/09/2019	water	X									
50	TP3a-I1	16/09/2019	water	X									
51	TP3a-I2	16/09/2019	water	X									
52	SS12-G1	16/09/2019	water	X									
53	SS12-G2	16/09/2019	water	X									
54	SS12-I1	16/09/2019	water	X									
55	SS12-I2	16/09/2019	water	X									
56	SS20-G1	16/09/2019	water	X									
57	SS20-G2	16/09/2019	water	X									
58	SS20-I1	16/09/2019	water	X									
59	SS20-I2	16/09/2019	water	X									

6 of 7

Laboratory Use Only								
Received By	Patrimal	SYD | BNE | MEL | PER | (ADL) | NEW | DAR	Date	16/9/19	Time	11 am	Signature	Temperature 6.27
Received By	Grace Tuckwell	(SYD) | BNE | MEL | PER | ADL | NEW | DAR	Date	17/9/19	Time	9:00	Signature	Report № 677385

QH2009 R3 Modified by F Vergara Approved by T Lakeland Approved on 18 Aug 2016

Submission of samples to the laboratory will be deemed as acceptance of Eurofins | mgt Standard Terms and Conditions unless agreed otherwise. A copy of Eurofins | mgt Standard Terms and Conditions is available on request

CHAIN OF CUSTODY RECORD

ABN 50 005 085 521

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Eurofins | mgt Brisbane Lab — Unit 1, 21 Smallwood Place, Murarrie, QLD 4172 P: +617 3902 4600 E: EnviroSampleQLD@eurofins.com.au

Eurofins | mgt Melbourne Lab — 2 Kingston Town Close, Oakleigh, VIC 3166 P: +61 3 8564 5000 F: +61 3 8564 5090 E: EnviroSampleVic@eurofins.com.au

Company	Ramboll	Purchase Order		Project Manager	Stephen Maxwell
Address	Level 2, Suite 18 Eastpoint, 50 Glebe Rd, The Junction, NSW 2291	Eurofins | mgt Quote №		Project №	318000780
Contact Name	Stephen Maxwell				
Contact Phone №	0478 658 194				
Special Direction					
Relinquished by (Signature)	Albert Juhasz				
(Time / Date)	10 : 00 16 / 9 / 19				

Project Name	Pb Bioaccessibility
Electronic Results Format	
Email for Results	smaxwell@ramboll.com; Albert.Juhasz@unisa.edu.au
Turn Around Requirements	☑ 1DAY* ☐ 2 DAY* ☐ 3 DAY* (* Surcharges apply) ☐ 5 DAY (Std.) ☐ Other ( )
Containers	1L Plastic; 250mL Plastic; 125mL Plastic; 200mL Amber Glass; 40mL vial; 125mL Amber Glass; Jar; Other
Method of Shipment	☑ Courier ( ) ☐ Hand Delivered ☐ Postal

Analysis (Note: Where metals are requested, please specify "Total" or "Filtered")

№	Client Sample ID	Date	Matrix	Dissolved Pb	Sample Comments / DG Hazard Warning
60	SS29-G1	16/09/2019	water	X	
61	SS29-G2	16/09/2019	water	X	
62	SS29-I1	16/09/2019	water	X	
63	SS29-I2	16/09/2019	water	X	
64	QC1-G1	16/09/2019	water	X	
65	QC1-G2	16/09/2019	water	X	
66	QC1-I1	16/09/2019	water	X	
67	QC1-I2	16/09/2019	water	X	
68	QC2-G1	16/09/2019	water	X	
69	QC2-G2	16/09/2019	water	X	
70	QC2-I1	16/09/2019	water	X	
71	QC2-I2	16/09/2019	water	X	

7 of 7.

Laboratory Use Only									
Received By	Pascual	SYD | BNE | MEL | PER | ADL | NEW | DAR	Date	16/9/19	Time	11 am	Signature		Temperature 6.27
Received By	Grace Tuxwell	(SYD) | BNE | MEL | PER | ADL | NEW | DAR	Date	17/9/19	Time	9.00	Signature		Report № 677385

Albert Juhasz

From: Albert Juhasz
Sent: Thursday, 12 September 2019 5:54 PM
To: Bob Symons; Stephen Maxwell
Cc: Nibha Vaidya; Anand Chandra; Charl Du Preez
Subject: RE: Concentrated lead in soil and bio accessibility extracts

Hi All,

Please find below some additional information regarding the Pb bioaccessibility analysis as detailed by Stephen.

Following initial and repeat analysis by ALS, significant variability in total Pb concentration (in the < 250 um particle size fraction) was observed (in some cases up to 2.5-fold). This impacts percentage bioaccessibility outcomes as total Pb concentration is the denominator in bioaccessibility calculations. In addition, Pb bioaccessibility values > 100% were observed for 2 samples (TP4a and TP5a; which is impossible!) which suggested a number of issues including potential digestion problems. This led us to undertake our own digestion (using USEPA 3051 and aqua-regia) and analysis of samples using 0.1, 0.2 and 0.5 g of material and 5 ml aqua-regia (see below). For 5 of the 6 samples, total Pb concentration was comparable when different sample amounts were used, however, for TP4a, digestion using 0.5 g resulted in significantly lower Pb concentrations compared to 0.1 and 0.2 g digests (see numbers highlighted in red). I have observed this before for Pb concentrate samples which can be overcome by using a more aggressive acid mix or decreasing the amount of material being digested. Although there was some variability in Pb bioaccessibility values (mg/kg) between the original and repeat analyses (i.e. liquid samples in a 0.1 M nitric acid matrix), these were within the realms of experimental error.

Total Pb in the < 250 um particle size fraction

Sample	Soil (g)	Soil [Pb] (mg/kg)	Average Soil [Pb]	StDev Soil [Pb]	ALS	ALS repeat
TP3a	0.501	23278				
TP3a	0.204	24252				
TP3a	0.102	24474	24001	636	24350	25000
TP4a	0.507	49864				
TP4a	0.203	201252				
TP4a	0.104	205142	203197	2751	33900	29700
TP5a	0.504	48377				

TP5a	0.205	51605				
TP5a	0.1	47663	49215	2100	12300	26400
SS12	0.504	50797				
SS12	0.203	54363				
SS12	0.101	53099	52753	1808	19050	52100
SS20	0.501	40117				
SS20	0.2	42122				
SS20	0.102	43616	41952	1755	16150	44100
SS29	0.504	7928				
SS29	0.202	7865				
SS29	0.104	7411	7735	282	7900	7790
2710a	0.202	5599				
	Certified value	5520				

In light of the above, Stephen and I have decided to:

1. Re-analyse the soils for total Pb. The soils have been dried and sieved to < 2 mm and < 250 um particle size fraction but there is limited volume of each material. There will be 5 replicates for TP4a and TP5a (both < 2 mm and < 250 um particle size fractions; ~15 g for each sample and replicate) which are the priority samples. Other soil samples have been included, however, for SS12, SS20 and SS29, < 5 g is available.
2. Re-run the bioaccessibility assessment. Gastric phase extraction is undertaken using 0.4 M glycine at pH 1.5 (adjusted using HCl) while for intestinal phase extraction, gastric conditions are changed by adjusting the pH to 7.0 (using NaOH) and through the addition of bile (1.75 g/l) and pancreatin (0.5 g/l). Samples are filtered (0.45 um) and diluted 1:10 in 0.1 M nitric acid. 10 ml samples for the determination of dissolved Pb will be supplied which are ICP ready. If you wish to have some blank gastric solution, I can supply but I think the 1:10 dilution will alleviate potential matrix effects.
3. The bioaccessibility analysis will be completed tonight and samples will be ready to courier tomorrow morning. Does Eurofins receive samples on Saturday? If not, I delay the courier until Monday.

I hope the above is clear – if further information is required, please don't hesitate to contact me.

Cheers

Albert

Dr Albert Juhasz
Associate Research Professor
Interim Strand Leader and Barbara Hardy Chair in Environmental Science and Engineering
Research Education Portfolio Leader (FII-NBE)

Future Industries Institute | University of South Australia
Building X, X1-17 | Mawson Lakes Campus | Mawson Lakes SA 5095

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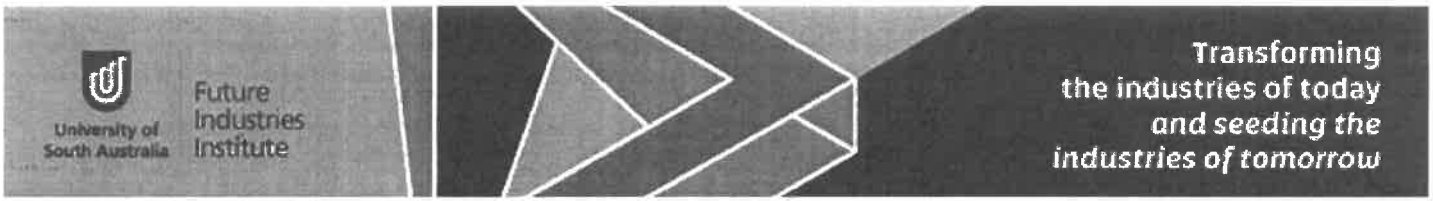
t +618 8302 5045 | **m** +61 (0) 418 818 121 | **e** Albert.Juhasz@unisa.edu.au
web http://unisa.edu.au/fii | **twitter** https://twitter.com/UniSAFII
CRICOS Provider Number: 00121B



From: Bob Symons <BobSymons@eurofins.com>
Sent: Thursday, 12 September 2019 3:30 PM
To: Stephen Maxwell <SMAXWELL@ramboll.com>
Cc: Albert Juhasz <Albert.Juhasz@unisa.edu.au>; Nibha Vaidya <NibhaVaidya@eurofins.com>; Anand Chandra <ACHANDRA@ramboll.com>; Charl Du Preez <CharlDuPreez@eurofins.com>
Subject: Re: Concentrated lead in soil and bio accessibility extracts

Stephen,
Thanks for your e-mail. I am at Cleanup2019 in Adelaide but will have a detailed look later tonight. As far as expediting the analysis this is Nibha or Charl to assess as well as dealing with the matrix.

@Albert - can you please provide details of the gastric fluids including supply of blank material that we can assess.

KR Bob

Sent from my Samsung Mobile on the Telstra Mobile Network

-------- Original message --------
From: Stephen Maxwell <SMAXWELL@ramboll.com>
Date: 12/9/19 15:20 (GMT+09:30)
To: Bob Symons <BobSymons@eurofins.com>
Cc: Albert Juhasz <Albert.Juhasz@unisa.edu.au>, Nibha Vaidya <NibhaVaidya@eurofins.com>, Anand Chandra <ACHANDRA@ramboll.com>
Subject: Concentrated lead in soil and bio accessibility extracts

EXTERNAL EMAIL*

Hi Bob

Ramboll are working with University of South Australia (Albert Juhasz – cced) to define bio accessibility of lead in soils impacted by ore concentrate from an historic mining operation. We had been using ALS out of South Australia to complete NATA accredited analyses though bio-accessible lead concentrations were reported higher than total lead concentrations. Albert is now preparing some additional gastric phase extracts and shipping to Eurofins to re run the analyses. Albert will provide some commentary on UniSA analyses (non-NATA) which infers potential incomplete extraction of total lead and hoping to have your oversight on Eurofins analysis to ensure the results generated accurately represent the lead impacts present. Samples are likely to arrive with Eurofins on Tuesday and we will be chasing fastest available TAT. Would you be available consider and co-ordinate non-standard processing as/if warranted?

In the hope that you are available, the figure below summarises findings from some of the analyses to date. Albert will provide some more.

Soil	Total Pb (mg kg^{-1})	In vitro Phase	Pb Bioacc. (mg kg^{-1})	Pb Bioacc.‡ (%)
TP3a	25000	SBRC-G	655	2.6
		SBRC-I	24.0	0.1
		Rel-SBRC-I*		1.0
TP4a	29700	SBRC-G	51550	>100
		SBRC-I	33750	>100
		Rel-SBRC-I*		>100
TP5a	26400	SBRC-G	31200	>100
		SBRC-I	9760	37.0
		Rel-SBRC-I*		98.2
SS12	52100	SBRC-G	12700	24.4
		SBRC-I	3440	6.6
		Rel-SBRC-I*		17.5
SS20	44100	SBRC-G	578	1.3
		SBRC-I	<1.0	<0.1
		Rel-SBRC-I*		<1.0
SS29	7790	SBRC-G	2295	29.5
		SBRC-I	389	5.0
		Rel-SBRC-I*		24.0
QC1[¤]	6400	SBRC-G	4405	68.8

‡Percentage lead bioaccessibility following gastric or gastrointestinal phase extraction was calculated by dividing the bioaccessible lead (SBRC-G or SBRC-I) by the total lead concentration multiplied by 100.

*Lead relative bioaccessibility was calculated by adjusting the solubility of lead from contaminated soil by the solubility of lead acetate at the corresponding intestinal phase pH value.

*Percentage lead bioaccessibility cannot exceed 100%.

[¤]Lead bioaccessibility for the QC1 soil was within an acceptable range for this reference material.

Kind regards

APPENDIX 3 – ANALYTICAL RESULTS AND QA/QC

Ramboll Environ Australia Pty Ltd
Level 3/100 Pacific Highway
North Sydney
NSW 2060

Attention: **Stephen Maxwell**

Report **677385-S**
Project name PB BIOACCESSIBILITY
Project ID 318000780
Received Date Sep 17, 2019

Client Sample ID			**TP4A-2A**	**TP4A-2B**	**TP4A-2C**	**TP4A-2D**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S19-Se25579**	**S19-Se25580**	**S19-Se25581**	**S19-Se25582**
Date Sampled			**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**
Test/Reference	LOR	Unit				
Heavy Metals						
Lead	5	mg/kg	180000	150000	150000	160000

Client Sample ID			**TP4A-2E**	**TP4A-250A**	**TP4A-250B**	**TP4A-250C**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S19-Se25583**	**S19-Se25584**	**S19-Se25585**	**S19-Se25586**
Date Sampled			**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**
Test/Reference	LOR	Unit				
Heavy Metals						
Lead	5	mg/kg	150000	180000	180000	180000

Client Sample ID			**TP4A-250D**	**TP4A-250E**	**TP5A-2A**	**TP5A-2B**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S19-Se25587**	**S19-Se25588**	**S19-Se25589**	**S19-Se25590**
Date Sampled			**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**
Test/Reference	LOR	Unit				
Heavy Metals						
Lead	5	mg/kg	190000	190000	37000	40000

Client Sample ID			**TP5A-2C**	**TP5A-2D**	**TP5A-2E**	**TP5A-250A**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S19-Se25591**	**S19-Se25592**	**S19-Se25593**	**S19-Se25594**
Date Sampled			**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**
Test/Reference	LOR	Unit				
Heavy Metals						
Lead	5	mg/kg	42000	39000	40000	48000

Client Sample ID			TP5A-250B	TP5A-250C	TP5A-250D	TP5A-250E
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S19-Se25595	S19-Se25596	S19-Se25597	S19-Se25598
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit				
Heavy Metals						
Lead	5	mg/kg	23000	24000	24000	26000

Client Sample ID			TP3A-2A	TP3A-2B	TP3A-250A	TP3A-250B
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S19-Se25599	S19-Se25600	S19-Se25601	S19-Se25602
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit				
Heavy Metals						
Lead	5	mg/kg	17000	25000	14000	23000

Client Sample ID			SS12-250A	SS20-250A	SS29-250A
Sample Matrix			Soil	Soil	Soil
Eurofins Sample No.			S19-Se25603	S19-Se25604	S19-Se25605
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit			
Heavy Metals					
Lead	5	mg/kg	48000	41000	7500

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Heavy Metals	Sydney	Sep 18, 2019	180 Days

- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS

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NATA # 1261
Site # 23736

Company Name: Ramboll Australia Pty Ltd
Address: Level 3/100 Pacific Highway
North Sydney
NSW 2060

Project Name: PB BIOACCESSIBILITY
Project ID: 318000780

Order No.:
Report #: 677385
Phone: 02 9954 8118
Fax: 02 9954 8150

Received: Sep 17, 2019 9:00 AM
Due: Sep 19, 2019
Priority: 2 Day
Contact Name: Stephen Maxwell

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Lead	Lead (filtered)
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217						X	X
Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	TP4A-2A	Sep 16, 2019		Soil	S19-Se25579	X	
2	TP4A-2B	Sep 16, 2019		Soil	S19-Se25580	X	
3	TP4A-2C	Sep 16, 2019		Soil	S19-Se25581	X	
4	TP4A-2D	Sep 16, 2019		Soil	S19-Se25582	X	
5	TP4A-2E	Sep 16, 2019		Soil	S19-Se25583	X	
6	TP4A-250A	Sep 16, 2019		Soil	S19-Se25584	X	
7	TP4A-250B	Sep 16, 2019		Soil	S19-Se25585	X	
8	TP4A-250C	Sep 16, 2019		Soil	S19-Se25586	X	
9	TP4A-250D	Sep 16, 2019		Soil	S19-Se25587	X	

Eurofins Environment Testing Unit F3, Building F, 16 Mars Road, Lane Cove West, NSW, Australia 2066
ABN : 50 005 085 521 Telephone: +61 2 9900 8400
Date Reported:Sep 19, 2019

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Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
10	TP4A-250E	Sep 16, 2019		Soil	S19-Se25588	X	
11	TP5A-2A	Sep 16, 2019		Soil	S19-Se25589	X	
12	TP5A-2B	Sep 16, 2019		Soil	S19-Se25590	X	
13	TP5A-2C	Sep 16, 2019		Soil	S19-Se25591	X	
14	TP5A-2D	Sep 16, 2019		Soil	S19-Se25592	X	
15	TP5A-2E	Sep 16, 2019		Soil	S19-Se25593	X	
16	TP5A-250A	Sep 16, 2019		Soil	S19-Se25594	X	
17	TP5A-250B	Sep 16, 2019		Soil	S19-Se25595	X	
18	TP5A-250C	Sep 16, 2019		Soil	S19-Se25596	X	
19	TP5A-250D	Sep 16, 2019		Soil	S19-Se25597	X	
20	TP5A-250E	Sep 16, 2019		Soil	S19-Se25598	X	
21	TP3A-2A	Sep 16, 2019		Soil	S19-Se25599	X	

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Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
22	TP3A-2B	Sep 16, 2019		Soil	S19-Se25600	X	
23	TP3A-250A	Sep 16, 2019		Soil	S19-Se25601	X	
24	TP3A-250B	Sep 16, 2019		Soil	S19-Se25602	X	
25	SS12-250A	Sep 16, 2019		Soil	S19-Se25603	X	
26	SS20-250A	Sep 16, 2019		Soil	S19-Se25604	X	
27	SS29-250A	Sep 16, 2019		Soil	S19-Se25605	X	
28	TP4A-G1	Sep 16, 2019		Water	S19-Se25606		X
29	TP4A-G2	Sep 16, 2019		Water	S19-Se25607		X
30	TP4A-G3	Sep 16, 2019		Water	S19-Se25608		X
31	TP4A-G4	Sep 16, 2019		Water	S19-Se25609		X
32	TP4A-G5	Sep 16, 2019		Water	S19-Se25610		X
33	TP4A-I1	Sep 16, 2019		Water	S19-Se25611		X

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Sydney Laboratory - NATA Site # 18217						X	X
Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
34	TP4A-I2	Sep 16, 2019		Water	S19-Se25612		X
35	TP4A-I3	Sep 16, 2019		Water	S19-Se25613		X
36	TP4A-I4	Sep 16, 2019		Water	S19-Se25614		X
37	TP4A-I5	Sep 16, 2019		Water	S19-Se25615		X
38	TP5A-G1	Sep 16, 2019		Water	S19-Se25616		X
39	TP5A-G2	Sep 16, 2019		Water	S19-Se25617		X
40	TP5A-G4	Sep 16, 2019		Water	S19-Se25618		X
41	TP5A-G5	Sep 16, 2019		Water	S19-Se25619		X
42	TP5A-I1	Sep 16, 2019		Water	S19-Se25620		X
43	TP5A-I2	Sep 16, 2019		Water	S19-Se25621		X
44	TP5A-I3	Sep 16, 2019		Water	S19-Se25622		X
45	TP5A-I4	Sep 16, 2019		Water	S19-Se25623		X

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Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
46	TP5A-I5	Sep 16, 2019		Water	S19-Se25624		X
47	TP3A-G1	Sep 16, 2019		Water	S19-Se25625		X
48	TP3A-G2	Sep 16, 2019		Water	S19-Se25626		X
49	TP3A-I1	Sep 16, 2019		Water	S19-Se25627		X
50	TP3A-I2	Sep 16, 2019		Water	S19-Se25628		X
51	SS12-G1	Sep 16, 2019		Water	S19-Se25629		X
52	SS12-G2	Sep 16, 2019		Water	S19-Se25630		X
53	SS12-I1	Sep 16, 2019		Water	S19-Se25631		X
54	SS12-I2	Sep 16, 2019		Water	S19-Se25632		X
55	SS20-G1	Sep 16, 2019		Water	S19-Se25633		X
56	SS20-G2	Sep 16, 2019		Water	S19-Se25634		X
57	SS20-I1	Sep 16, 2019		Water	S19-Se25635		X

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Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
58	SS20-I2	Sep 16, 2019		Water	S19-Se25636		X
59	SS29-G1	Sep 16, 2019		Water	S19-Se25637		X
60	SS29-G2	Sep 16, 2019		Water	S19-Se25638		X
61	SS29-I1	Sep 16, 2019		Water	S19-Se25639		X
62	SS29-I2	Sep 16, 2019		Water	S19-Se25640		X
63	QC1-G1	Sep 16, 2019		Water	S19-Se25641		X
64	QC1-G2	Sep 16, 2019		Water	S19-Se25642		X
65	QC1-I1	Sep 16, 2019		Water	S19-Se25643		X
66	QC1-I2	Sep 16, 2019		Water	S19-Se25644		X
67	QC2-G1	Sep 16, 2019		Water	S19-Se25645		X
68	QC2-G2	Sep 16, 2019		Water	S19-Se25646		X
69	QC2-I1	Sep 16, 2019		Water	S19-Se25647		X

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Report #: 677385
Phone: 02 9954 8118
Fax: 02 9954 8150

Received: Sep 17, 2019 9:00 AM
Due: Sep 19, 2019
Priority: 2 Day
Contact Name: Stephen Maxwell

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Lead	Lead (filtered)
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217						X	X
Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
70	QC2-I2	Sep 16, 2019		Water	S19-Se25648		X
71	TP5A-2G3	Sep 16, 2019		Water	S19-Se25659		X
Test Counts						27	44

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram

mg/L: milligrams per litre

ug/L: micrograms per litre

ppm: Parts per million

ppb: Parts per billion

%: Percentage

org/100mL: Organisms per 100 millilitres

NTU: Nephelometric Turbidity Units

MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Lab Sample ID	QA Source	Units	Result 1	Result 2	RPD	Acceptance Limits	Pass Limits	Qualifying Code
Method Blank									
Heavy Metals									
Lead			mg/kg	< 5			5	Pass	
LCS - % Recovery									
Heavy Metals									
Lead			%	86			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Heavy Metals				Result 1					
Lead	N19-Se25667	NCP	%	118			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Lead	N19-Se25666	NCP	mg/kg	13	11	17	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By

Andrew Black	Analytical Services Manager
Gabriele Cordero	Senior Analyst-Metal (NSW)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Ramboll Environ Australia Pty Ltd
Level 3/100 Pacific Highway
North Sydney
NSW 2060

Attention: **Stephen Maxwell**

Report **677385-W**
Project name PB BIOACCESSIBILITY
Project ID 318000780
Received Date Sep 17, 2019

Client Sample ID			**TP4A-G1**	**TP4A-G2**	**TP4A-G3**	**TP4A-G4**
Sample Matrix			**Water**	**Water**	**Water**	**Water**
Eurofins Sample No.			**S19-Se25606**	**S19-Se25607**	**S19-Se25608**	**S19-Se25609**
Date Sampled			**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	59	59	59	62

Client Sample ID			**TP4A-G5**	**TP4A-I1**	**TP4A-I2**	**TP4A-I3**
Sample Matrix			**Water**	**Water**	**Water**	**Water**
Eurofins Sample No.			**S19-Se25610**	**S19-Se25611**	**S19-Se25612**	**S19-Se25613**
Date Sampled			**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	59	35	36	37

Client Sample ID			**TP4A-I4**	**TP4A-I5**	**TP5A-G1**	**TP5A-G2**
Sample Matrix			**Water**	**Water**	**Water**	**Water**
Eurofins Sample No.			**S19-Se25614**	**S19-Se25615**	**S19-Se25616**	**S19-Se25617**
Date Sampled			**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	36	36	35	34

Client Sample ID			**TP5A-G4**	**TP5A-G5**	**TP5A-I1**	**TP5A-I2**
Sample Matrix			**Water**	**Water**	**Water**	**Water**
Eurofins Sample No.			**S19-Se25618**	**S19-Se25619**	**S19-Se25620**	**S19-Se25621**
Date Sampled			**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**	**Sep 16, 2019**
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	35	35	10	10

Client Sample ID			TP5A-I3	TP5A-I4	TP5A-I5	TP3A-G1
Sample Matrix			Water	Water	Water	Water
Eurofins Sample No.			S19-Se25622	S19-Se25623	S19-Se25624	S19-Se25625
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	10.0	10	11	0.63

Client Sample ID			TP3A-G2	TP3A-I1	TP3A-I2	SS12-G1
Sample Matrix			Water	Water	Water	Water
Eurofins Sample No.			S19-Se25626	S19-Se25627	S19-Se25628	S19-Se25629
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	0.72	0.007	0.13	14

Client Sample ID			SS12-G2	SS12-I1	SS12-I2	SS20-G1
Sample Matrix			Water	Water	Water	Water
Eurofins Sample No.			S19-Se25630	S19-Se25631	S19-Se25632	S19-Se25633
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	14	3.8	3.9	0.69

Client Sample ID			SS20-G2	SS20-I1	SS20-I2	SS29-G1
Sample Matrix			Water	Water	Water	Water
Eurofins Sample No.			S19-Se25634	S19-Se25635	S19-Se25636	S19-Se25637
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	0.67	< 0.001	< 0.001	2.7

Client Sample ID			SS29-G2	SS29-I1	SS29-I2	QC1-G1
Sample Matrix			Water	Water	Water	Water
Eurofins Sample No.			S19-Se25638	S19-Se25639	S19-Se25640	S19-Se25641
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	2.6	0.12	0.12	5.1

Client Sample ID			QC1-G2	QC1-I1	QC1-I2	QC2-G1
Sample Matrix			Water	Water	Water	Water
Eurofins Sample No.			S19-Se25642	S19-Se25643	S19-Se25644	S19-Se25645
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	5.1	0.57	0.51	< 0.001

Client Sample ID			QC2-G2	QC2-I1	QC2-I2	TP5A-2G3
Sample Matrix			Water	Water	Water	Water
Eurofins Sample No.			S19-Se25646	S19-Se25647	S19-Se25648	S19-Se25659
Date Sampled			Sep 16, 2019	Sep 16, 2019	Sep 16, 2019	Sep 16, 2019
Test/Reference	LOR	Unit				
Heavy Metals						
Lead (filtered)	0.001	mg/L	< 0.001	< 0.001	< 0.001	33

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Heavy Metals (filtered)	Sydney	Sep 17, 2019	180 Days

- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS

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Site # 23736

Company Name: Ramboll Australia Pty Ltd
Address: Level 3/100 Pacific Highway
North Sydney
NSW 2060

Project Name: PB BIOACCESSIBILITY
Project ID: 318000780

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Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Lead	Lead (filtered)
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217						X	X
Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	TP4A-2A	Sep 16, 2019		Soil	S19-Se25579	X	
2	TP4A-2B	Sep 16, 2019		Soil	S19-Se25580	X	
3	TP4A-2C	Sep 16, 2019		Soil	S19-Se25581	X	
4	TP4A-2D	Sep 16, 2019		Soil	S19-Se25582	X	
5	TP4A-2E	Sep 16, 2019		Soil	S19-Se25583	X	
6	TP4A-250A	Sep 16, 2019		Soil	S19-Se25584	X	
7	TP4A-250B	Sep 16, 2019		Soil	S19-Se25585	X	
8	TP4A-250C	Sep 16, 2019		Soil	S19-Se25586	X	
9	TP4A-250D	Sep 16, 2019		Soil	S19-Se25587	X	

Eurofins Environment Testing Unit F3, Building F, 16 Mars Road, Lane Cove West, NSW, Australia 2066
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Date Reported:Sep 19, 2019

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Sydney Laboratory - NATA Site # 18217						X	X
Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
10	TP4A-250E	Sep 16, 2019		Soil	S19-Se25588	X	
11	TP5A-2A	Sep 16, 2019		Soil	S19-Se25589	X	
12	TP5A-2B	Sep 16, 2019		Soil	S19-Se25590	X	
13	TP5A-2C	Sep 16, 2019		Soil	S19-Se25591	X	
14	TP5A-2D	Sep 16, 2019		Soil	S19-Se25592	X	
15	TP5A-2E	Sep 16, 2019		Soil	S19-Se25593	X	
16	TP5A-250A	Sep 16, 2019		Soil	S19-Se25594	X	
17	TP5A-250B	Sep 16, 2019		Soil	S19-Se25595	X	
18	TP5A-250C	Sep 16, 2019		Soil	S19-Se25596	X	
19	TP5A-250D	Sep 16, 2019		Soil	S19-Se25597	X	
20	TP5A-250E	Sep 16, 2019		Soil	S19-Se25598	X	
21	TP3A-2A	Sep 16, 2019		Soil	S19-Se25599	X	

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Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
22	TP3A-2B	Sep 16, 2019		Soil	S19-Se25600	X	
23	TP3A-250A	Sep 16, 2019		Soil	S19-Se25601	X	
24	TP3A-250B	Sep 16, 2019		Soil	S19-Se25602	X	
25	SS12-250A	Sep 16, 2019		Soil	S19-Se25603	X	
26	SS20-250A	Sep 16, 2019		Soil	S19-Se25604	X	
27	SS29-250A	Sep 16, 2019		Soil	S19-Se25605	X	
28	TP4A-G1	Sep 16, 2019		Water	S19-Se25606		X
29	TP4A-G2	Sep 16, 2019		Water	S19-Se25607		X
30	TP4A-G3	Sep 16, 2019		Water	S19-Se25608		X
31	TP4A-G4	Sep 16, 2019		Water	S19-Se25609		X
32	TP4A-G5	Sep 16, 2019		Water	S19-Se25610		X
33	TP4A-I1	Sep 16, 2019		Water	S19-Se25611		X

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Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
34	TP4A-I2	Sep 16, 2019		Water	S19-Se25612		X
35	TP4A-I3	Sep 16, 2019		Water	S19-Se25613		X
36	TP4A-I4	Sep 16, 2019		Water	S19-Se25614		X
37	TP4A-I5	Sep 16, 2019		Water	S19-Se25615		X
38	TP5A-G1	Sep 16, 2019		Water	S19-Se25616		X
39	TP5A-G2	Sep 16, 2019		Water	S19-Se25617		X
40	TP5A-G4	Sep 16, 2019		Water	S19-Se25618		X
41	TP5A-G5	Sep 16, 2019		Water	S19-Se25619		X
42	TP5A-I1	Sep 16, 2019		Water	S19-Se25620		X
43	TP5A-I2	Sep 16, 2019		Water	S19-Se25621		X
44	TP5A-I3	Sep 16, 2019		Water	S19-Se25622		X
45	TP5A-I4	Sep 16, 2019		Water	S19-Se25623		X

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46	TP5A-I5	Sep 16, 2019		Water	S19-Se25624		X
47	TP3A-G1	Sep 16, 2019		Water	S19-Se25625		X
48	TP3A-G2	Sep 16, 2019		Water	S19-Se25626		X
49	TP3A-I1	Sep 16, 2019		Water	S19-Se25627		X
50	TP3A-I2	Sep 16, 2019		Water	S19-Se25628		X
51	SS12-G1	Sep 16, 2019		Water	S19-Se25629		X
52	SS12-G2	Sep 16, 2019		Water	S19-Se25630		X
53	SS12-I1	Sep 16, 2019		Water	S19-Se25631		X
54	SS12-I2	Sep 16, 2019		Water	S19-Se25632		X
55	SS20-G1	Sep 16, 2019		Water	S19-Se25633		X
56	SS20-G2	Sep 16, 2019		Water	S19-Se25634		X
57	SS20-I1	Sep 16, 2019		Water	S19-Se25635		X

eurofins | Environment Testing

ABN – 50 005 085 521
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Site # 1254 & 14271

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NATA # 1261 Site # 20794

Perth
2/91 Leach Highway
Kewdale WA 6105
Phone : +61 8 9251 9600
NATA # 1261
Site # 23736

Company Name: Ramboll Australia Pty Ltd
Address: Level 3/100 Pacific Highway
North Sydney
NSW 2060

Project Name: PB BIOACCESSIBILITY
Project ID: 318000780

Order No.:
Report #: 677385
Phone: 02 9954 8118
Fax: 02 9954 8150

Received: Sep 17, 2019 9:00 AM
Due: Sep 19, 2019
Priority: 2 Day
Contact Name: Stephen Maxwell

Eurofins Analytical Services Manager : Andrew Black

Sample Detail						Lead	Lead (filtered)
Melbourne Laboratory - NATA Site # 1254 & 14271							
Sydney Laboratory - NATA Site # 18217						X	X
Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
58	SS20-I2	Sep 16, 2019		Water	S19-Se25636		X
59	SS29-G1	Sep 16, 2019		Water	S19-Se25637		X
60	SS29-G2	Sep 16, 2019		Water	S19-Se25638		X
61	SS29-I1	Sep 16, 2019		Water	S19-Se25639		X
62	SS29-I2	Sep 16, 2019		Water	S19-Se25640		X
63	QC1-G1	Sep 16, 2019		Water	S19-Se25641		X
64	QC1-G2	Sep 16, 2019		Water	S19-Se25642		X
65	QC1-I1	Sep 16, 2019		Water	S19-Se25643		X
66	QC1-I2	Sep 16, 2019		Water	S19-Se25644		X
67	QC2-G1	Sep 16, 2019		Water	S19-Se25645		X
68	QC2-G2	Sep 16, 2019		Water	S19-Se25646		X
69	QC2-I1	Sep 16, 2019		Water	S19-Se25647		X

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Brisbane Laboratory - NATA Site # 20794							
Perth Laboratory - NATA Site # 23736							
70	QC2-I2	Sep 16, 2019		Water	S19-Se25648		X
71	TP5A-2G3	Sep 16, 2019		Water	S19-Se25659		X
Test Counts						27	44

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Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram | **mg/L:** milligrams per litre | **ug/L:** micrograms per litre

ppm: Parts per million | **ppb:** Parts per billion | **%:** Percentage

org/100mL: Organisms per 100 millilitres | **NTU:** Nephelometric Turbidity Units | **MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Heavy Metals							
Lead (filtered)	mg/L	< 0.001			0.001	Pass	
LCS - % Recovery							
Heavy Metals							
Lead (filtered)	%	108			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
Heavy Metals				Result 1					
Lead (filtered)	S19-Se21124	NCP	%	94			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1	Result 2	RPD	Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Lead (filtered)	M19-Se12212	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By

Andrew Black	Analytical Services Manager
Gabriele Cordero	Senior Analyst-Metal (NSW)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

APPENDIX 3: US EPA ADULT LEAD METHODOLOGY RESULTS

Table 16-1: ALM input parameters and results for blood lead calculation

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
PbS	Soil lead concentration	µg/g or ppm	40975
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S,D}$	Absorption fraction (same for soil and dust)	--	0.04
$EF_{S,D}$	Exposure frequency (same for soil and dust)	days/yr	39
$AT_{S,D}$	Averaging time (same for soil and dust)	days/yr	91
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	28.7
$PbB_{fetal,0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	67.9
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB, assuming lognormal distribution**	**%**	**94.7%**

Table 16-2: ALM calculation of safe level for current site works based on target blood lead of 10 µg/dL

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
$PbB_{fetal, 0.95}$	Target PbB in fetus (e.g., 2-8 µg/dL)	µg/dL	10
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.04
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	39
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	91
PRG in Soil for no more than 5% probability that fetal PbB exceeds target PbB		**ppm**	**5,287**

Table 16-3: ALM calculation of clean-up level for future site works based on target blood lead of 5 µg/dL

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
$PbB_{fetal, 0.95}$	Target PbB in fetus (e.g., 2-8 µg/dL)	µg/dL	5
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.04
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	39
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	91
PRG in Soil for no more than 5% probability that fetal PbB exceeds target PbB		**ppm**	**2,206**