7 April 2016

COSTERFIELD, VICTORIA

HEALTH RISK ASSESSMENT

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REPORT

Report Number. 1413212-032-R-Rev0

Distribution:

Delivered to the Chair of the Victorian Government Reference Group.
1 copy - Department of Economic Development, Jobs, Transport and Resources
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Key Points

- This health risk assessment (HRA) confirms the key conclusion of the Rapid Health Assessment conducted in June 2014 that antimony is not likely to cause adverse health effects in Costerfield.
- This report provides results of a tank water monitoring program conducted over six months of the year both in tanks that were cleaned and those that were not. The program identified that the levels of antimony in tank water remained higher than the drinking water guideline despite tank cleaning and refilling. For this reason as previously advised in June 2014 the tank water should not be used as a drinking water source.
- This report provides an in-depth analysis of environmental data collected over an 18 month period. Of the many metals investigated three metals (antimony, arsenic and lead) were identified to be elevated above background levels in the environment and also above trigger levels for further health investigation.
- In Costerfield, antimony and arsenic levels in soil, water and air are typically elevated when compared to other parts of Victoria that have not been mined for gold. This is consistent with the natural geology of Costerfield and the mining legacy in the Costerfield Area. The current mining operations are not a major contributor to antimony, arsenic or lead in tank water, dust or soil.
- Whilst lead is also a naturally occurring metal in the Costerfield formation, the concentrations found in soil within the Dome are higher than expected if the lead was all due to the local geology, therefore it is likely that there are other anthropogenic (man made) sources of lead in the Costerfield environment. For this reason lead is different to antimony and arsenic.
- The HRA was done on a regional basis (i.e. it is not a property specific assessment). It was done in a conservative manner and according to national and international guidelines. It looked at many factors that can change exposure between different people. Two sets of estimates were made: average; and reasonable worst case. It is concluded:
    - that there is no concern for adverse health effects from average exposures to multiple metals at Costerfield (i.e. for the average person it is safe to live in Costerfield).
    - For reasonable worst case exposures (i.e. this estimate applies to a small minority of people (particularly young children) within Costerfield) the HRA found that there is some concern for adverse health effects. The main reason for the conclusion of some concern is because a small proportion of tanks and soil had lead contamination, noting that this pattern of lead contamination are typical of urban/rural Victoria. Residents with high lead contamination have been provided with soil and tank water results during the monitoring program together risk management advice.
    - For both average and reasonable worst case weekend residents there is no concern for adverse health effects. This conclusion also applies to occasional visitors (up to 104 days per year).
- The air monitoring results for dust (PM_{10} and $PM_{2.5}$), metals, and crystalline silica found that levels are lower than health guidelines. For this reason the chemicals in dust measured in air are not harmful to health.
- The HRA considered antimony, arsenic and lead levels with respect to bathing / showering in tank water and ingestion of homegrown food (eggs and lamb). These activities were minor contributors to antimony, arsenic and lead exposure and can be continued without concern for adverse health effects.
- Dust levels in air from the current mining operations were found to be within compliance levels and national standards on practically all days. The antimony, arsenic and lead in dust levels were well below health based air guideline values. However dust from the mining operations is expected to contribute a small level (less than 15%) to soil loads over an extended period of time (10 years).

Executive Summary

Introduction

This independent report by Golder Associates Pty Ltd (Golder) commissioned by a Government of Victoria Reference Group (GVRG) details a health risk assessment (HRA) to inform the Costerfield community, Government and the current mining operations on two important questions:

- Do the environmental levels of antimony and other metals present a health risk to people living in Costerfield? This question could also be expressed as – "Is it safe to live in Costerfield?"
- What strategies can be put in place to manage environmental levels of antimony and associated metals in Costerfield? This question could also be expressed as – "What can be done to manage exposure within Costerfield?"

Additional questions that are important to the Costerfield stakeholders (community, government and mining operations) are also addressed within the body of this report.

Background

Health risk assessment (referred to as HRA in this report) is an objective, scientifically-based tool used to provide answers to the above questions. The HRA conducted in this report is consistent with Australian and International guidelines. It has been designed by experienced health risk and toxicology experts in consultation with experts within the Victorian Department of Health and Human Services and the Victorian Environment Protection Authority (EPA).

This HRA assists in the development of strategies and procedures to address health concerns for chemical exposures. However management and planning are separate pieces of work that require consideration of economic, social, and political factors, as well as technical feasibility of any proposed management strategies. This HRA informs such strategies but these strategies are not detailed in this report.

Golder conducted a rapid health assessment in June 2014 and concluded that adverse health effects were unlikely. This assessment focussed on the likelihood of adverse health effects due to antimony exposure. They were not intended to address other metals nor the details of how best to manage exposure.

The HRA was needed to answer the above questions because the field program (described below) identified that environmental levels of three metals (antimony, arsenic and lead) were elevated out of 18 metals evaluated in Costerfield. Elevated in this context means that the concentrations of these three metals were occasionally above normal background levels in the environment (soil, water and air samples) and/or they were above health based screening guidelines used to indicate the need for further investigation.

Field Program

A field program to collect data and information was undertaken over a fifteen month period (June 2014 – December 2015). The program was designed and reviewed by experienced environmental scientists and engineers, and meets guidelines and standards for the conduct of such programs. The scientific and technical details of this program are described within this HRA report. The elements of the program included:

- An air quality analysis program, including dust in homes and outdoor locations.
- A soil sampling and analysis program.
- A tank water monitoring program.
- Lamb and egg sampling program.

Field Program Findings

In Costerfield, antimony is a naturally occurring compound in soil and rock. Mining activities over the past 100 years have created tailings and leftover material such as rock, sand and earth which may contain antimony at concentrations higher than the surrounding soil and rock. A range of metals and inorganic chemicals were measured during the field program based on the natural history, mining legacy and current mining operations in Costerfield.

The field program found that antimony and arsenic in Costerfield (particularly in soil and water) are generally higher than in other parts of Australia. It also identified occasional instances where lead contamination was present. Lead contamination in soil and water is common in urban/rural Victoria. The pattern of lead concentrations in soil and tank water was not found to be unique to Costerfield.

HRA Approach

The HRA estimated risks due to individual metal exposure to antimony, arsenic and lead, and cumulative exposure (i.e. combined health risk). That is, health risks were assessed for each of the three metals, and then the combined health risk of these metals was assessed.

In this HRA the amount of chemical entering the body (the intake) is referred to as the estimated daily intake (EDI).

The EDI combines many estimates (soil, tank water concentrations) with many factors (human activities and behaviours). As a consequence it is necessary to consider a range of environmental concentrations and a range of human activities and behaviours to make the EDI representative and relevant to different people and different circumstances. This is done in a statistical manner so that the variation between estimates and uncertainties in the factors can be understood.

The first question above (“Is it safe to live in Costerfield?”) was addressed by using a range of exposure estimates that are most applicable to residents of Costerfield. The EDI estimation relies on many factors. The selection of a value for each of these factors is described in Appendix E of this HRA report. The combination of factors to calculate an EDI errs on the side of caution, yet avoids over-estimation.

The exposure estimates are not property specific and utilise the data across the Costerfield dome (i.e. it is a regional assessment).

Two estimates of the EDI have been provided:

- Average Estimate of EDI. Combining the averages in soil, tank water and air with average circumstances of exposure results in an EDI that is relevant to most people in Costerfield.
- Upper Estimate of EDI. Combining a range of upper statistical estimates for many inputs such as the soil concentration and the amount of soil ingested each day by a person results in what is known as a “reasonable worst case”. These two terms (upper and reasonable worst case) are equivalent and interchangeable. The reasonable worst case, or upper estimate is intended to exceed the EDI for most people in Costerfield. It is intended as a plausible yet unlikely estimate of upper end exposure.

Both EDI estimates have been provided as it is important to describe a range of different circumstances and also to account for uncertainties in the information available on which to make estimates.

The second question (“What can be done to manage exposure within Costerfield?”) requires a more detailed evaluation of the Upper Estimate. The upper estimates are not likely estimates of exposure but are plausible. For instance, the upper estimate assumes that a person spends two hours a day, each day of the year in a spot where the highest soil concentrations of all three metals anywhere in Costerfield co-occur. In addition, this person ingests every day of the year two litres of tank water containing one of the highest tank water results reported in Costerfield for each metal. This unlikely occurrence is included in the HRA to understand the uncertainties in the EDI.

To assist stakeholders to understand the key ways to manage exposure, the HRA contains a total of sixteen estimates of the EDI.

Type of Resident	Resident Age Groups	Exposed Each Day Via	Use of Tank Water
Permanent Residents Stays in Costerfield 365 days per year.	☑ Infant (1 year old) ☑ Young child (2 year old) ☑ Older Child (10 year old) ☑ Adult	☑ Soil ingestion ☑ Home-grown food (egg meat), ☑ Breathing in dust in air ☑ Bathing using tank water	☑ Use tank water as their primary drinking water source. ☒ Do not use tank water for drinking purposes (but do bathe in tank water)
Weekend Residents Stays in Costerfield 104 days per year (2 days per week).	☑ Infant (1 year old) ☑ Young child (2 year old) ☑ Older Child (10 year old) ☑ Adult	☑ Soil ingestion ☑ Home-grown food (egg meat), ☑ Breathing in dust in air ☑ Bathing using tank water	☑ Use tank water as their primary drinking water source. ☒ Do not use tank water for drinking purposes (but do bathe in tank water)

Once the EDI is estimated for each age group and exposure combination, it is then compared to a health benchmark called a tolerable daily intake (TDI) for each metal. The TDI is the amount of chemical that can be ingested over a lifetime without appreciable health risk. Because the TDI is a lifetime average daily intake, the estimated lifetime EDI is calculated and used for assessing health risk for a community.

The EDI is divided by the TDI. The ratio of the EDI to the TDI (this ratio is called the 'hazard quotient' or 'HQ') is then used to make decisions about the risk of adverse health effects. When the EDI is less than the TDI (i.e. a margin of less than 1) this means health risks are unlikely. When the EDI is greater than the TDI (i.e. a margin of greater than 1) then the magnitude of the margin is further considered to provide context to what that means. For example, there may be uncertainty in the EDI estimate that could be reduced with additional data. Alternatively, actions may be required to address the health risk.

To consider health risks due to the combined exposure of each metal, each of the HQs is added up. That is, the total health risk is assumed to be the sum of the health risk due to each metal. The sum of HQ's is referred to as the hazard index (HI). This is a conservative assumption that in reality is likely to overestimate the health risk. However it is done to err on the side of caution.

Given the multiple levels of conservatism built into a HRA, there is generally a high level of confidence that risks are not under-estimated. The following key[1] is used to interpret the HI.

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[1] The key has been adapted from the United States National Toxicology Program 'Level of Concern' Categories NTP (2005).

Serious Concern

a HQ of greater than 5 and a HI of 10 or greater

Concern

a HQ of less than 5 and a HI of less than 10

Some Concern

HQ less than 3 and a HI of less than 5

Minimal Concern

HQ of less than 1 .5 and a HI of less than 3

Negligible Concern

HQ of less than 0.5 and HI of less than 1

Conclusions Specific to Living with Antimony and Arsenic within the Costerfield Dome

Antimony and arsenic soil concentrations are different in Costerfield than other parts of Victoria because of the geological and mining legacy in Costerfield. The results are summarised in Table ES1 using the key described above.

Table ES1 concludes that it is safe to live in Costerfield. Table ES1 is specific to mining legacy in Costerfield. That is it includes consideration of metals (antimony and arsenic) that are different to other parts of Victoria.

Table ES1 Conclusion for health risk to Costerfield Permanent Residents (Antimony and Arsenic)

Estimate Type	Key Assumption	Conclusion
Upper Estimate **Permanent Residents**	**Use tank water** as their primary drinking water source.	Minimal Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects
Average Estimate **Permanent Residents**	**Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects

Table ES2 provides the results for weekend residents either including or excluding tank water use. The results show a negligible concern for adverse health effects. Results for permanent residents using tank water as a drinking water source show a minimal concern for adverse health effects.

Table ES2 Conclusion for health risk to Costerfield Weekend Residents (Antimony and Arsenic)

Estimate Type	Key Assumption	Conclusion
Upper Estimate **Permanent Residents**	**Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects
Average Estimate **Permanent Residents**	**Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects

Conclusions Including Lead

Occasionally in Costerfield, as is in many other parts of Victoria, high levels of lead in tank water and soil are encountered. It is most likely that these high levels are due to widespread historical anthropogenic (man made) uses of lead. Table ES3 summarises the results for permanent residents using the key described above.

Because the conclusions in Table ES3 are based on occasional circumstances of high lead concentrations in soil and tank water and these do not co-occur at the same property, these results are considered unlikely to be representative of most Costerfield residents.

However lead exposure from soil and tank water is plausible and the results in Table ES3 emphasise the need for careful management of exposure.

Table ES3: Conclusion for health risk - Costerfield Permanent Residents (Antimony, Arsenic and Lead)

Estimate Type	Key Assumption	Conclusion
Upper Estimate **Permanent Residents**	■ **Use tank water** as their primary drinking water source.	Some Concern for adverse health effects
	■ **Do not use tank water** for drinking purposes (but do bathe in tank water)	Minimal Concern for adverse health effects
Average Estimate **Permanent Residents**	■ **Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	■ **Do not use tank water** for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects

Table ES4 provides the results for weekend residents either including or excluding tank water use. The results show a negligible concern for adverse health effects. Results for permanent residents using tank water as a drinking water source show a minimal concern for adverse health effects.

Table ES4: Conclusion for health risk to Costerfield Weekend Residents (Antimony, Arsenic and Lead)

Estimate Type	Key Assumption	Conclusion
Upper Estimate **Weekend Residents**	■ **Use tank water** as their primary drinking water source.	Minimal Concern for adverse health effects
	■ **Do not use tank water** for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects
Average Estimate **Weekend Residents**	■ **Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	■ **Do not use tank water** for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects

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Acronyms and Abbreviations

ADI	**Acceptable Daily Intake**
AGV	Air Guideline Value
As	Arsenic
ADWG	Australian Drinking Water Guideline
BMD	Benchmark Dose
BMDL	Benchmark Dose upper confidence limit
Cd	Cadmium
CSM	Conceptual site model
CoC	Chain of Custody
COI	Chemicals of Interest
COPC	Chemicals of Potential Concern
Cu	Copper
DEDJTR	Victorian Department of Economic Development, Jobs, Transport and Resources
DEPI	Former Victorian Department of Environment and Primary Industries
DHHS	Victorian Department of Health & Human Services
DQIs	Data Quality Indicators
DQOS	Data Quality Objectives
EDI	Estimated Daily Intake
EPA	Environment Protection Authority Victoria
Fe	Iron
FSANZ	Food Standards Australia and New Zealand
Hg	Mercury
HI	Hazard Index
HQ	Hazard Quotient
HRA	Health Risk Assessment
IARC	International Agency for Research on Cancer
JECFA	Joint FAO/WHO Expert Committee on Food Additives
LOAEL	Low Observed Adverse Effect Level
LOR	Limit of Reporting
Mining PEM	Mining and Extractive Industries Protocol for Environmental Management
Mn	Manganese
N/A	Not applicable
NATA	National Association of Testing Authority
NEPC	National Environment Protection Council
NEPM (2013)	National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 2013
NEPM (AAQ)	National Environment Protection (Ambient Air Quality) Measure 2003
NHMRC	National Health and Medical Research Council
Ni	Nickel
NMI	National Measurement Institute
NOAEL	No Observed Adverse Effect Level

ADI	**Acceptable Daily Intake**
NOEL	No Observed Effect Level
NTP	National Toxicology Program (U.S.)
Pb	Lead
PCR	Primary Contact Recreation
$PM_{2.5}$	Particulate Matter less than 2.5µm in size
PM_{10}	Particulate Matter less than 10µm in size
RPD	Relative Percentage Difference
SEPP	State Environment Protection Policy
SEPP (AQM)	SEPP (Air Quality Management)
Sb	Antimony
TDI	Tolerable Daily Intake
TRV	Toxicity Reference Value (TDI is an equivalent term)
UF	Uncertainty Factor
US EPA	United States Environment Protection Authority
WHO	World Health Organization
Zn	Zinc

1.0 INTRODUCTION

1.1 Background

Golder Associates Pty Ltd (Golder) was engaged as an independent expert by the Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR) and Department of Health & Human Services (DHHS) to undertake a Health Risk Assessment (HRA) at Costerfield, Victoria, Australia.

Golder was engaged to undertake environmental monitoring at Costerfield, and an assessment of human health risks.

The assessment was undertaken over three stages:

- Rapid Health Assessment, June 2014. This work involved ambient air monitoring, and soil and tank water sampling. The rapid health assessment is discussed further in Section 1.5.1.
- Further site assessment to support the HRA, September 2014 to September 2015. This work involved stock sampling (lamb and eggs), air modelling, desktop study, tank water and soil sampling and ambient air monitoring.
- HRA, as documented in this report.

1.2 Issue Identification

In early 2014, the Costerfield community voiced concern with the former Department of State Development, Business and Innovation (DSDBI)[2] that the mining operations in the Costerfield area may be a source of elevated antimony detected in biological samples collected from a local resident, and water samples collected from local water tanks and nearby Tin Pot creek.

1.3 Project Location

Costerfield is located in rural Victoria, approximately 100 km north-west of Melbourne and 50 km south-east of Bendigo. The largest township within close proximity of Costerfield is Heathcote. The population of the Heathcote District (including the Costerfield area), during 2011, was less than 4000 residents.

The desktop review considered a study area including the broader Costerfield area with particular focus on geological conditions and related mining activities. For the purposes of the HRA, the study area is considered to be the area within the Costerfield Dome, as shown in Figure 1.

Further details on the historical and current mining activities are presented in the Desktop Review (Golder 2015, Appendix A).

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[2] Now Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR)

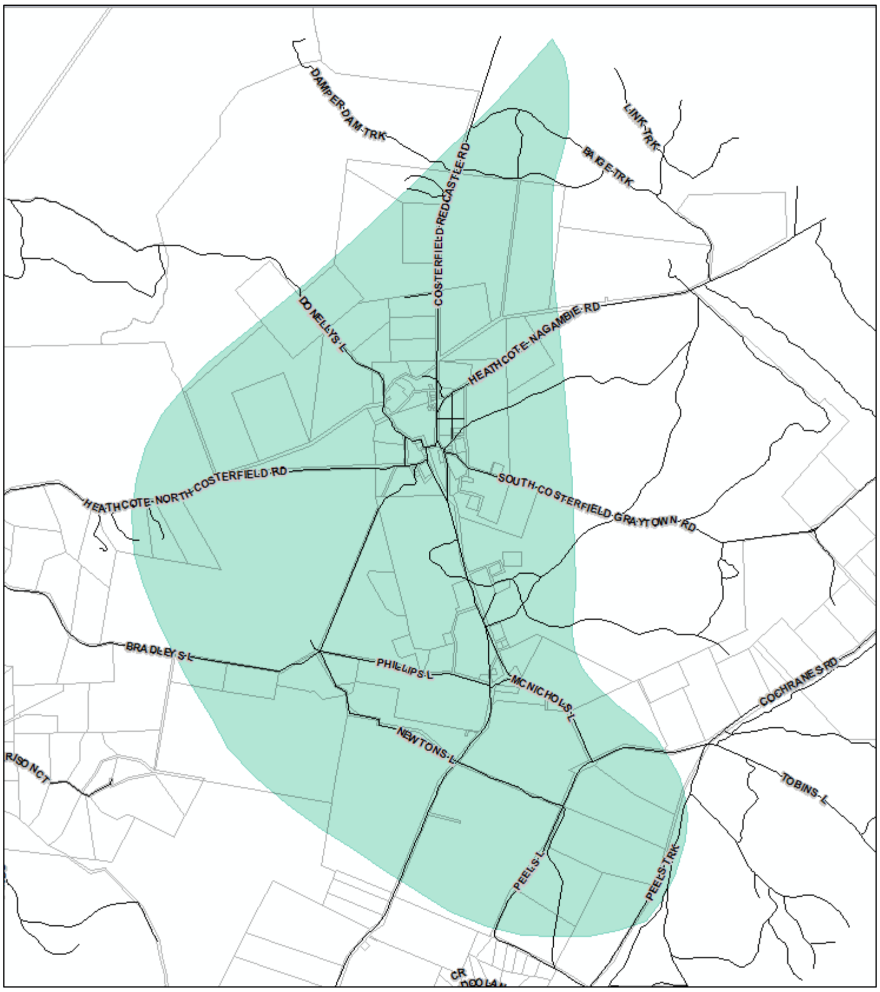

Figure 1: Costerfield Township, showing Costerfield Dome (HRA Study Area)

1.4 Structure of the HRA Report

This HRA is a technical report. However to make the report more accessible to all stakeholders it is reported at three layers of detail:

- Overall Summary. A summary of key outcomes of the HRA are provided in the Sections titled “Key Points” and “Executive Summary”.
- Body of report. The body of this report provides more detail on the environmental assessments at Costerfield than that provided in the Key Points and Executive Summary. To make the report more readable and user friendly, detailed technical discussions supporting a particular aspect of the assessment or presentation of scientific information have been confined to Appendix A to I to this report.
- Appendices A to I in this HRA report. The appendices detail the technical HRA undertaken. The appendices are reported in a scientific manner to allow accurate description of a large collection of data. They transparently describe the objective manner in which the assessment is undertaken. Equations and factors used in equations are provided, as well as the results of the HRA. The content of the technical HRA (Appendices) is outlined in Table 1.

Table 1: Technical HRA - Report Structure

Appendix	Title	Content
A	Desktop Review - Antimony in the Costerfield Area	A copy of the Golder (2015) background report on the nature, transport and distribution of antimony in the environment, for the Costerfield area, Victoria.
B	Risk Assessment Methodology	An outline of the HRA approach, and summary of the document structure.
C	Problem Formulation	This is the first part of the issue identification stage. Includes the development of the Conceptual Site Model (CSM) to describe the sources, receptors and pathway(s) by which stressors (e.g., chemicals) can move from the source to the receptor, and identifies the complete pathways that have been assessed in further stages of the HRA.
D	Environmental Data Review & Selection of COPC	This is the second part of the issue identification stage and is often referred to as a Tier 1 risk assessment. The available environmental data is reviewed and screened against published environmental guidelines (relevant to the pathways and receptors to be assessed) to select the chemicals of potential concern (COPC) that have been assessed in further stages of the HRA.
E	Exposure Assessment	An outline of the equations and exposure parameters used to calculate the estimated daily intakes of the COPC for children and adults in Costerfield.
F	Toxicity Assessment and Interaction Profile	This appendix presents a review of toxicity information and an interaction profile for the COPC. This section is referred to as the ‘hazard assessment’ in the Australian Risk Assessment Framework.
G	Risk Characterisation	Details of the model used to calculate the estimated daily intakes and the hazard quotients, and a summary of the results.
H	Variability Assessment	An analysis of the uncertainties and sensitivities in the risk characterisation results.
I	Sources of Metals in the Environment	A review of various data sets to assist in understanding the key sources of the metals modelled in the HRA.

1.5 Previous Reports Relevant to the HRA

1.5.1 Golder Rapid Assessment

The Golder rapid assessment was based on data collected in a two week period during June 2014. Samples were collected from shallow soils and tank water. Ambient air monitoring was undertaken from one measuring station. The results of the rapid risk assessment were reported in *Rapid Health Assessment and Preliminary Report on Monitoring Program Based on Information and Data Available to 15 June 2014* (Golder 2014).

The key findings of the rapid assessment were as follows:

- Regional soil antimony levels are naturally elevated. This is the reason antimony is mined in Costerfield. The rapid assessment did not attribute antimony concentrations in urine, soil, water or any other media to any source natural, historical or current.
- Antimony was the key metal measured above guideline levels. At 33 of 34 residential properties, antimony concentrations in tank water were greater than the Australian Drinking Water Guideline. For soil, 13 of 34 residential properties reported an exceedance of the provisional antimony investigation level.
- The preliminary air monitoring results indicated low particulate levels (PM_{10} and $PM_{2.5}$). Antimony was measured within these particulates with a maximum ambient air concentration of 0.011 µg/m^3 [3].

Using conservative assumptions the rapid assessment found that for both adults and children adverse health effects were unlikely. The assessment did conclude that further investigations and a comprehensive risk assessment were warranted to inform ways to reduce antimony exposures to residents.

The rapid assessment found that, although most residences within Costerfield are likely to have low exposures, there are a small number of residences that if children were present every day there would be a need to reduce exposure levels. The rapid assessment recommended implementation of precautionary mitigation measures in the interim between the rapid assessment and completion of the HRA. The following measures were recommended to reduce exposure:

- Using drinking water that complies with the drinking water standard
- Reducing indoor dust
- Reducing soil exposures (e.g. replace soil in play areas and garden beds).

The rapid health assessment fulfilled the purpose of addressing the immediate health concerns of the Costerfield community. The outcomes and recommendation of the rapid health assessment are essentially superseded by the results of the HRA.

2.0 WHY IS A HRA NEEDED FOR COSTERFIELD ?

Monash University (Monash 2014) conducted an independent assessment of urinary antimony levels reported to the Victorian Department of Health from Costerfield and other parts of Victoria. Monash state "*The creatinine-corrected values from Costerfield from 1 to >35 nmole Sb/mmole cr were substantially higher than most reference values in unexposed populations from the literature (generally < 1 nmole Sb/mmole cr)*". The Monash University (2014) report also states that the high levels may be due to antimony contamination from the urinary collection/storage in PET bottles or tubes. It is Golder's understanding that a subsequent investigation of the collection and storage procedures identified that collection/storage bottles and tubes contained antimony and some of this was leachable into urine.

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[3] This is lower than the human health risk screening level derived by Golder (refer Appendix F) of 1 µg/m^3.

Monash University (2014)[4] commented that the following general exposure pathways were relevant for Costerfield residents:

- Ingestion of contaminated food and water. This is the pathway that generally accounts for most of the exposure in non-occupationally exposed groups.
- Direct ingestion of soil. This pathway is not normally a significant source for adults, although there can be some hand-to-mouth and food preparation transfer from household dusts. Direct ingestion of soil and dusts by hand-to-mouth transfer can be a more significant exposure source in children (enHealth 2012 a, b).
- Inhalation of dusts, including those of local geochemical origin from soils in the region and possibly from dusts drifting across from mine operations.
- Contamination of drinking water, sourced mainly from rainwater tanks collecting water from contaminated surfaces on individual properties.

Subsequent public meetings and consultation[5] with the community indicated that there was also a concern about health effects resulting from not only antimony but other metals that might interact with antimony to cause adverse health effects. In particular the community were concerned about interactions between antimony and arsenic.

Golder was commissioned to prepare a desktop review with the objective of providing information to support the understanding of the nature, transport and distribution of antimony and related chemicals in the Costerfield area. This review was necessary to understand the source contributions of antimony and related metals in Costerfield. The main source of antimony in the Costerfield area is mineralised zones of sulphide minerals such as stibnite and adjacent altered host rocks of the Costerfield Formation. Historical mining activities have resulted in the relocation (and in some cases) concentration of antimony in the Costerfield environment. Distinguishing the natural, historical and current mining operations is difficult, but is important for the stakeholders. The desktop review[6] is provided as Appendix A of this report.

Minister D'Ambrosio, the Minister for Industry, and Minister for Energy and Resources, engaged RM Consulting Group (RMCG) to consult with the Costerfield community to seek a greater understanding of community concerns and advise on appropriate responses to those concerns (RMCG 2015)[7].

The Costerfield Community identified potential health concerns associated with current mining operations. In particular the Community identified that dust from a mobile crusher installed at the Brunswick Processing Plant, had increased volumes of dust production (RMCG 2015).

Given that HRA helps answer common questions for people who might be exposed to chemicals in the environment, it is a suitable tool to assist addressing community concerns, assessing the current mining operations contribution and providing clarity on the uncertainties in interpreting the significance of exposure to antimony and other mining related metals in Costerfield.

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[4] https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&ved=0ahUKEwiWp5rQwIzLAhVB_GMKHQH2CW4QFgg_MAY&url=https%3A%2F%2Fwww2.health.vic.gov.au%2FApi%2Fdownloadmedia%2F%257B05D0678F-56B9-4402-87F9-AF3FB798E54A%257D&usg=AFQjCNF5a6Ur4hKNrcSM4nZQDUz07H2lJA&bvm=bv.114733917,d.cGc

[5] Personal communications during June-August 2014 with residents.

[6] http://www.energyandresources.vic.gov.au/__data/assets/pdf_file/0003/1145487/Antimony-in-the-Costerfield-Area.pdf

[7] http://www.energyandresources.vic.gov.au/__data/assets/word_doc/0020/1198100/Independent_Engagement_Costerfield_Report.docx

3.0 WHAT IS A HEALTH RISK ASSESSMENT (HRA)

HRA helps to answer common questions for people who might be exposed to chemicals in the environment, in this case antimony and other metals that are found at relatively high concentrations in the Costerfield area. This HRA is used to answer questions such as:

- Under what circumstances might I and my family and neighbours be exposed to antimony and other metals?
- Is it possible we might be exposed to antimony and other metals at levels higher than those determined to be safe?
- If the levels of antimony and other metals are higher than regulatory standards, what are the health effects that might occur?
- What can be done to reduce exposure to antimony and other metals?

A conceptual site model (CSM) describes three elements: sources, receptors and pathway(s) by which stressors (e.g., chemicals) can move from the source to the receptor. These three elements need to be integrated to characterise the risk, as described in Figure 2. This figure illustrates that unless there is a pathway from the chemical source to the receptor, a risk cannot occur.

Figure 2: Risk Assessment Fundamentals

The CSM for the Costerfield HRA is presented in Appendix C. This CSM considers the potential sources of antimony and associated metals in the environment and the pathways of exposure for the residents of Costerfield.

The fundamental concept of risk assessment is that there should be an exposure pathway linking the source of contamination and the exposed population. Where this linkage exists, an assessment of the nature and significance of the exposure pathway is required to assess the level of risk (NEPC 2013). The pathways of exposure potentially relevant to the residents of Costerfield are as follows:

- Soil – incidental ingestion during outside activities (e.g. gardening, children playing)
- Soil – dermal contact during outside activities (e.g. gardening, children playing)

- Dust – inhalation outdoors and indoors
- Water – ingestion via drinking tank water or bottled water
- Water – dermal contact and ingestion whilst showering or bathing in tank water
- Water – dermal contact and ingestion whilst swimming in local dams or swimming pools
- Locally grown foods – ingestion of locally grown produce

The above exposure pathways are all complete linkages and relevant to the study area.

All of the above exposure pathways with the exception of swimming in local dams or swimming pools have been modelled in the HRA. The exposure risks due to dermal contact and ingestion of water whilst swimming in local dams or swimming pools has not been included in the modelling as there is insufficient information regarding the concentrations of COPC in dams or swimming pools to support the calculation of an estimated daily intake (EDI) from this pathway.

The objective of the overall program was to develop a HRA for the metals of interest to:

- Provide an understanding of the potential level of risk to human health in the area
- Establish how much of the risk to human health is contributed to mine activities.

4.0 WHAT ARE CHEMICALS OF INTEREST?

A chemical of interest (CoI) is defined in this report as a chemical that is related to:

- Geology of Costerfield. The Costerfield township is located within the Costerfield Dome (a geological term) which is at or close to the surface approximately 1 km west of the Costerfield Township. This dome includes zones of mineral enrichment (enriched with metals including gold, antimony and arsenic) that are relatively unique in Australia.
- Historical mining in Costerfield. Historic mining occurred by both open cut and underground mining and was most productive during two periods, 1860 to 1883 and 1904 to 1925, with only intermittent small scale production during 1934 to 1950. During 1995, a processing plant was constructed for the re-treatment of tailings and the oxide portion of the mine wastes at the Brunswick open pit mine (Mandalay Resources, 2012). These activities redistributed mineral content within the Dome and also introduced additional processing chemicals.
- Current mining in Costerfield. The Brunswick Processing Plant comprises a two-stage crushing process, two milling stages in series, with closed circuit classification and gravity concentration. The flotation circuit produces antimony-gold flotation concentrate (SKR Consulting, 2013). The flotation tailings are sent to an onsite tailings storage facility. Flotation processes typically use chemical conditioning agents and intense agitation and/or sparging of the crushed ore slurry to produce mineral rich foam concentrate.
- A component of construction materials that are commonly used in construction of water tanks and/or house roofs.

Golder (2015) undertook a Desktop Review of the history of the Costerfield township (Appendix A). This review considered the geological setting of the area and the current/ historical mine activities which have occurred, or are occurring, in the Costerfield area. It concluded that antimony and to a lesser extent arsenic are the two metals present in the environment that are related to the geology, historical and current mining operations.

One of the objectives of the Desktop Review was to produce a target list of chemicals to inform the analytical schedule for the environmental sampling. To generate the target list a number of data sets were evaluated and assessed. These included:

- Desktop review of mining processes.
- Department of Primary Industries (DPI) dataset of geochemical results across central Victoria,containing 73,812 samples that were tested for the following metals: gold (Au), silver (Ag), arsenic (As), antimony (Sb), mercury (Hg), tungsten (W), aluminium (Al), calcium (Ca), iron (Fe), manganese (Mn) and lead (Pb).
- Mandalay ore data from August 2014, containing 20 samples (10 ore samples and 10 low grade samples) analysed for the following metals gold (Au), silver (Ag), aluminium (Al), arsenic (As), boron (B), barium (Ba), beryllium (Be), bismuth (Bi), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), potassium (K), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), phosphorus (P), lead (Pb), sulfur (S), antimony (Sb), selenium (Se), tin (Sn), strontium (Sr), titanium (Ti).

This information was used together with initial field sample results to consider which chemicals should be included in the field program.

The process of selecting CoI considered a number of factors including:

- Is the chemical a natural constituent of the body, in its mineral form, is it a hazardous chemical?
- Are the levels of the chemical above levels normally found in soil or water?
- Are the levels of minerals in the ore below health screening values?

Using a prioritistation screening process (reported in Appendix A) the list of CoI was determined. In all, more than 18 chemicals were assessed for whether they met the criteria as CoI. Chemicals were “screened in” if they were:

- Present in the ore above normal soil concentrations; and/or
- Found in tank water and/or roof construction materials; and/or
- Related to historical mining processes; and/or
- A marker of soil quality (geochemistry).

This process of screening chemicals in and out of a risk assessment is a standard process defined within international and national HRA methodology.

The reason for screening chemicals out is that these are unlikely to contribute to health risk (individually) and are unlikely to contribute or interact with other chemicals.

The COI informed the analytical schedule for the environmental data collected during the data collection phase of the project (June 2014 to September 2015).

Table 2 provides a summary of the COI, the reason for selection and the analytical schedule. Analysis undertaken during the environmental monitoring program in 2014-2015 assessed these COI.

Table 2: COI Identified for Next Phase of Works

Chemical of Interest		**Reason for selection**	**Recommended Analytical Schedule**					
			Soil	Water	Sediment	Air	Eggs	Lamb
1	Antimony	Present in ore above normal soil levels	✓	✓	✓	✓	✓	✓
2	Arsenic	Present in ore above normal soil levels	✓	✓	✓	✓	✓	✓
4	Copper	Found in tank and roof construction materials	✓	✓	✓	✓	✓	✓
5	Cyanide[1]	Historical mining process chemical	✓	×	×	×	×	×
6	Iron	Soil quality (geochemistry) marker	✓	✓	✓	✓	✓	✓
7	Lead	Found in tank and roof construction materials	✓	✓	✓	✓	✓	✓
8	Manganese	Soil quality (geochemistry) marker	✓	✓	✓	✓	✓	✓
9	Mercury	Historical mining processes	✓	✓	✓	✓	✓	✓
10	Zinc	Found in tank and roof construction materials	✓	✓	✓	✓	✓	✓
11	Cadmium	Found in tank and roof construction materials	✓	✓	✓	✓	✓	✓
12	Nickel	Found in tank and roof construction materials	✓	✓	✓	✓	✓	✓

✓- recommended for analysis × - not recommended for analysis

[1] Cyanide is recommended for analysis in soils only as it is considered unlikely to be present in other matrices based on historical use and low potential for bioaccumulation.

5.0 CHEMICALS OF POTENTIAL CONCERN (COPC)

5.1 Selection of COPC and their toxicity values

The 12 COI (plus an additional 6 for some samples) were reported within the environmental data collected from June 2014 to September 2015. Three COPC were subsequently selected for consideration in the HRA.

The process of selecting COPC begins with the review of the environmental data set collected during the 18 month field program, including soil, tank water, and outdoor air dust data. This was followed by a screening process that considered the individual contaminant toxicity, the prevalence of a chemical within and across media (soil, water, air), and the likelihood that a detected chemical was related to the identified issues at Costerfield. The goal of the process was to identify those chemicals that people could be exposed to at levels of health concern.

Chemical concentrations in each of the environmental media identified in the CSM are discussed in the following appendices:

- D1 – Soil
- D2 – Water
- D3 – Air
- D4 – Food
- D5 – Surface Dust.

The process for selecting COPC is described in Appendix D. Antimony, arsenic and lead were selected as COPC based on review of all results for metals in soil, tank water, metals in PM_{10} (dust in air), eggs, sheep and other information evaluated. Appendix I provides additional information about the sources of these COPCs.

The following COPC (chemicals that people are most likely exposed to at levels of health concern) were identified:

- Antimony. Antimony was found to exceed the health based criterion for soil of 200 mg/kg in 63 of 248 soil sample results. In tank water it exceeds the drinking water guideline in almost all samples within the Costerfield.

  The World Health Organisation in 2003 (WHO 2003) reviewed the toxicology of antimony and its compounds. The WHO determined that the level where no adverse effects was observed was 6,000 micrograms per kilogram body-weight per day. At higher doses (45,000 micrograms per kilogram body-weight) marked, but reversible, loss of body-weight gain occurred, together with slight changes to liver and spleen, probably related and in conjunction with distinctly reduced food and water intake at this dose. The WHO applied a safety factor of 1000 fold to derive a tolerable daily intake (TDI[8]) of 6 micrograms per kilogram body-weight per day. The use of the TDI in assessing health risk is discussed in Section 7.0 and Appendix G.

- Arsenic. Arsenic was found to exceed the health based screening criterion for soil of 100 mg/kg in only a small proportion (20 of 248) soil sample results. In all tank water samples tested, arsenic was below the Australian Drinking Water Guideline (both total and filtered).

  The Australian Pesticides and Veterinary Medicines Authority (APVMA, 2005) conducted a toxicity review of arsenic and concluded that arsenic appears to behave like a carcinogen which exhibits a

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[8] The tolerable daily intake (TDI) is defined as the amount of daily intake of a substance that can occur over a lifetime without appreciable lifetime health risk. It is typically expressed in units of micrograms per kilogram body-weight per day (WHO 1994).

threshold effect. Based on the assessment that a threshold dose-response approach for the assessment of carcinogen effects associated with arsenic exposure is considered appropriate, the National Environment Protection Council (NEPC 2013) adopted a TDI of 2 µg/kg/day. The TDI is a lifetime average daily dose that is protective of both non cancer and cancer effects due to arsenic exposure.

- Lead. Only 8% of lead soil sample results contained lead at concentrations above the health based screening criterion of 300 mg/kg. Only 5% of tank water samples were above the Australian Drinking Water Guideline. Appendix I provides a detailed analysis of whether these occasional exceedances are related to the geology or mining legacy of Costerfield. It was concluded that the elevated lead concentrations in soil and water are likely due to a mixture of sources, with the highest concentrations due to anthropogenic (man made) sources of lead contamination some of which are common to all urban areas (lead in fuel, paint and other industrial products). This conclusion was based on very specific testing called isotope analysis (reported in Appendix D6) and a comparison of soil and tank water results from other parts of Victoria and Australia (Appendix I). It is not possible to distinguish between the man made sources of lead based upon the available data.

  In May 2015 the National Health and Medical Research Council (NHMRC 2015) produced a statement titled *Evidence on the Effects of Lead on Human Health*[9] The Statement concludes that the "*health effects of lead found an association between blood lead levels less than 10 micrograms per decilitre and health effects, including reduced Intelligence Quotient and academic achievement in children, behavioural problems in children, increased blood pressure in adults and a delay in sexual maturation in adolescent boys and girls"*. It recommends that *"if a person has a blood lead level greater than 5 micrograms per decilitre, the source of exposure should be investigated and reduced*."

  The toxicity benchmark for lead (equivalent to a TDI) used in this HRA has been derived by the World Health Organization as a level that will not result in any detectable level of adverse health effects in children (0.6 µg/kg body weight/day) or in adults (1.3 µg/kg body weight/day). Exposure at or around this toxicity value would result in blood lead levels of less than 3 micrograms per decilitre and it is therefore consistent with the NHMRC statement. The use of this approach is highly conservative and is based on the latest research on the health effects of lead. Additional technical details are provided in Appendix F.

Figure 3 provides a consolidated summary of the soil data for the COPC. The boxes in the figures show the most frequent soil concentrations for each COPC. The figure is a statistical description of the soil data. The technical detail of this figure is provided in Appendix I. The figure shows:

- The concentrations of lead, antimony and arsenic selected to represent an average exposure in Costerfield are higher than most of the soil results in Costerfield for all three metals. This is particularly true for lead. The average value used in the HRA calculations is higher than 80% of the soil values in Costerfield.
- The concentrations selected to represent the upper exposure of lead, antimony and arsenic in Costerfield is one of the highest results in the entire dataset. This demonstrates that the "upper estimate" is an appropriate value to describe a reasonable maximum exposure scenario (refer to Section 6 and Appendix E).
- Antimony and arsenic levels in the Mandalay Ore are much higher than those in Costerfield soil. However the lead concentrations in ore are less than most values in soil. An examination of why this is so is provided in Appendix I, indicates that the occassional high lead values in soil are not unique to Costerfield and most likely represent common environmental sources of lead contamination.

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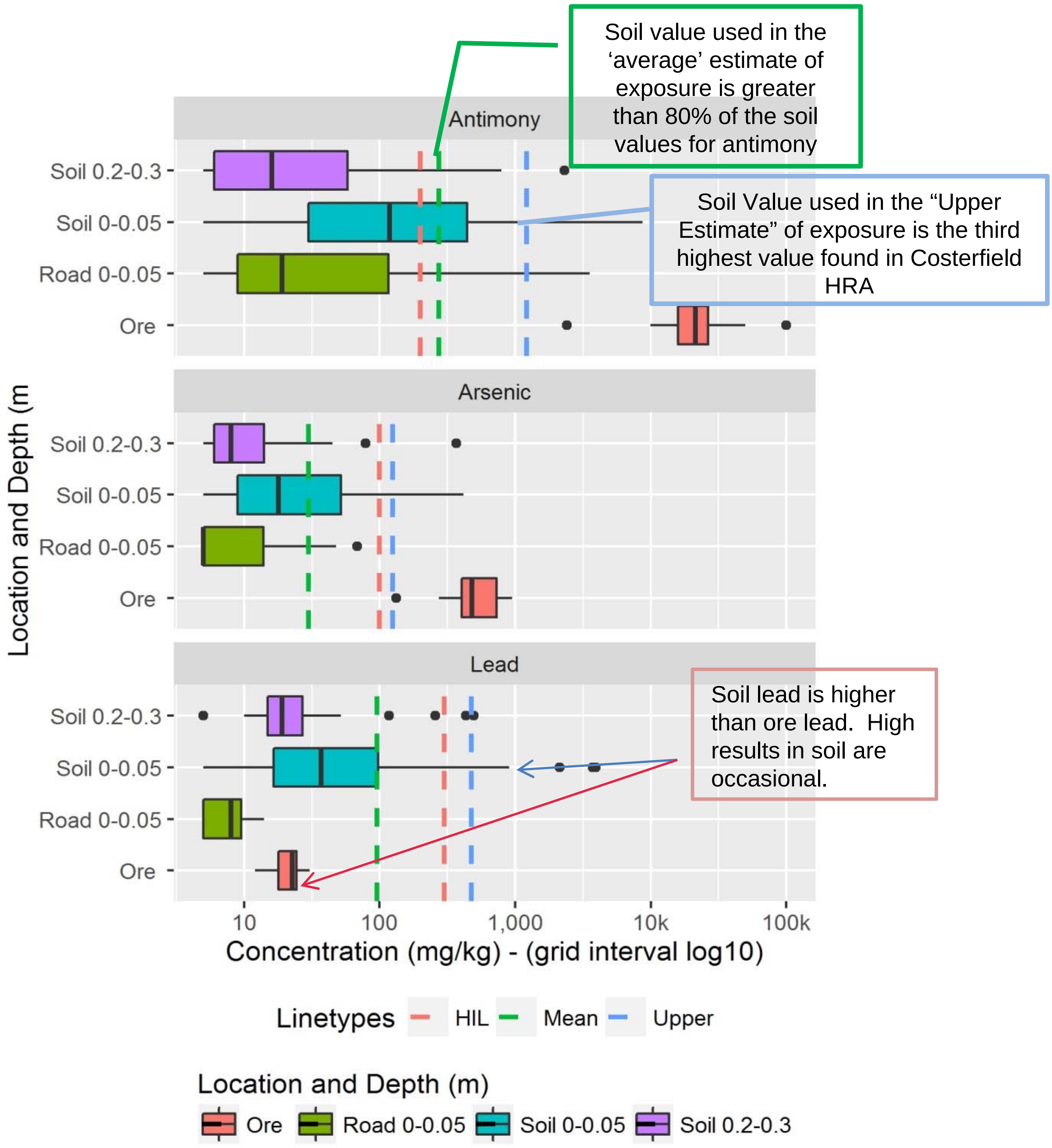
[9] https://www.nhmrc.gov.au/guidelines-publications/eh58

The HRA assumes that a person (1 year old, 2 year old, 10 year old, adult) plays/works outdoors at a location where the soil concentration for each of the COPC is present for two hours per day each day of the year. As can be seen from the Figure this is unlikely at any individual properties in Costerfield.



Soil value used in the ‘average’ estimate of exposure is greater than 80% of the soil values for antimony

Soil Value used in the “Upper Estimate” of exposure is the third highest value found in Costerfield HRA

Soil lead is higher than ore lead. High results in soil are occasional.

Figure 3: Statistical Summary of Soil COPC Values.

Description of soil values used in the HRA (green and blue dotted lines). Comparison between surface soil values (light blue and purple boxes) and ore concentration (red boxes) for each COPC. The black dots are outliers (i.e. the highest concentrations in soil for each metal).

5.2 Sources of COCP in Costerfield

To assist in understanding the potential exposure of residents in Costerfield to the COCP, a review of the environmental data, available historical information (Appendix A) and published data on these chemicals in the Australian environment (where available has been considered.

5.2.1 Antimony and Arsenic

Review for the environmental data for soil and water in Costerfield indicate that the concentrations are different in Costerfield compared to other parts of Victoria because of the geological and mining legacy in the area. The results (refer Appendix I) suggest that the elevated levels of antimony and arsenic are positively correlated as these metals are found co-located naturally in the Costerfield geology. Antimony and arsenic are known components of the local geology; specifically the mineralised zones of sulphide minerals such as stibnite and adjacent altered host rocks of the Costerfield Formation. The extensive distribution of mine wastes (particularly tailings) within Costerfield is likely to be a significant source of antimony and associated arsenic in the environment. This is supported by the soil data which indicates that the antimony and arsenic concentrations are closely correlated in the Dome, and their presence is consistent with the geology of the area.

In summary, the analysis of the data in Appendix I found that the soil concentrations of antimony and arsenic are naturally occurring in the geology of the Costerfield Dome, with an increase in the soil concentration of up to 15% due to current mining related dust contributions.

Farming and residential development within the Costerfield area is unlikely to have significantly contributed to the antimony load within the local environment.

5.2.2 Lead

Throughout the HRA report and its appendices there is information on lead. This section consolidates the information on lead to assist the reader to contextualise the conclusions around lead in Costerfield.

Occasionally in Costerfield, as is in many other parts of Victoria, high levels of lead in tank water and soil are encountered. It is most likely that these high levels are due to widespread historical anthropogenic (man made) uses of lead rather than the geological features that make Costerfield different to other regions.

The reason for this conclusions are based on multiple lines of evidence. These include:

1) **Lead in Costerfield tank water is typical of lead in other parts of Australia (Appendix D2)**

- Lead is a common metal found in in tank water due to roofing, guttering and pipework materials (CSIRO 2008; enHealth 2010; Andra et al. 2014).
- Five percent of tank water samples from Costerfield were above the Australian Drinking Water Guideline (ADWG). This is within what is expected based on Australian surveys of lead in rainwater tanks.
- The lead in Costerfield tank water was mostly identified in the unfiltered samples. Most but not all filtered samples did not exceed the ADWG. This indicates that the lead is mainly insoluble and particulate bound. This is a consistent pattern with literature in other parts of Australia.
- Chapman et al (2006) conducted a national survey of rainwater tank water quality. This included 38 tanks from Adelaide, Brisbane, Canberra, Broken Hill, Melbourne, Sydney and Wolllongong. The survey concluded that the main health concern with use of tank water as a potable water supply is lead. Lead was detected in 79% of tanks, with 9% of tanks having levels equal to or exceeding the ADWG. The high lead values originated from a variety of tanks in practically all the towns/cities tested indicating that the contamination is common and widespread.
- Magyar et al (2008) conducted a survey of 55 rain water tanks and concluded that lead concentrations were elevated in approximately 33% of the tank water at up to 35 times the ADWG.

2) **Lead present in Costerfield Dust in Air (Ambient lead in PM_{10} Appendix D3) is within levels measured in urban areas.**

- The annual average lead concentrations in Costerfield are 350 times less than the national annual standard of 0.5 micrograms per cubic metre of air (µg/m^3).

  Appendix D3 Table 8 and Table 10 provide the lead in PM_{10} results for the two monitoring locations in Costerfield. The lead concentrations in air range between less than detection (< 0.0004) to 0.011 µg/m^3. The annual average lead in air concentration was 0.0011 µg/m^3 and 0.0014 µg/m^3 at residence 1 and 2 respectively.

- The maximum concentration in Costerfield (0.011 µg/m^3) is less than levels measured in metropolitan Melbourne (0.02 µg/m^3)[10] and within levels measured in urban (cities and towns) areas of NSW (0.002 – 0.099 µg/m^3) [11]

3) **A statistical analysis of lead in soil found that the distribution of high lead concentrations is not correlated to the geology of Costerfield suggesting an alternative source of lead in these elevated results.**

- Appendix I Figure 3 provides a detailed analysis of whether the elevated concentrations of lead are related to the geology of Costerfield. Where there are high concentrations of lead, the corresponding antimony concentrations are not significantly higher than other samples. This suggests that at the lower concentrations, the presence of the two metals is correlated, as would be expected within Costerfield, as lead is present in the ore, however at higher concentrations there may be an alternative source of lead in the environment.

- The concentrations of lead within Costerfield appear to follow a similar distribution to the other data gathered in Victoria. Olszowy et al (1995) for a Victorian old suburb with low traffic volume. This suggests that the lead in the Costerfield environment is similar to that of an established urban environment with low impact from vehicle traffic.

4) **Lead Isotope analysis found that the soil samples tested are unlikely to be of the same geological origin as the Costerfield ore. This suggestion alternative sources of lead in these samples.**

- Appendix D6 Section 4 details lead isotope testing conducted by the University of Melbourne School of Earth Sciences. The isotope testing was conducted on four Costerfield soil samples. The soil samples were selected based on total lead results (all four contain elevated lead concentrations).

  The results suggest that the lead in soil is most likely a mixture of anthropogenic sources and unlikely to be solely from the Costerfield ore. The isotope analysis does not allow additional characterisation of the anthropogenic source (i.e. it is not possible to distinguish between common sources of lead and lead nitrate used in mining).

5.2.3 Mining in Costerfield and Lead

Appendix I Section provides a summary of lead use in both historical and current mining operations.

The lifecycle of lead in current operations can be described as:

- **The ore** mined is mostly made up of stibnite Sb_2S_3 but also contains some bournonite, a lead antimony sulphide $PbCuSbS_3$ and other lead sulphides which make up the lead content. The concentrations of lead in the ore (12 to 31 mg/kg) are presented in Appendix I Table 1.

- Lead nitrate (a soluble man made compound of lead) is used in current **mining processing** as an activator for stibnite (Sb_2S_3) in antimony ores. In the current process lead nitrate is added during the

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[10] EPA Victoria (2012) Table 93: Annual average lead (Collingwood 1995–2004)

[11] NSW (2002)

flotation process to produce the mineral concentrate. It is added within a managed aqueous system. As such it is not expected to enter the environment as dust or be emitted to the environment with waste rock (note this expectation is consistent with the results of tank water testing and ambient air monitoring).

With respect to lead, current reagent consumption rates for lead nitrate is 400 g per one dry metric tonne of processed ore (Mandalay 26/02/16). Lead nitrate ($Pb(NO_3)_2$)is added in liquid solution into the slurry (ore rock mixed with water) during the processing of ore to aid recovery of metals. The process occurs in a liquefied form and no dust is generated. This is equivalent to a concentration of 400 mg/kg, which remains mainly in the flotation circuit although some could be expected to be in the processed ore (concentrate) and tailings.

- A limited environmental assessment of Mandalay's processes (undertaken by Snowden, 2012) reported that potential contaminants to the environment associated with the Costerfield mines may include antimony (from stibnite), arsenic from (arsenopyrite), cyanide (from historical processing) as well as lead (lead nitrate), caustic soda, acids and other flotation reagents used in the gold extraction process (Snowden, 2012).
- Data on the composition of the concentrate and tailings is limited. Mandalay Resources proved two sets of data, one is as referred to in Appendix D5 (Mandalay 07/07/15 email re:'Concentrate' Place:Frangos) and more recent information provided in February 2016 (Mandalay 26/02/16 email re:'Concentrate data - lead analysis' Brauns:Foot).
- In **the Concentrate**, Mandalay (26/02/16) report that the lead concentration ranges from 1100 mg/kg to 2000 mg/kg (results taken from 6 of the last 8 shipments to China), due to the concentration of antimony minerals including bournonite which contains naturally occurring lead. The concentrate is thickened and pressed into polypropylene concentrate bags and sealed in sea containers for shipping to China. Mandalay advise that the concentrate has an average moisture content of 14% (2015 average moisture content) and no dust is generated during packing and shipment.
- **In the tailings**, Mandalay report that the lead concentration is 224 mg/kg due to the addition of the lead nitrate in processing. Mandalay advise that the liquid tailings are pumped by closed pipeline to the Brunswick tailings storage facility where solids settle out and sink below the water level (Mandalay 26/02/16).
- It was also suspected in 2014 before the field works began that **historical waste materials** may have been used to pave roads in Costerfield. Road samples were taken during the field investigations. The surface road sample lead concentrations were found to be within soil background levels (i.e. approximately 1-30 mg/kg).

  Air emission sources were examined during the development of a dust deposition model (Appendix D3). The main source of dust generation in current mining operations is truck movement. The road lead results are consistent with ambient air monitoring indicating low lead in airborne dust.

Appendix A and Appendix I Section 2.1 provides a summary of the **historical mining activities**.

- Historic mining occurred by both open cut and underground mining and was most productive during two periods, 1860 to 1883 and 1904 to 1925, with only intermittent small scale production during 1934 to 1950.
- It was not possible to document the extent of lead nitrate use historically.
- Appendix A notes that there is a potential for lead to be present in historic mining waste areas however targeted sampling of the waste areas has not be conducted.

It is most likely that these occasional high levels of lead in soil and tank water are due to widespread historical anthropogenic (man made) uses of lead rather than the geological features that make Costerfield different to other regions.

Based on the above lines of evidence it can be concluded that the elevated lead concentrations are unlikely to be related to the Costerfield ore. It is likely that there are a mixture of anthropogenic (man made) sources that contribute to the elevated lead in soil.

6.0 HOW DO WE ESTIMATE THE EXPOSURE OF PEOPLE TO CHEMICALS IN THE ENVIRONMENT?

Humans come into contact with COPC in the environment in many ways. For example, we may inhale dust as we breathe, eat food that carry chemical residues, drink water, touch soils, or absorb chemicals through our skin. In each case, the HRA needs to estimate exposure and intake using several variables.

Exposure is defined as contact between a COPC and the exterior of an exposed person's body (skin and openings into the body such as mouth, nostrils, and cuts or breaks in the skin).

Intake is defined as the processes through which COPC cross the boundary from outside to inside the body. Intake refers to processes like ingestion and inhalation that physically move the COPC through an opening in the outer body, such as the mouth, nose, or a skin puncture. Intake includes the fraction of the COPC that enters the body through the gut or skin. ·In this HRA “intake” is referred to as “Estimated Daily Intake” or “EDI”.

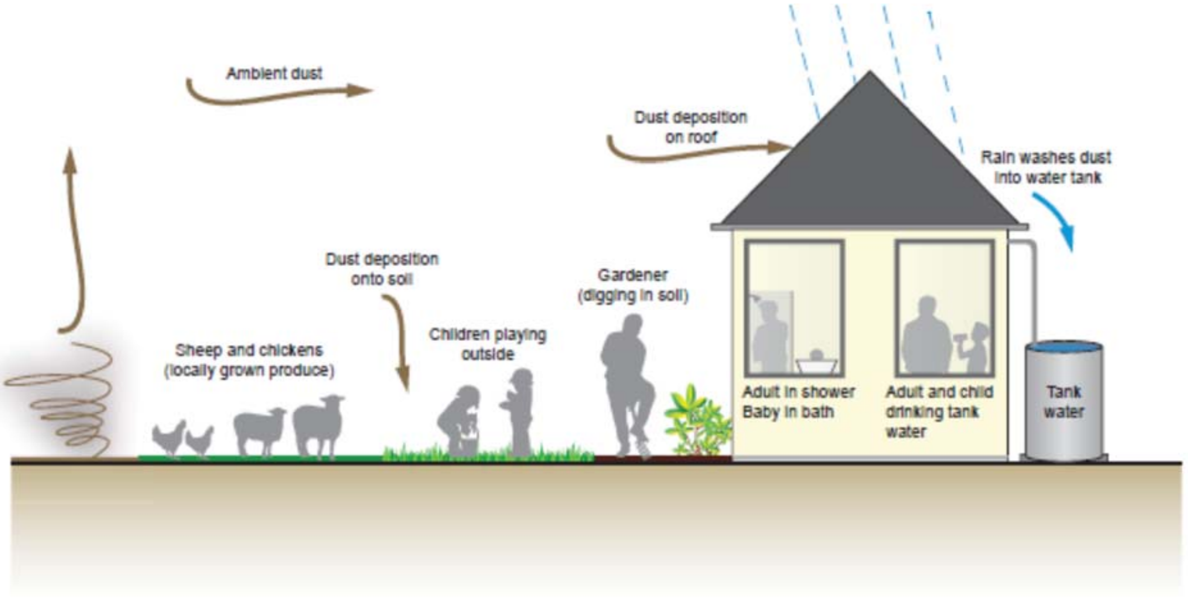

Figure 4: Conceptual Exposure Model

Note: The Exposure model includes contributions from current mining activity. The air monitoring, soil and tank water results measured in Costerfield include any potential contribution of mine related dust within Costerfield. The possible contributions of the current mining activities to these pathways is discussed in Appendix I.

Figure 4 is a generalised version of how people may be exposed to the COPC. The exposure assessment needs to inform stakeholders not only about health risk but under what conditions these health risks are manifested.

Exposure assessments describe how frequently contact occurs, how long it lasts, its intensity (i.e. the concentration of the chemical), and the route by which COPC enter the body.

Exposure assessment is a multi-step process that requires a lot of concentration data combined with a lot of estimates of exposure. The exposure assessment requires information on the physical and chemical properties of each COPC, the medium by which each COPC comes into contact with humans, and how concentrated each COPC is within that medium. The exposure assessment also needs data on the demographics of the exposed population, major routes of exposure for that group, and relevant behaviour and lifestyle issues, such as how much water is consumed and how frequently people are outdoors or at their properties.

The exposure model describing the possible mechanisms of exposure is presented in Figure 4. This model is referred to in this HRA as a “Conceptual Exposure Model” or “CSM”.

Appendix E provides the detailed technical exposure assessment. It contains a summary of all equations and accompanying input parameters and assumptions. The calculated EDI are also provided.

Exposure assessment requires consideration of the:

- Variations in concentrations used for different exposure estimates (e.g. soil and water concentrations for each COPC)
- Uncertainty in the intake values (different rates of consumption of soil or water)
- Different behaviours (e.g., permanent residents or part time residents)
- Different body types of older and younger people (i.e., body weight and skin surface area calculations for different age groupings)
- Contribution of different sources of COPC (e.g. natural versus current mining operations)

Because the EDI combines the estimates of the concentrations of the metals in the environment with human activities that might result in exposure to the metals, it is necessary to consider a range of environmental concentrations and a range of human activities and behaviours to make the EDI representative and relevant to different people and different circumstances. This requires statistical descriptions of each factor that contribute to the EDI.

The EDI estimates also need to inform stakeholders on the findings of the HRA. In this HRA two questions are posed and the EDI are calculated to support the answers to these questions.

The first question (Is it safe to live in Costerfield?) is addressed using a range of exposure estimates that is most applicable to the current residents of Costerfield. Two EDI estimates are provided:

- Average Estimate of EDI. Combining the averages in soil, water and air with average circumstances of exposure results in an EDI that is relevant to most people in Costerfield.
- Upper Estimate of EDI. Combining a range of statistical estimates for many inputs such as the soil concentration and the amount of soil ingested each day by a person results in what is known as a reasonable worst case. This estimate is intended to exceed the EDI for most people in Costerfield. It is intended as a plausible yet unlikely estimate of exposure.

Both estimates are important as it is important to describe a range of different circumstances and also to account for uncertainties in the information available on which to make estimates.

The second question (What can be done to manage exposure within Costerfield?) requires a more detailed evaluation of the Upper Estimate. The upper estimates are not likely estimates of exposure but are plausible. For instance this estimate assumes that a person spends 2 hours a day each day of the year in the same spot and the worst case result (anywhere in Costerfield) and that one of the highest soil concentrations anywhere in Costerfield for all three metals co-occurs at this spot. The person ingests two litres of tank water containing one of the highest tank water results anywhere in Costerfield for each metal every day of the year. This would be an unusual occurrence however it is included in the HRA to understand the uncertainties in the EDI.

6.1 Exposure Assessment Results

Table 4 describes the circumstances and scenarios used to calculate EDI. The calculated EDI are provided in Appendix E.

Table 3: Exposure Assessment: Age Groupings, Pathways, Scenarios and Key Assumptions

Type of Resident	Resident Age Groups	Exposed Each Day Via	Use of Tank Water
Permanent Residents Stays in Costerfield 365 days per year.	☑ Infant (1 year old) ☑ Young child (2 year old) ☑ Older Child (10 year old) ☑ Adult	☑ Soil ingestion ☑ Home-grown food (egg meat), ☑ Breathing in dust in air ☑ Bathing using tank water	☑ Use tank water as their primary drinking water source. ☒ Do not use tank water for drinking purposes (but do bathe in tank water)
Weekend Residents Stays in Costerfield 104 days per year (2 days per week).	☑ Infant (1 year old) ☑ Young child (2 year old) ☑ Older Child (10 year old) ☑ Adult	☑ Soil ingestion ☑ Home-grown food (egg meat), ☑ Breathing in dust in air ☑ Bathing using tank water	☑ Use tank water as their primary drinking water source. ☒ Do not use tank water for drinking purposes (but do bathe in tank water)

6.2 Contribution of Different Exposure Pathways to the EDI

Appendix E includes tables of each EDI and graphs showing the contribution of each exposure pathway to the total EDI. The following general conclusions are drawn from this analysis:

- When EDI are calculated assuming tank water is the primary source of drinking water for residents in Costerfield, the results indicate that, in most cases, the majority of the EDI is due to tank water ingestion.
  - For the Upper Estimate of exposure, tank water and soil ingestion are both important contributors to the EDI of antimony.
  - For the Average Estimate of exposure, soil ingestion contributes a greater proportion to the overall EDI of lead than tank water.
- When the EDIs are calculated excluding tank water, the main contributor to the EDI is ingestion of soil.
- Bathing (showering and baths) is not a significant contributor to the overall EDI.
- Eating locally grown lamb or eggs is not a significant contributor to the overall EDI.
- Breathing in the dust in the air (indoors or outdoors) is not a significant contributor to the overall EDI.

7.0 FINDINGS OF THE HEALTH RISK ASSESSMENT

Appendix G presents the findings of the HRA. The technical approach to making findings is to calculate what is known as a hazard quotient (HQ) and a hazard index (HI).

- The hazard quotient (HQ). Each estimated EDI (refer section 6.0) for each metal is compared to a health benchmark called a tolerable daily intake (TDI), which is specific for each metal. The TDI is a safe intake expressed as an average daily intake that should not cause adverse health effects to a person over a lifetime. Because the TDI is a lifetime average daily intake, the estimated lifetime EDI is calculated and used for assessing health risk for a community. The hazard quotient is calculated by dividing the EDI by the TDI. The ratio of the EDI to the TDI (the margin) is then used to make decisions about the risk of adverse health effects.
- The hazard index (HI). To consider health risks due to the combined exposure of each metal, each of the HQs is added up to derive the hazard index. That is, the hazard index equals the sum of the hazard quotients. This is a conservative assumption that in reality is likely to overestimate the health risk. However it is done to err on the side of caution.

Given the multiple levels of conservatism built into a HRA, there is generally a high level of confidence that risks are not under-estimated. On this basis the following Figure 5is used to interpret the HI.

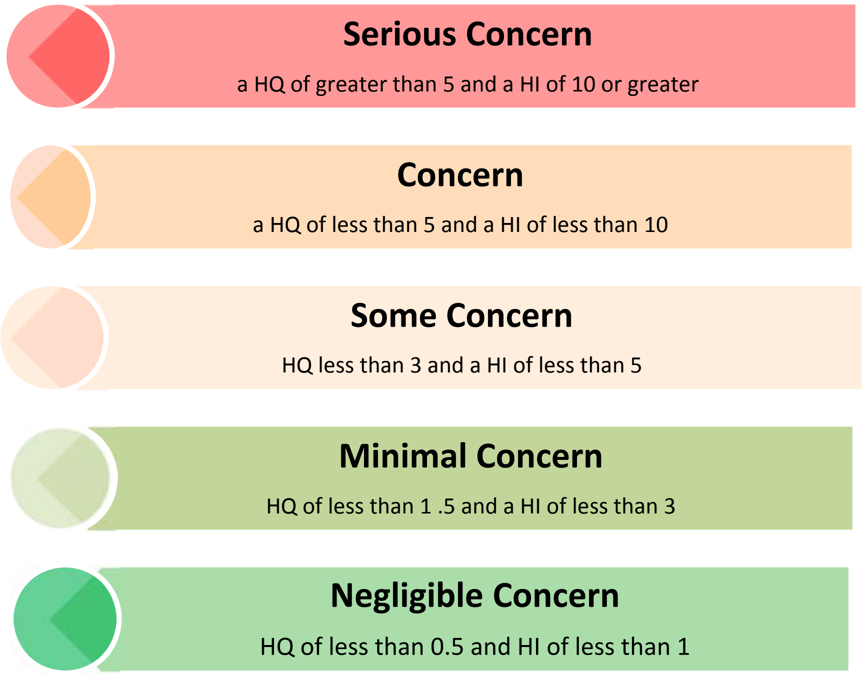

Figure 5: Interpreting Findings (hazard quotient HQ and hazard index HI).

Appendix G provides additional information on how findings of the HRA can be interpreted. It provides the HQ and HI for each of the 16 exposure estimates made in the HRA.

7.1 Is it safe to live in Costerfield?

The question is technically expressed as:"*Do the environmental levels of antimony and other metals present a health risk to people living in Costerfield ?*"

Given that the purpose of the HRA is to identify potential risks associated with the Costerfield Dome and the mining activities within it, the risk characterisation results (HQ and HI) are presented for antimony and arsenic.

7.1.1 Conclusions Specific to Living with the Mining Legacy within the Costerfield Dome

Antimony and arsenic soil levels in Costerfield are different to other parts of Victoria because of the geological and mining legacy in Costerfield. The results of the risk assessment for permanent residents in Costerfield (Upper and Average exposure estimates) are summarised in Table 4 using the key described in Figure 5.

Table 4: Conclusion for health risk to Costerfield Permanent Residents (Antimony and Arsenic)

Estimate Type	Key Assumption	Conclusion
Upper Estimate Permanent Residents	**Use tank water** as their primary drinking water source.	Minimal Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects
Average Estimate Permanent Residents	**Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects

Table 4 concludes that the environmental levels of antimony and arsenic in Costerfield do not present a health risk.

Table 5 presents the results for **weekend residents** either including or excluding tank water use show a **negligible concern for adverse health effects.**

Table 5: Conclusion for health risk to Costerfield Weekend Residents (Antimony and Arsenic)

Estimate Type	Key Assumption	Conclusion
Upper Estimate Permanent Residents	**Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects
Average Estimate Permanent Residents	**Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects

A full set of results for each age group is provided in Appendix G.

It is safe to live in Costerfield. Although the antimony and associated metals (arsenic) in Costerfield are generally higher than other parts of Victoria, these present minimal to negligible concern for adverse health risks.

7.1.2 Conclusions Including Lead Contamination

On some occasions in Costerfield, as is in many other parts of Victoria, high levels of lead in tank water and soil are encountered. It is most likely that these high levels are due to widespread historical use of anthropogenic (man made) lead. Table 6 summarises the results using the key described in Figure 5.

Table 6: Conclusion for health risk to Costerfield Permanent Residents (Antimony, Arsenic and Lead)

Estimate Type	Key Assumption	Conclusion
Upper Estimate Permanent Residents	**Use tank water** as their primary drinking water source.	Some Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Minimal Concern for adverse health effects
Average Estimate Permanent Residents	**Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects

The conclusions in Table 6 are based on high lead concentrations in soil and tank water. These do not co-occur at the same property, thus these results are considered unlikely to be representative of Costerfield residents.

However lead exposure from soil and tank water is plausible and the results in Table 6 emphasise the need for careful management of exposure.

Table 7 provides the results for **weekend residents** and, either including or excluding tank water use show a **negligible concern for adverse health effects.**

Table 7: Conclusion for health risk to Costerfield Weekend Residents (Antimony, Arsenic and Lead)

Estimate Type	Key Assumption	Conclusion
Upper Estimate Weekend Residents	**Use tank water** as their primary drinking water source.	Minimal Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects
Average Estimate Weekend Residents	**Use tank water** as their primary drinking water source.	Negligible Concern for adverse health effects
	Do not use tank water for drinking purposes (but do bathe in tank water)	Negligible Concern for adverse health effects

7.2 Is the dust harmful to health?

Appendix D3 presents a summary of the air quality monitoring program conducted by Golder in the vicinity of Mandalay Resources gold-antimony operation at Costerfield.

Dust monitoring was undertaken at two community locations referred to as Residence 1 and Residence 2.

- Residence 1 is approximately 1.3 km north of the Brunswick Plant.
- Residence 2 is approximately 1 km south east of the Brunswick Plant.

The locations were chosen to investigate the current mining operations dust levels over an extended period of time (12 months). At each location, air quality monitors were used to measure:

- PM_{10} Particulate matter with an equivalent aerodynamic diameter (EAD) less than 10 microns.
- $PM_{2.5}$ Particulate matter with an EAD less than 2.5 microns (PM2.5).
- Particulate metal, measured in the PM_{10} fraction. The metals measured were mercury, arsenic, cadmium, copper, manganese, nickel, lead, antimony, zinc and iron.
- Indicative PM_{10} , which was estimated using a continuous laser light scattering instrument, co-located with the PM_{10} monitors. The indicative results provide a measure of PM_{10} trends and variation.
- Respiratory Crystalline Silica (residence 1 only).

In addition to the air quality monitoring program, dust deposition gauge results were provided by Mandalay Resources for review and a dust deposition model was generated by Golder (refer Appendix D3).

The results on air quality assessment show that:

- All measures of air quality were within Victorian Government compliance requirements.
- The dust in air (PM_{10} and $PM_{2.5}$) was below national standards.
- The metals in the dust were not at harmful levels. This e antimony, arsenic and lead levels were always below health based air guideline values.

- Dust from the direction of current mining activities was found to contribute to dust and antimony levels in air on approximately a third of the days in the monitoring period (Appendix D3).

Residence 1

The dust levels and concentrations of antimony in PM_{10} (respirable dust in air) at Residence 1 and 2 measured in Costerfield are not at levels harmful to health.

7.3 Is tank water safe to drink?

Tank cleaning at select properties was undertaken from 10 July until 22 August 2014. To assess the success of tank cleaning, post cleaning water monitoring was undertaken from October 2014 until May 2015. At eight properties, approximately monthly water sampling was undertaken during this period.

The total antimony concentrations reported for this tank water monitoring are described in Appendix D2. A decrease in antimony concentrations was observed following tank cleaning. However, in most cases the reduced concentration of antimony still exceeded the Australian Drinking Water Guideline (ADWG) for antimony. In addition, the antimony concentrations were observed to trend upwards during the monitoring period, following the initial decrease.

Antimony concentrations in tank water regularly exceeded the ADWG both before and following tank cleaning. For this reason, residents should not continue to drink tank water.

The tank cleaning and subsequent monitoring did not support tank cleaning as a suitable measure to mitigate exceedences to the ADWG.

Residence 2

7.4 Is it safe to shower / bath in tank water?

The exposure pathways included in the HRA included ingestion and dermal contact while bathing / showering with tank water.

For permanent residents, the HRA assumed that a resident showers/baths for 20 minutes every day of the year. The amount of tank water ingested during bathing was conservatively considered to be the same as that ingested during swimming (i.e. this swimming water ingestion is a standard risk assessment parameter). The rate of dermal penetration of the metals through the skin (dermal permeability coefficient of compound in water) was estimated using US EPA default values for metals. It is noted that these defaults are uncertain and chosen by the US EPA to be conservative estimates of dermal permeability.

The HRA found that the contribution of bathing water ingestion to the EDI of antimony, arsenic and lead is negligible.

At the concentrations of arsenic, antimony and lead present in tank water (low microgram per litre levels) evidence for allergic reactions was not identified in the scientific literature.

The estimates for dermal permeability and thus the contribution to daily exposure (EDI) would increase if large areas of skin were damaged, such as when there is a pre-existing skin conditions. However given the relatively short exposure time it is unlikely that the contribution of bathing to the EDI would increase significantly even under these circumstances.

Tank water can continue to be used for showering and bathing.

7.5 Is it safe to consume home-grown eggs and lamb?

As part of the ongoing works to assess antimony levels within the environs of Costerfield, egg and sheep samples were collected and submitted for laboratory analysis in October 2014.

Sheep sampling was coordinated and undertaken by the Department of Environment and Primary Industries (DEPI), and analysis of the samples of meat was completed by the National Measurement Institute (NMI). Egg samples were collected by Golder and analysis of egg samples was also completed by NMI.

For permanent residents it was assumed that a resident consumes home grown eggs or lamb every day of the year. The consumption rates are based on average and upper estimates of consumption based on Australian Bureau of Statistics surveys of Australian food consumption rates. The consumption rates vary based on age and are documented in Appendix E.

The contribution of home grown produce (egg and lamb) to the EDI of arsenic, antimony and lead is very low.

The analytical results for the eggs and lamb meat did not exceed Australian food standards for contaminant levels (where available).

Home grown eggs and lamb in Costerfield are not harmful to health.

7.6 Is it safe to play in the yard and work in the garden?

Direct ingestion of soil is not normally a significant source of chemical exposure for adults, although there can be some hand-to-mouth transfer from household dusts during food preparation.

Direct ingestion of soil and dusts by hand-to-mouth transfer can be a more significant exposure source in children (enHealth 2012 a, b).The reason for this is that children (particularly young children aged 1-7 years of age) can have intimate contact with soil during play.

Using average estimates of exposure, where a child plays outdoors on every day of the year, the HRA found that it is safe to play in the yard and work in the garden.

Using upper estimates of exposure (i.e. reasonable worst case exposure estimates) there is minimal to some concern for adverse health effects. Assuming tank water is not consumed, the contribution of lead in soil to the overall HI is approximately 90%.

In most cases it is safe to play in the yard and work in the garden. However in some unlikely exposure circumstances (children play or adults work at the point in the yard where the highest lead concentrations are present everyday) it is not safe to play in the yard and work in the garden. Mitigation measures are discussed in Section 9.0.

7.7 Is it safe to swim in a swimming pool?

Monitoring of swimming pool water located within the study area was undertaken approximately monthly from October 2014 until May 2015 (excluding November). The results of this are discussed in Appendix D3. The results suggest that there are potential risks to health if the pool is left uncovered, which allows dust deposition over a period of time. This risk can be managed though regular cleaning or covering the pool whilst not in use. If the pool is covered or cleaned regularly, risks of swimming are considered to be acceptable.

Swimming pools can be used safely, however they require regular cleaning and cover to avoid dust deposition and subsequent accumulation of antimony concentrations.

8.0 VARIABILITY IN HRA

The risk assessment process involves a number of steps (e.g. exposure assessment, toxicity assessment and risk characterisation), each of which incorporates the use of assumptions and simplifications to manage uncertainty or lack of knowledge about the correct value. Without such assumptions and simplifications it would not be possible to quantitatively evaluate the potential for health effects.

Although uncertainties in the risk assessment may influence its accuracy, the assumptions are used to manage uncertainties and err on the side of safety. Therefore there is a bias in the evaluation to over - estimate health risks.

In any risk assessment, the conservatism surrounding one parameter (such as metal concentrations in soil, or the amount of soil ingested) at least adds to the level of risk, and most times multiplies it. Conservatisms in other parameters leads to a cumulative or compound conservatism for the overall assessment which can be very large. This is especially so when gross, unrealistic default parameters are used in lieu of measured data.

The above issues are why in this HRA, a range of risk estimates are produced. These are intended to describe a range of assumptions in order to consider uncertainties.

To the extent possible, uncertainties and assumptions are described within the HRA. However Appendix H provides a more detailed look at some of the most important assumptions.

There are some uncertainties in individual parameters used to estimate exposure. In particular soil concentrations and human behaviour assumptions related to soil contact are variable. The HRA has been designed to take a conservative approach to these issues. As a consequence there is a high degree of confidence that risks have not been under-estimated in this HRA.

9.0 WHAT ARE THE NEXT STEPS?

Risk Management

The HRA provides considerable detail about the context of exposure to metals in Costerfield and the magnitude of potential risks. The results are intended to be reviewed by all stakeholders in the context of how exposure can be reduced. The process for considering measures to minimise exposure is called risk management.

The main elements of risk management, as outlined in AS/NZS 4360:2009, are:

- Communicate and consult, this is an ongoing process and is not a single event or outcome.
- Establish the context
- Identify risks
- Analyse risks
- Evaluate risks
- Treat risks
- Monitor and review

9.1 Risk Communication

The risk management process can be used to address some of the current issues at Costerfield. Many of these are identified within the RM Consulting Group (RMCG 2015) report. In particular issues around communication and establishing the context have been improved since May 2014.

In addition to the communication strategies and protocols that have been implemented since May 2014, the Victorian Government should produce and communicate advice to residents about ways of reducing exposure to metals in the environment. Many of these messages have been published in previous newsletters and factual communications. However these should be revisited in light of the detailed analysis presented in the HRA. The emphasis in such communications should be on ways to reduce exposure. Some of the messages/recommendations to consider include:

- Cleaning indoor areas regularly to reduce the collection of dust by mopping frequently with a damp cloth.
- Using gloves when gardening and wash hands thoroughly before eating.
- Washing locally grown vegetables clean of soil with water that meets Australian Drinking Water Guidelines before eating.
- Keeping toys clean of any soil or dust.
- Ensuring children clean their hands thoroughly after playing outside.
- Considering covering bare soil in play areas and garden beds with a layer of fresh soil or mulch where preschool-aged children may be present.

9.2 Dust management

Mining and processing project risks are generally identified and managed at all stages of an operation’s life cycle. Significant risks that are defined, communicated, understood and satisfactorily addressed early in the mine life cycle are more likely to be accepted as well managed by stakeholders who have an interest in the mining project. Materials stewardship provides a central framework for an integrated risk approach to responsible management of materials used in mining and mineral processing, particularly wastes, hazardous substances and products. The project risks should be reviewed on a regular basis.

In terms of air quality, elevated PM_{10} and PM_{10} antimony concentrations were reported on days when winds were blowing both from the direction of current mining activities, and not from the direction of the current mining activities suggesting that the source of PM_{10} and PM_{10} antimony in Costerfield are diverse. The levels of PM_{10} and antimony are within national standards and health based air guideline values respectively. Dust from current mining activities was found to contribute to dust and antimony levels in air on approximately a third of the days in the monitoring period.

The dust deposition model presented in Appendix D3 investigated each activity within the current mining operation that could contribute to dust emissions. It was found that truck movement was the largest factor for dust emissions.

Lead nitrate is currently used in mining operations and lead waste (at levels (approximately 200 mg/kg) less than health screening levels (300 mg/kg)) are stored in tailings dam.

Although a reactive dust management strategy is in place and improvements to dust management have been made, a continuous improvement culture should be encouraged to review dust and waste management practices on a regular basis with the aim of achieving dust and waste levels as low as reasonably practicable.

Dust management practices at the current mining operations and other activities (e.g. road grading, land disturbance activities in the area) should be reviewed and aim to achieve dust levels as low as reasonably practicable.

9.3 Use of Tank Water

Rainwater tanks attached to house roofs when used as the primary source of drinking water were found to be a significant contributor to exposure to antimony and also lead. Many tank water results were higher than the Australian Drinking Water Guidelines for antimony. A few results were higher than the Australian Drinking Water Guidelines for lead.

A program of cleaning the tanks and refilling these with drinking water from a reticulated water supply did reduce levels of antimony. However within 6 months the antimony levels were above the guideline levels.

As discussed in Appendix I even a small amount of dust, within compliance levels for dust deposition, is likely to contribute to antimony levels in rain water tanks attached to roofs. As a consequence:

- At present tank water should not be used as a source of drinking water in Costerfield. This includes use in preparing food for infants.
- A cost benefit analysis should be conducted to consider a range of alternative supply options as well as technologies that can be applied to tanks or taps to remove metals from the water.

9.4 Maintenance of Swimming Pools

The pool results for antimony reported concentrations less than the adopted primary contact recreation (swimming) guideline, with the exception of the initial round of sampling undertaken in October 2014. The pool was emptied, cleaned and refilled with potable water following the first round of sampling, resulting in the decreased antimony concentration in subsequent sampling. However, it is noted that the reported antimony concentrations appeared to be increasing each month from December to May.

As a consequence:

- Swimming pools should be cleaned on a regular basis
- Measures to avoid dust deposition should be considered (see Section 9.2).

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11.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled - “Important Information Relating to this Report”, which is included in Appendix J of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

Report Signature Page

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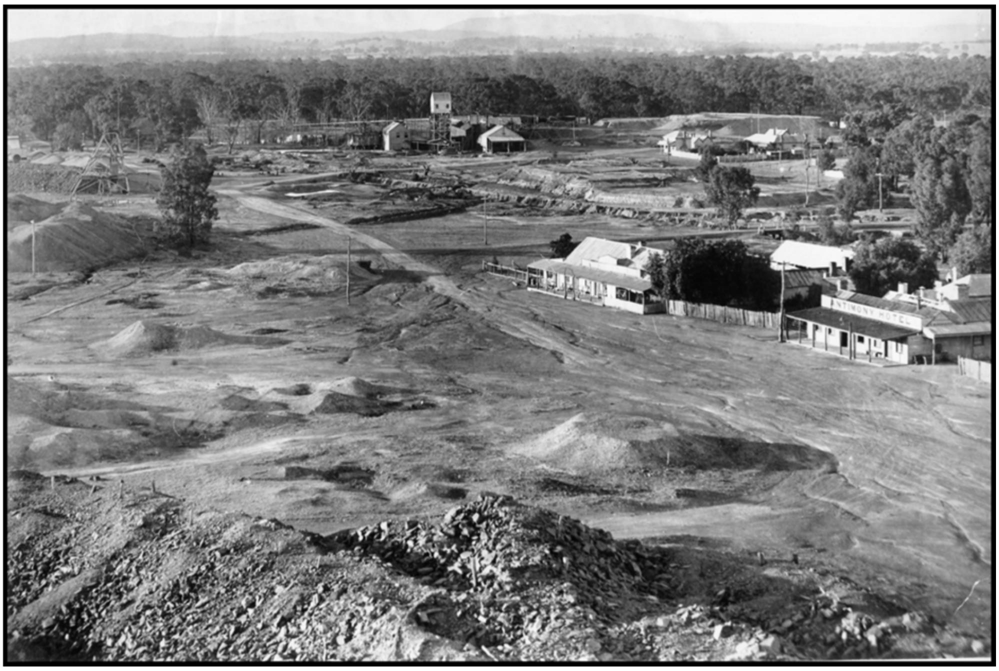
APPENDIX A

Desk Top Review - Antimony in the Costerfield Area

13 March 2015

DESKTOP REVIEW

Antimony in the Costerfield Area



Submitted to:
Victorian Government Reference Group
c/o Department of Economic Development, Jobs,
Transport and Resources
Level 9, 121 Exhibition Street,
Melbourne, 3000

REPORT

Report Number. 1413212-002-R-Rev0

EXECUTIVE SUMMARY

Background

Golder Associates Pty Ltd (Golder) was commissioned by the Government of Victoria Reference Group (GVRG), chaired by the Department of Economic Development, Jobs, Transport and Resources (DEDJTR), to prepare this desktop review of the nature, transport and distribution of antimony in the environment, for the Costerfield area. This desktop review has been prepared following the completion of a series of environmental assessments in the Costerfield area, which were commissioned in response to concerns raised by the Costerfield community in early 2014 about exposure to antimony related to the local mining operations.

This desktop review has been undertaken to support the development of a comprehensive health risk assessment for antimony and related chemicals of interest in the Costerfield area. Although focused on antimony, the scope of this desktop review considers other potential chemicals of interest that may be present with antimony in the Costerfield area, either due to geological, mining and/or other development activities.

This review was undertaken to answer the following questions:

- What are the sources of antimony in the Costerfield area?
- What is the distribution of antimony and related chemicals within the Costerfield area?
- How do antimony and related chemicals of interest behave in the environment?
- What further assessment or information is required to assess risks to human health, associated with exposure to antimony and related chemicals?

In order to address these questions, Golder reviewed information provided by Mandalay Resources and publically available data, maps and literature. The review considered:

- The environmental setting (including the geology and hydrogeology of Costerfield).
- Historical activities and associated potential sources of antimony and related chemicals.
- Potential pathways for movement of antimony and related chemicals.
- Identification of potential receiving environments.

Environmental Setting

The Costerfield area lies within a distinct geological unit, referred to as the Costerfield Dome (see Figure i), which contains zones of mineral enrichment (enriched with metals including gold, antimony and arsenic).

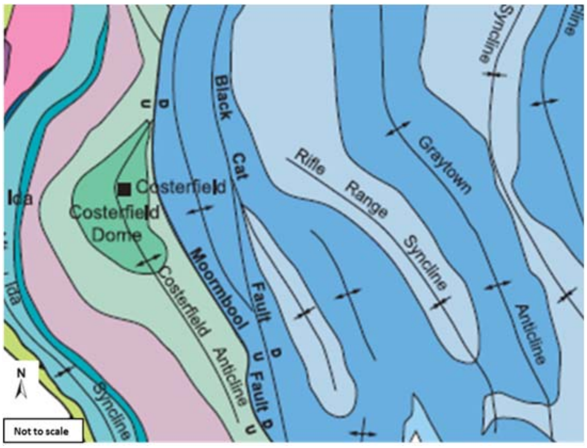


Figure i: Regional Geology, showing the Costerfield Dome

Mining activities have occurred extensively within the Costerfield area, predominantly along the Costerfield Anticline shown in Figure i). Halos of metal enrichment have been reported within rock immediately surrounding mineral ore deposits (Arne, 2009a). Metal enrichment halos typically extend up to 50 metres from the ore deposit, characterised by antimony concentrations up to 50 mg/kg. Other elements (gold, molybdenum, copper, manganese, and bismuth) are also reported to be naturally enriched within close proximity (typically within 10 metres) of ore deposits (Arne, 2008). However enrichment of these metals is less consistent than that of antimony.

Surface water features within the area include Tin Pot Gully and Wappentake Creek. The catchment area around Costerfield typical flows south, into Wappentake Creek which feeds into the Goulburn River.

Perched groundwater is present within near surface alluvial material, typically less than 4 metres below ground level and is likely connected to localised surface water features. Many manmade surface water features are present within the Costerfield area including evaporation ponds, water diversion channels and tailing dams.

The deeper groundwater aquifer in the Costerfield area is expected to be at approximately 20 metres below ground level, and flows in a northerly direction towards the Murray Darling Basin.

Groundwater flow direction is in a northerly direction, therefore it is expected that groundwater below operating mines (Cuffley Lode and Augusta Mine) is likely to flow towards the Costerfield Township.

Historical Activities in Costerfield

The rural town of Costerfield was developed during the gold rush, due to the presence of antimony and gold. The area around the town has been extensively mined since the 1860's. A timeline of historical activities in Costerfield is summarised in Figure ii).

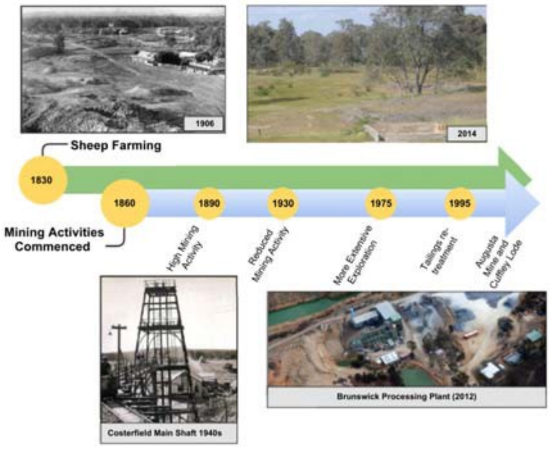


Figure ii: Timeline of historical activities in Costerfield

Current mining activities are present south of the township, at Augusta Mine and the Cuffley Lode. Current and former mining activities are presented in Figure iii.

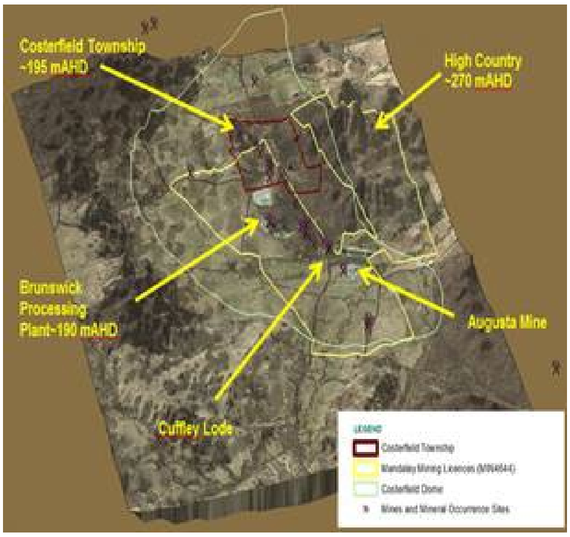


Figure iii: Historical and current mine locations within the Costerfield Dome

The natural soil profile within Costerfield has been disturbed by extensive mining activities and land clearing. These activities are likely to have resulted in:

- Addition of mine wastes to the soil surface.
- Excavation and re-distribution of surface soils and overburden.

- Increased weathering due to land clearing and changes in surface water movement.
- Physical and chemical changes to soil and rock properties during mine processes (including crushing).

Mine processing activities including crushing, milling, roasting, cyaniding and smelting have occurred at many of the historical mine sites within the Costerfield area, as presented in Figure iii.

Mine waste materials including tailings are distributed within the town and have been exposed to weathering over the past 150 years, as presented in Figure iv. Mine wastes vary in metal content and particle size (from waste rock/slum to fine grained tailings and particulates emitted from roasting of material). Weathering and dust generation is likely to be significantly greater from fine grained mine wastes (such as tailings) compared to coarse mine waste rocks.

Figure iv: Historical mine tailings within the Costerfield township

Concentrations of antimony in the surface soils of the Costerfield area are greater than those within the underlying alluvial soils and are greater than those expected concentrations within mineral halos (as defined within Arne and House, 2009a). This data suggests that antimony concentrations at the soil surface may be associated with redistribution of mine wastes including waste rock and tailings, sourced from the Costerfield).

Other chemicals of interest include manganese, copper, gold, bismuth, lead, mercury, zinc, chlorine, floatation agents, acids, alkalis and cyanide that may be present within mine wastes due to mineral ore extraction processes. Of these potential chemicals of interest, antimony and to a lesser extent arsenic are considered the priority chemicals of interest in relation to human health risk assessment (due to their likely widespread distribution and reported concentrations within the Costerfield soils).

Antimony Sources, Pathways and Receiving Environments

A review of distribution of antimony within the Costerfield environment suggests that mine wastes (rather than weathering of insitu minerals) are the key source of added antimony to surface soils in the Costerfield Area.

Insitu minerals (i.e. unmined stibnite and arsenopyrite) may also be a source of antimony to the environment, particularly to surface and groundwater.

Pathways for movement of antimony in the environment include direct movement via, trucking and hauling of ore and mine waste, and indirect secondary movement, via dust, run off, or infiltration into surface water or groundwater.

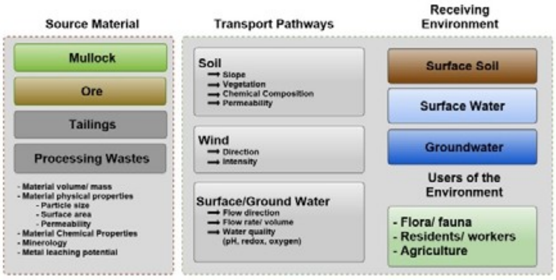


Figure v: Summary of antimony sources, pathways and receiving environments

Activities or processes which may increase the distribution of antimony include:

- Generation of dust (such as vehicles on unpaved roads, use of dirt bikes on tailing piles, crushing of mined material).
- Erosion of stockpiled materials (i.e. surface water run off).
- Surface water and groundwater extraction/relocation.

Areas and environmental features which may experience added antimony concentrations due to migration of metals from mine wastes and/or undisturbed mineralised materials include surrounding surface soils, surface water features and groundwater as well as users of the environment.

1. *What are the sources of antimony in the Costerfield area?*

The main source of antimony in the Costerfield area is mineralised zones of sulphide minerals such as stibnite and adjacent altered host rocks of the Costerfield Formation. Mining activities have resulted in the relocation (and in some cases) concentration of antimony in the Costerfield environment.

2. *What is the distribution of antimony and related chemicals within the Costerfield area?*

During historic mining activities, mine wastes have been distributed widely within the township and across the landscape. There may also be some local point sources of chemicals in the Costerfield environment primarily related with processing and/or extraction of antimony and gold. Early processing occurred around waterways leading to direct discharges without containment. Potential mining related chemicals include manganese, copper, gold, bismuth, lead, mercury, zinc, chlorine, floatation agents, acids, alkalis and cyanide.

3. *How do antimony and related chemicals of interest behave in the environment?*

The concentration and mobility of antimony and related chemicals within mine wastes can be influenced by mine processing, the particle sizes within the wastes, and the prevailing environmental conditions. The weathering of antimony containing minerals commonly results in the formation of metal oxides which have limited mobility within the environment except under highly oxidised conditions (oxygen rich). Therefore the physical size of antimony containing particles and land disturbance practices have a significant influence on its redistribution in the environment following the initial relocation of mine waste to the land surface.

Golder has not undertaken chemical assessment of groundwater or surface water within the Costerfield area, however, oxidation of mineralised rock, during dewatering activities, could potentially result in mobilisation of antimony into the environment.

4. *What further assessment or information is required to assess risks to human health, associated with exposure to antimony and related chemicals?*

Further soil assessment should be considered to understand the distribution of antimony and related chemicals within the Costerfield area, specifically where mine wastes are present at the surface. Golder is currently undertaking soil assessment at selected residential properties and road reserves.

To assist in understanding the potential risk of antimony and related chemicals to human health and the environment, the following further information is considered important:

- Arsenic and antimony leachability within different mine wastes (particularly tailings and dewatered mineralised zones).
- Arsenic and antimony impacts to groundwater and surface water. The EPA has been commissioned to review the water (surface and groundwater) management issues. The EPA findings will also inform the HRA.
- Arsenic and antimony bioaccessability and bioavailability (for humans, flora and fauna). The bioaccessibility and bioavailability of antimony and related chemicals are typically limited in the environmental media. Investigations will inform the HRA.

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APPENDICES

1.0 INTRODUCTION

Golder Associates Pty Ltd (Golder) was commissioned by the Government of Victoria Reference Group (GVRG), chaired by the Department of Economic Development, Jobs, Transport and Resources (DEDJTR), to prepare this desktop review of the nature, transport and distribution of antimony in the environment, for the Costerfield area, Victoria.

This desktop review has been undertaken as part of a series of staged environmental assessment works to support the development of a comprehensive human health risk assessment for antimony and related chemicals of interest in the Costerfield area. Although focussed on antimony, the scope of this desktop review considers other potential chemicals of interest that may also be present in the Costerfield area, either due to geological conditions, mining and/or other development activities.

This scope of work was prepared in consultation with Department of Health and Human Services, Environment Protection Authority (EPA) and DEDJTR. The scope of this desktop review evolved based on the evaluation of findings from a rapid environmental assessment, undertaken during June 2014, (Golder, 2014) and feedback from community consultations held since the delivery of the rapid assessment report, as discussed below.

1.1 Background

The rural town of Costerfield was developed during the gold rush, due to the presence of ore containing antimony and gold. The local area has been extensively mined since the 1860's. Current mining activities in the Costerfield area comprise underground ore extraction at Augusta Mine and Cuffley Lode, and ore processing at the Brunswick processing plant, south of the township. These mining activities are operated by Mandalay Resources Corporation (Mandalay Resources).

During early 2014 the Costerfield community raised concerns of exposure to antimony related to the local mining operations. In response to the concerns of the Costerfield community, Golder was engaged as an independent expert by a Reference Group of State Government Agencies to conduct an environmental monitoring program and a human health risk assessment.

In addition to the above works, and recognising the need to address immediate health concerns, a rapid assessment was conducted. The rapid assessment focussed on important sources for human exposure, including drinking water obtained from tanks, surface soils and ambient air particulates. Within a two week period from 2 June 2014 to 13 June 2014, sampling was undertaken at properties within 3 kilometres of the Brunswick Processing Plant and at one residential property at Heathcote (approximately 8 kilometres away).

The rapid assessment, titled "*Rapid Health Assessment and Preliminary Report on Monitoring Program Based Information and Data Available to 15 June 2014*" (Golder, 2014) concluded that, based on the limited sample results, immediate adverse health effects are not expected from exposure to antimony in the Costerfield area. However, further investigation is required to assess the significance and extent of antimony and related chemical levels in the Costerfield area.

In order to further assess risk to human health, a range of additional investigations are continuing. These investigations include monthly tank water sampling, stock sampling, air monitoring and this desktop review.

1.2 Objectives

The objective of this desktop review is to provide information to support the understanding of the nature, transport and distribution of antimony and related chemicals in the environment, in the Costerfield area.

This objective will be met by answering the following questions:

1) What are the sources of antimony in the Costerfield area?

2) What is the distribution of antimony and related chemicals within the Costerfield area?

3) How do antimony and related chemicals behave in the environment?

4) What further assessment or information is required to assess risks to human health, associated with exposure to antimony and related chemicals?

1.3 Scope of Desktop Review

In order to address these questions, Golder reviewed information provided by Mandalay Resources and publically available data, maps and literature. The scope of this review considered:

- The environmental setting (including the geology and hydrogeology of Costerfield).
- Historical activities and associated potential sources of antimony and related chemicals.
- Potential pathways for movement of antimony and related chemicals.
- Identification of potential receiving environments.

1.4 Information Sources

The following information sources have been reviewed:

- Publically available Mandalay Resource reports and economic assessment reports.
- Maps and soil data produced by the former Department of Primary Industries.
- Historical Victoria Geological Survey reports, books and maps.
- Publically available hydrogeological information.
- Historical newspaper articles, aerial photographs and photo records.

Reviewed documents used within this report are listed within Section 10.0 of this report.

2.0 ENVIRONMENTAL SETTING

2.1 Location and General Description

Costerfield is located in rural Victoria, approximately 100 km north-west of Melbourne and 50 km south-east of Bendigo (Figure 1). The largest township within close proximity of Costerfield is Heathcote. The population of the Heathcote District (including the Costerfield area), during 2011, was less than 4000 residents.

Land uses within the township of Costerfield comprise mining, agriculture, low density residential development, and limited commercial and recreational activities. Land south of the Costerfield Township (south of Cochranes Road) is currently part of the Puckapunyal Military Area.

Figure 1: Costerfield Location Plan

For the purposes of this desktop review, the study area includes the broader Costerfield area with particular focus on geological conditions and related mining activities. The Costerfield Township and the extent of the current mining licence (owned by Mandalay Resources) are presented in Figure 2.

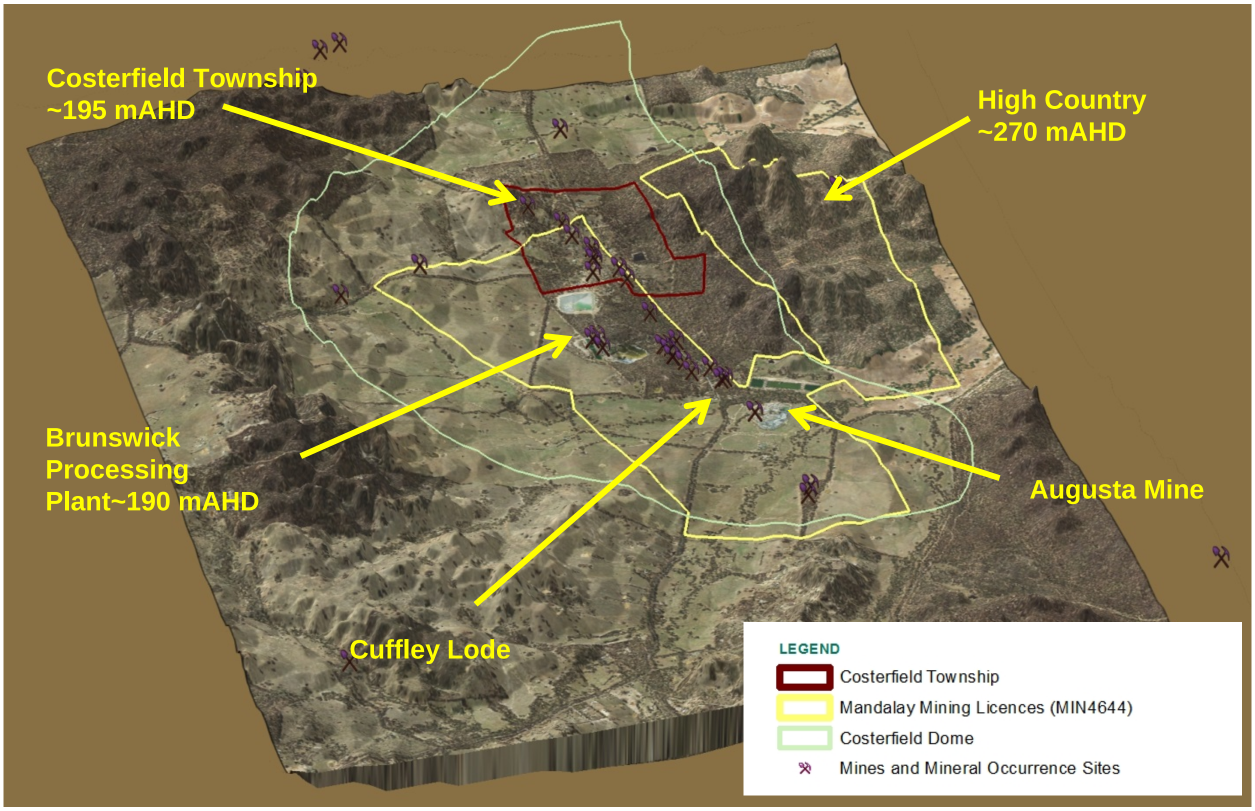


Figure 2: Topographical plan showing the Costerfield Township, current active mine sites and the extent of Mandalay Resources mining licence

The Costerfield Township is located within relatively flat to undulating terrain at an approximate elevation of 200-300 metres above sea level (Federation University, 2014). The township is bound by rugged hill country, undulating rises, gentle slopes and drainage depressions (Mandalay Resources, 2012). The low lying areas of Costerfield (north and east) act as a floodplain during periods of high rainfall (SRK Consulting, 2013). Open forest is present within the valleys and shrubby box gum is scattered across the stony gravelly hills (Mandalay Resources, 2012). Most of the undulating to flat areas of the region has been cleared for farming purposes (Mandalay Resources, 2012).

The Costerfield area has a Mediterranean climate with temperatures ranging from -2^{o}C in winter to +40^{o}C in summer (SRK Consulting, 2013). The area is typically dry with annual pan evaporation of 1300 mm to 14000 mm, exceeding the average annual rainfall of 500 mm (SRK Consulting, 2013). Prevailing winds within the Costerfield area are generally from the south-south east direction, except in winter when they are more from the north east direction.

2.2 Geological Setting

Metals such as antimony are naturally present within the environment. The concentration of metals naturally present in the environment is highly variable and is influenced by many factors including the underlying geology from which the soil has formed and the extent of weathering.

Human activities, including industrialisation, mining, agricultural and domestic activities has resulted in the re-distribution of metals within the environment.

The following sections describe the geology and soil condition of the Costerfield area, including how and where antimony is naturally enriched (i.e. present at a higher concentration than average) in the Costerfield environment and a summary of the expected concentration of antimony and related chemicals within different geological materials.

2.2.1 Geology and Antimony Mineralisation

Costerfield is located within the western portion of the 'Melbourne Structural Zone' (SRK Consulting, 2013). The Melbourne Structural Zone encompasses a large portion of central and eastern Victoria and consists of a thick sequence of marine sedimentary rocks.

The Melbourne Zone has been deformed into a series of folds, including the Mount Ida Syncline; the Costerfield Dome/anticline; the Black Cat and the Graytown anticlines; and the Rifle Range Syncline. The folds have been deformed and truncated by movement along faults.

The Costerfield Township is located within the Costerfield Dome anticline, which is truncated in the east by the Moormbool Fault, resulting in an asymmetric dome like structure (Figure 3). The eroded peak of the Costerfield Dome (comprising Costerfield Siltstone) is exposed approximately 1 km west of the Costerfield Township.

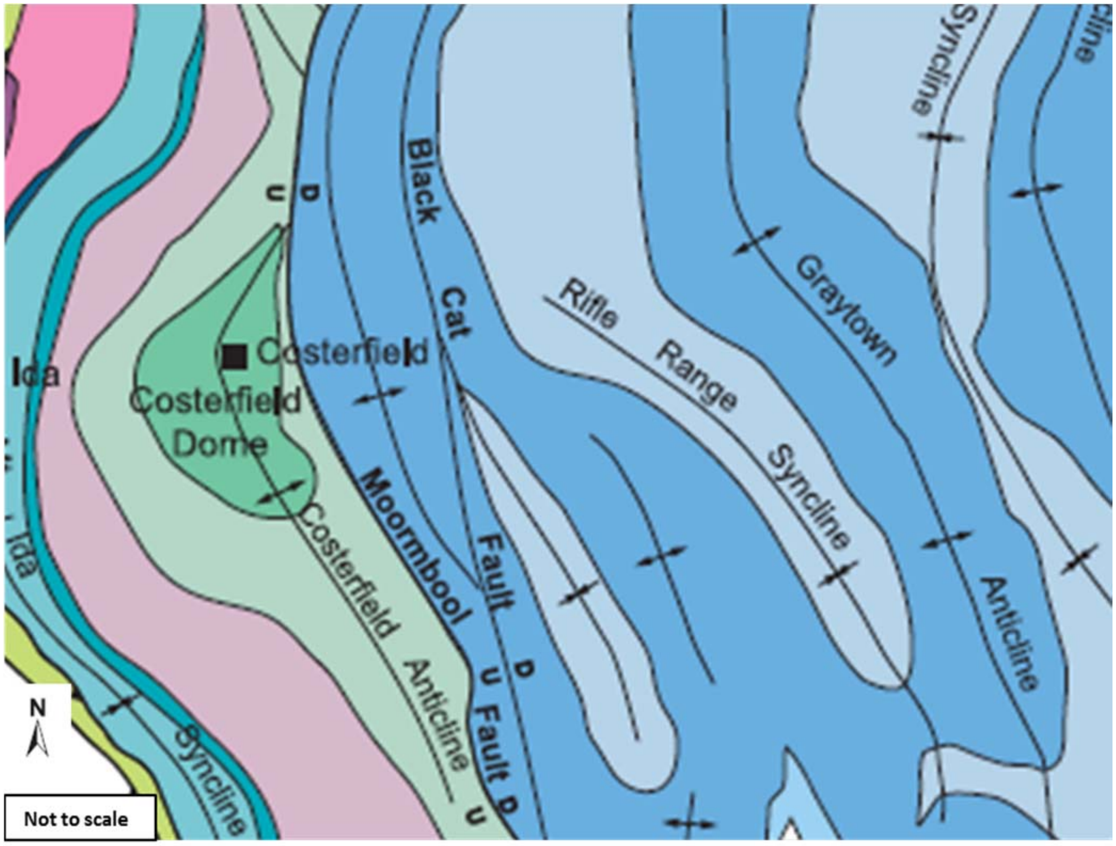


Figure 3: Regional Geology, showing Costerfield Dome

(extracted from SRK Consulting 2013 and created by Vandenberg et. al 2000)

The Costerfield Dome is part of a broad gold-antimony province. Mineralisation in the area is thought to have occurred approximately 380 to 370 million years ago, during subduction of a region of crust (referred to as the 'Selwyn Block') under the mafic volcanic region of the Bendigo Zone. During the subduction event deposits rich in stibnite, and gold, were intruded along steeply dipping cracks east of the crest of the Costerfield Dome.

Five zones of significant mineralisation have been identified within the Costerfield area comprising the following:

- The Costerfield Zone, located within close proximity to the axial region of the Costerfield Dome including the Costerfield Township and dome peak. This zone hosts the major ore deposits.
- The Western Zone, about 1.5 km west of Costerfield, on the western boundary of the Costerfield Zone.
- The Antimony Creek Zone, located approximately 6.5 km south-west of Costerfield, on the outer west boundary of the Costerfield Dome.
- The Robinsons-Browns Zone, 2 km east of Costerfield.
- The North Western Zone, approximately 2- 3 km, north-west of the Costerfield Main mine, comprising Damper mine and Shellback Gully.

These zones of mineralisation have been mined for ore containing gold and antimony. The historic mines located within each of the five identified areas of mineralisation are presented in Figure 4.

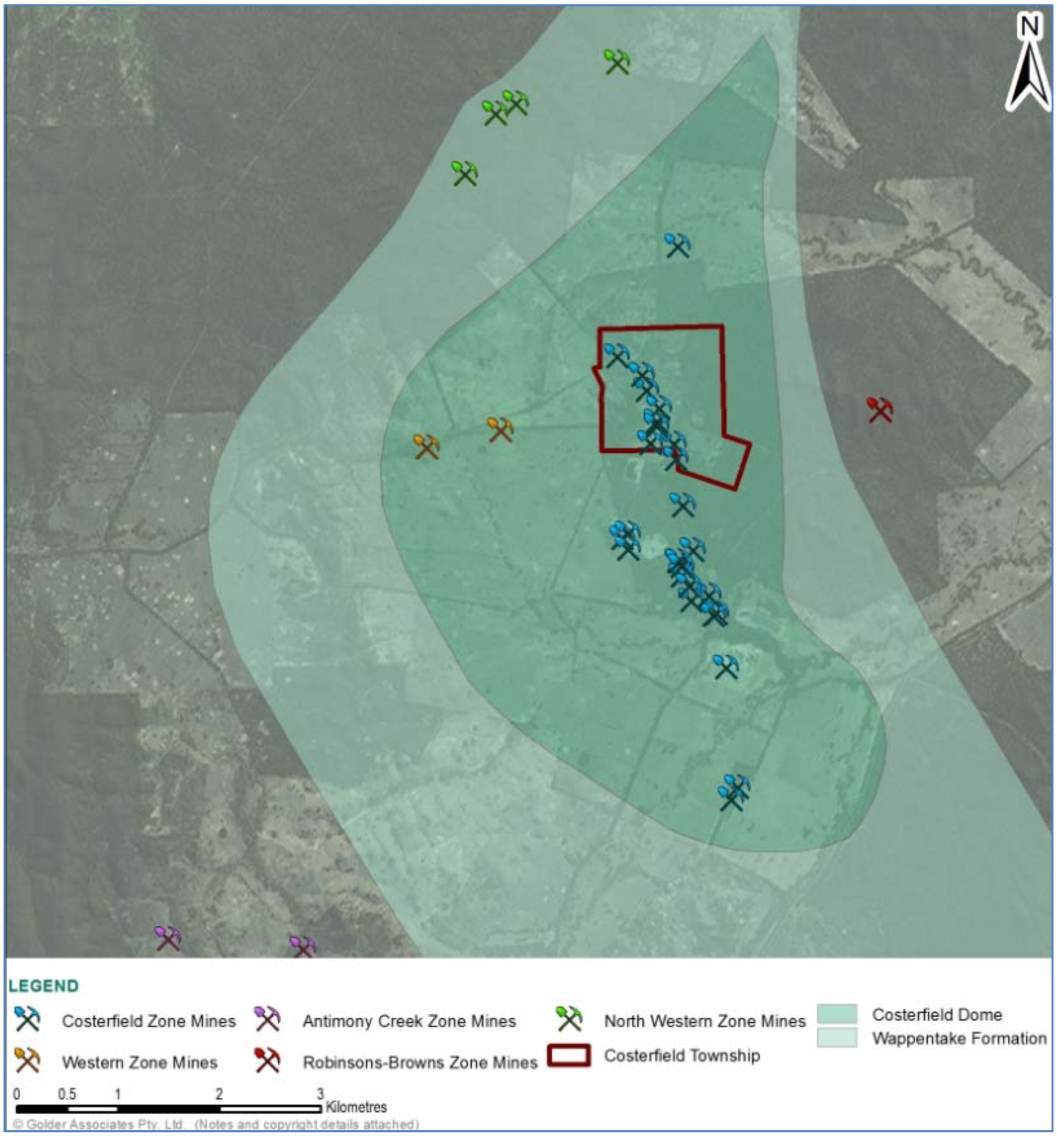
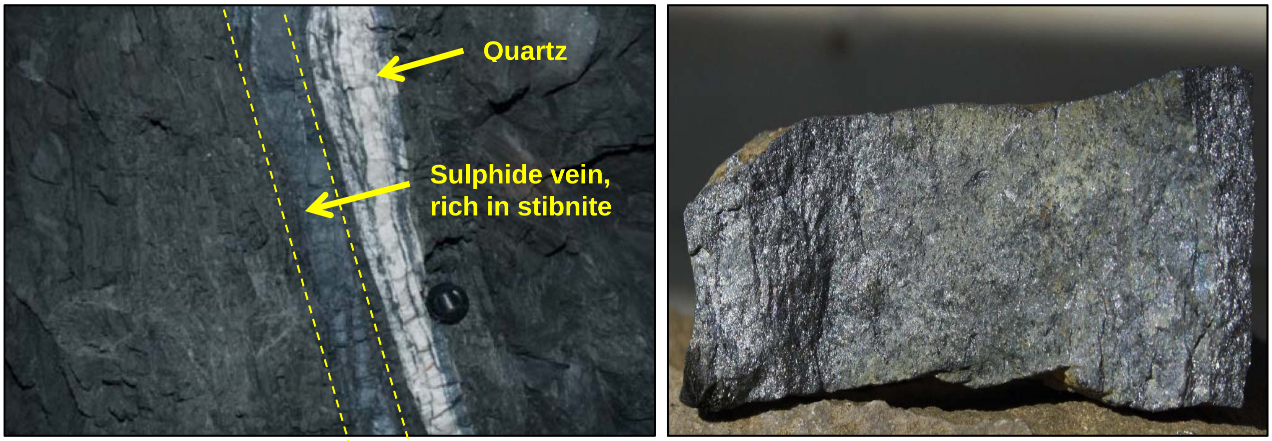


Figure 4: Five primary zones of mineralisation, as indicated by the presence of historic mines

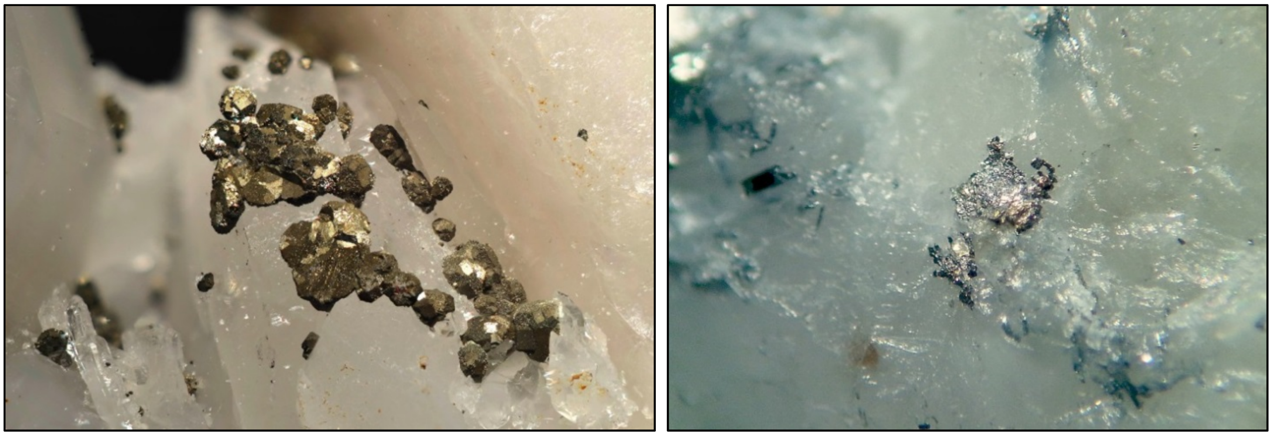
2.2.2 The Ore

Mineralised zones within the Costerfield Formation typically consist of quartz veins and adjacent altered host rocks, which contain sulphide minerals. The principal sulphide minerals present are stibnite (Sb_2S_3), pyrite (FeS_2) and arsenopyrite (FeAsS). There are also minor occurrences of chalcopyrite ($CuFeS_2$), sphalerite (Zn,Fe)S), gelana (PbS) and aurostibite ($AuSb_2$), (Mandalay Resources, 2012). Examples of mineral deposits in the Costerfield area are presented in Figure 5.



(a) Stibnite mineralisation, adjacent to quartz vein, at Costerfield. The lens cap is 67 mm in diameter

(b) *Massive, fine grained, stibnite from Alison's mine, Costerfield*



(c) *Small pyrite crystals, from Augusta mine*

(d) Aurostibnite (from Cuffley Lode)

Figure 5: Examples of mineral deposits in the Costerfield area [1]

The stibnite deposits in Costerfield are dissimilar to gold deposits found within the central Victorian Gold Mining Region, they formed at a different time under different geological conditions.

Costerfield has the largest known concentration of stibnite ore in Victoria (Phillips et al., 1996). The two next largest known concentrations of stibnite occur at Ringwood and Coimadai (Phillips et al., 1996). Low quantities of stibnite have also been found at other gold mining locations within the Melbourne zone, including Nagambie, Clonbinane and Whroo (Phillips et al., 1996), however antimony deposits at other mines within Victoria are not comparable to the quantity extracted at Costerfield.

2.2.3 Mineral Enrichment Halos

Stibnite mineralisation within Costerfield is thought to have occurred by the intrusion and solidification of low temperature deep igneous fluids, along existing faults in a host rock. The igneous intrusions typically contain a range of minerals and base metals such as antimony and gold.

Halos of metal enrichment (i.e. elevated metal concentrations) have been reported within rock immediately surrounding mineral ore deposits (Arne and House 2009). The findings of a geochemical

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[1] Images (a) sourced from SRK Consulting (2013).Images (b), (c), (d) sourced from www.mindat.org.com

study, of sub-surface soils (collected from the C-horizon) at Augusta and Brunswick Mine in Costerfield, reported dispersion halos of metal enrichment, around mineral deposits. The results of this geochemical study (undertaken by Department of Primary Industries, and reported by Arne et. al., (2008) and Arne and House (2009)) are summarised below:

- Metal enrichment halos typically extend up to 50 metres from the ore deposit, characterised by antimony concentrations up to 50 mg/kg.
- Low levels of antimony enrichment were reported greater than 140 metres from ore deposits.
- Other elements (gold, molybdenum, copper, manganese, and bismuth) were also reported enriched within close proximity (typically within 10 metres) of ore deposits; however enrichment of these metals was less consistent than that of arsenic and antimony.
- The assessment indicated that mercury concentrations may also be elevated above background concentrations within enrichment halos in Costerfield, however data supporting this was limited and mercury concentrations were commonly below or very close to laboratory detection limits.
- Sulphur, carbon and calcium are also associated with metal enrichment halos.

A summary of the reported metal concentrations within ore, mineral enrichment halos and soils, in the Costerfield area are presented in Table 1. The soil data is further described in Section 2.3.

Table 1: Metal concentrations within Costerfield Ore, Enrichment Halos and Background in mg/kg

Element	Mineral Ore mg/kg[1]	Concentration within enrichment halo in mg/kg[2] (enrichment halo extent in m)	Costerfield exploration lower threshold concentration mg/kg[2)]	Average Concentration within the earth crust mg/kg[3]
Antimony	2400-100,000	50 (45)	5	0.15-1
Arsenic	132-954	150 (5)	20	1.7-5
Gold[4]	1.55-19.9	0.135 (5)	< 0.005	0.001-0.005
Copper	28-41	40 (70)	-	14-100
Manganese	392-795	800 (25)	-	155-1549
Bismuth	1.9-5.9	0.7 (10)	<0.7	0.0029-0.2
Molybdenum	<1	0.5 (10)	-	1-15
Mercury	< 2	-	-	0.03-0.5

Notes:
1. Mineral ore data provided to Golder by Mandalay resources, August 2014, data presented within Appendix B.
2. Samples predominantly collected in the C horizon, data reported within Arne and House 2008 and Arne and House 2009. Data reported as the lower threshold concentration used to identify the presence of enrichment halo's. Lower threshold concentrations not reported for all metals.
3. Estimates of expected crustal abundance of metals (Smith and Huyck, 1999).
4. Results for gold presented in g/tonne.

Concentrations of antimony, arsenic, gold and bismuth, within mineralisation halos around ore deposits in the Costerfield area, are significantly elevated compared to average concentrations of these metals within the earth's crust.

Based on the lower concentration threshold, which is used during exploration to distinguish mineral enrichment halos from background conditions, background concentrations of antimony within soils outside of mineralisation halos are typically less than 5 mg/kg.

2.3 Soil

2.3.1 Soil Profile

Surface soils in the Costerfield area comprise of mine wastes (material which has been disturbed during mining activities) and natural soils (i.e. soils, which have not been significantly excavated, moved or contaminated by human activities). Examples of the soil types are shown in Figure 6.

a) Shallow Weathered Costerfield Soils (Siltstone)

(b) Disturbed Costerfield Siltstone – mine waste

Figure 6: Examples of Surface soils in the Costerfield area

Undisturbed, near surface soils in the Costerfield Township typically comprise Quaternary sediments and alluvial and colluvial soils eroded from the Silurian siltstones and sandstones of the Wappentake Formation, Dargile Formation, McIvor Sandstone and Costerfield Formation. The thickness of the alluvial and colluvial soils ranges from shallow deposits at the peak of the Costerfield Dome, to 6 m thick, near the Augusta Mine site (SRK Consulting, 2013). The alluvial and colluvial soils overlie the Costerfield Formation. The Costerfield Formation comprises siltstones of greater than 600 m thick.

Much of the natural soil profile within the Costerfield area has been modified by the following:

- Increased weathering due to land clearing and changes in surface water movement.
- Excavation of sub-surface soils and re-distribution at the surface.
- Mine processes (including crushing) leading to physical and chemical changes to soil and rock properties.
- Addition of mine wastes to the soil surface.

The Department of Environment and Primary Industries (DEPI), which is now part of DEDJTR has compiled soil, sediment and rock data collected within the Costerfield area and surrounds, for the purpose of mineral exploration (Arne and House, 2009).

In order to understand the distribution and concentration of antimony in the Costerfield area, Golder has extracted the DEPI data, collected within the Costerfield Dome area[2], and separated the data into the following inferred soil units:

- *Shallow soils (0-30 cm)* - comprising both disturbed and natural soils.
- *Inferred alluvial soils (30 cm to 6 m)* - likely to comprise predominantly of alluvial soils of the Wappentake Formation, but may include disturbed soils/fill within the near surface and weathered soils of the Costerfield Formation.
- *Bedrock (soils greater than 6 m below ground level)* - inferred to be Costerfield siltstones.

Of the potentially enriched metals (listed in Table 1) antimony and arsenic were the only metals which had adequate depth data to undertake statistical assessment.

A summary of DEPI data for soil and bedrock samples collected from within the Costerfield Dome area is presented in Appendix B. A statistical summary of the data is presented in Table 2.

Table 2: Summary of DEPI soil and Bedrock data within the Costerfield Dome

Metal	Depth (m bgl)	Sample Count	Minimum (mg/Kg)	Maximum (mg/Kg)	Mean (mg/Kg)*	95% Upper Confidence Limit (mg/Kg)*
Antimony	0-0.3	4375	2	710,000	46.5	47.6
	0.3 to 6	272	2	10,000	9.4	10.5
	> 6	50	4	950	27.7	29.1
Arsenic	0-0.3	298	2	200	11.4	12.5
	0.3 to 6	272	2	999	10.2	11.3
	> 6	50	2	251	10.4	11.9

* NOTE: The original datasets are skewed to the right, so the mean and confidence intervals were calculated on natural log-transformed data, and then transformed back to the original scale by inversing the log summary statistics.

The surface soils in the Costerfield area contain concentrations of antimony greater than the concentration within the underlying alluvial soils and greater than the expected concentration within mineral enrichment halos (as defined within Arne and House, 2009). This suggests that antimony has been added to the soil surface and is unlikely (at least in some areas) a result of natural soil enrichment associated with mineralisation.

The mean arsenic concentrations in the surface soils are comparable to concentrations within the underlying alluvial soils (0.3-6 m) and consistent with expected levels associated within mineral halos (as defined within Arne and House, 2009).

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[2] The area was defined based on the geological boundary of the Costerfield Dome presented as shown in Figure 4.

2.3.2 Metal Enrichment Patterns in Soil

Assessments undertaken by DEPI report that arsenic concentrations in Costerfield soils positively correlate with elevated antimony soil concentrations (i.e. where antimony concentrations are high, arsenic concentrations are also likely to be elevated) (Arne, 2009).

Where strong geochemical correlations are present, these relationships can be used to distinguish whether the soil has been disturbed or not (i.e. distinguish natural insitu material of the Costerfield Formation from mine waste soils). For example; natural undisturbed soils may have a different ratio of antimony to arsenic compared to material that has been subjected to antimony extraction, via mine processes. This theory of using geochemical indices to distinguish background metal concentrations from human inputs of contamination has been adopted within Australian legislation (NEPC, 2013).

Golder has assessed correlations between antimony and other soil parameters within the DEPI data set. The assessment results indicate that:

- Antimony concentrations in soil moderately correlate with arsenic concentrations.
- Arsenic concentrations in soil positively correlate with iron concentrations.
- Antimony concentrations in soil were poorly positively correlated with iron concentrations.

These observed correlations provide an indication of potential relationships which may assist in understanding the origin of the material (i.e. whether it has undergone mineral extraction processes). However due to high variation in the dataset, the current information does not provide a conclusive means for distinguishing soils of natural mineral enrichment from mine waste.

Other indicators, such as particle size and the presence of processing chemicals may also be used as indicators mine processing.

2.4 Hydrogeological Setting

2.4.1 General

The Costerfield township is located in the western extent of the Goulburn Broken Catchment Region, which extends from Heathcote to Mt Buller in an East West direction and from Marysville to the Murray River in a north south direction.

The local groundwater systems consist of two aquifers; the near surface perched alluvial aquifer and the deeper regional aquifer, within the Costerfield Formation.

The near surface perched alluvial aquifer is fed by soaks and surface water systems and is laterally discontinuous. It occurs sporadically within the near surface alluvial silts, sands and gravels of the Wappentake Formation. The depth of groundwater within the perched alluvial aquifer is typically less than 4 m below the ground level (SRK Consulting, 2013). The perched alluvial aquifer is likely to connect surface water features, on a local scale, but is unlikely to be connected to the deeper regional aquifer (SRK Consulting, 2013).

The deeper regional aquifer is present within the Costerfield Siltstones. The depth of groundwater within the deeper regional aquifer is typically greater than 20 metres from the natural surface (SRK Consulting, 2013). Groundwater is predominantly transmitted through fracture systems and faults and as such is highly variable in yield and quality.

Regional groundwater typically flows in a northerly direction eventually flowing into the deep lead system and the Murray Darling System (SRK Consulting, 2013). Piezometer results support the northerly groundwater flow direction (SRK Consulting, 2013).

The fault structures in the Costerfield Formation strike north. Groundwater drawdown, associated with mine works has a strong north south orientation, likely associated with the strike direction (SRK Consulting, 2013).

The total dissolved solids (TDS) content of groundwater in the area of the site is expected to be in the range of 3,501 – 13,000 mg/L, indicating moderately saline conditions.

A review of groundwater bores undertaken using the Visualising Victoria's Groundwater database indicated that 46 registered groundwater bores are within 5 km of the township. The location of these bores is shown in Figure 7 below. Bores were listed for the following purposes:

- 17 registered as non-groundwater bores.
- 14 registered for investigation or observation.
- 4 domestic bores, three located north of the township and 1 located south of the township.
- 1 registered for irrigation, located between the Augusta Mine (where groundwater is being actively dewatered for mining purposes) and Brunswick mine. Construction details indicate that the bore is 75 m deep and therefore screened within the deeper regional aquifer.
- 3 registered for industrial use at or near the current mining operation.
- 7 for unknown use.

Data collected by Visualizing Victoria indicates that yield rates from stock bores (at depths of 30 to 50 meters) within the Costerfield area varies from approximately 0.25 to 2.7 litres per second, with greater yields within areas of high sand content.

It is noted that groundwater and surface water extraction may occur at additional locations, during unlicensed water extraction processes. During Golder's discussions with property owners in the area in late 2014, it was indicated that residents typically do not extract groundwater for drinking or recreational use.

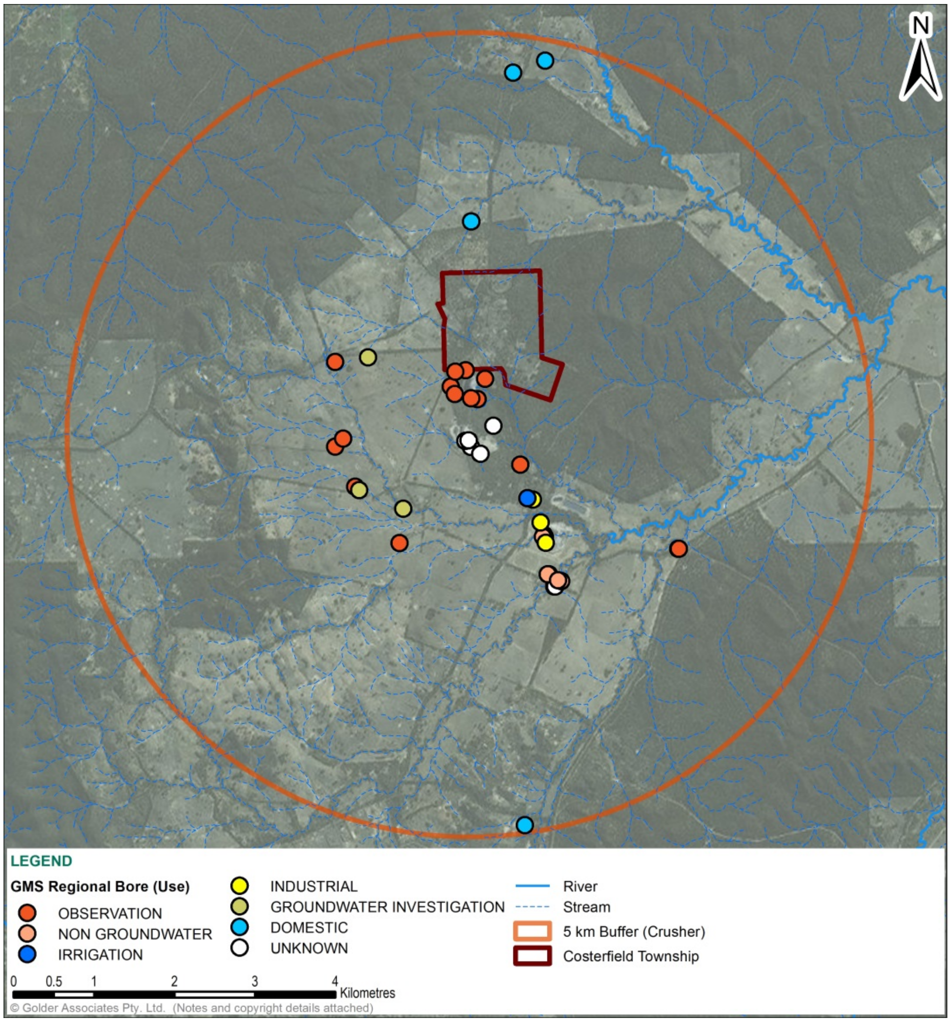

Figure 7: Groundwater Bores within the Costerfield area

2.4.2 Dewatering

Dewatering works at the Augusta Mine have created a cone of depression in the regional water table in the vicinity of the mine workings at approximately 100 m from the surface at its lowest point (Figure 8).

Current and historical mine processes including dewatering, water storage and discharge of treated water to surface water is likely to have had a significant influence on local hydrogeology.

In addition, dewatering, during mining activities, has the potential to cause oxidation of the bedrock. Oxidation of rock, high in sulphides, may cause chemical changes, which result in increased metal mobility (i.e. movement in the environment).

Current water management practices at the Augusta mine are discussed in Section 3.5.

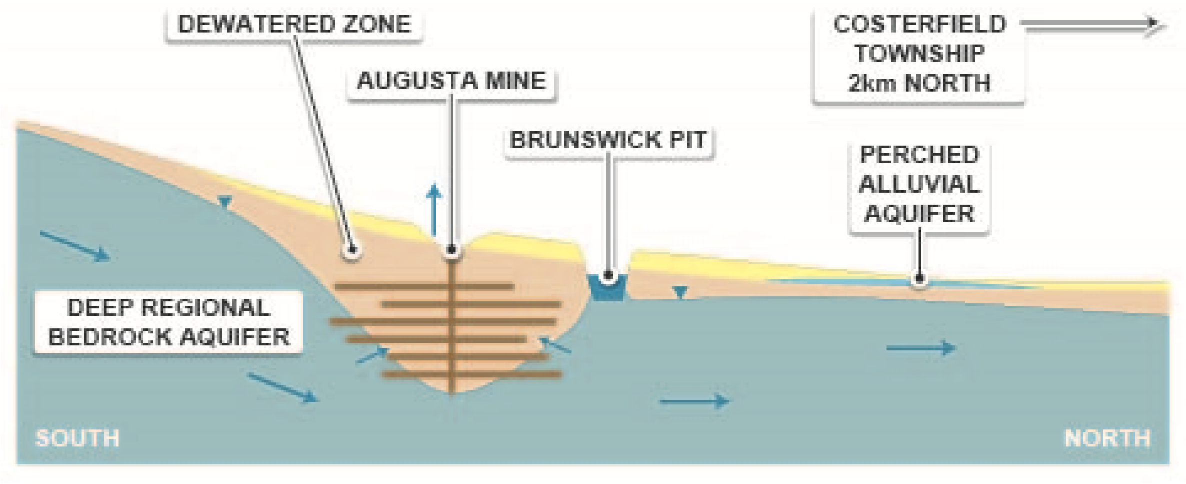

Figure 8: Conceptual groundwater flow, showing influence of dewatering at Augusta Mine

Figure adapted from SRK Consulting (2013).

2.5 Surface Water

The Costerfield area is interlaced with a network of shallow water ways and tributaries that feed into the Wappentake Creek system, which runs in a north easterly direction, south of the Costerfield Township and culminating in the Goulburn River.

Tin Pot Gully is a minor creek bed running roughly parallel to the Heathcote-Nagambie Road in a southerly direction, through the Costerfield township. Tin Pot Gully Creek flows into Wappentake Creek approximately 500 m south-east of the present day Augusta Mine site.

Multiple alluvial streams were explored in the early days of mining in the area along the Tin Pot Gully Creek and surrounds, resulting in significant disturbance of local waterways. In addition, it is likely that during historic mining activities, mine wastes, such as tailings, would have been released to surface water features with little or no pre-treatment.

3.0 HISTORY OF THE COSTERFIELD AREA

The following sections describe historical activities which have occurred in the Costerfield area, which may have resulted in contamination of the environment, particularly relating to disturbance of soil/rock and the movement of soil and mine wastes. These activities have included mining, agriculture and residential development.

The history of Costerfield is summarised on the timeline presented in Figure 9.

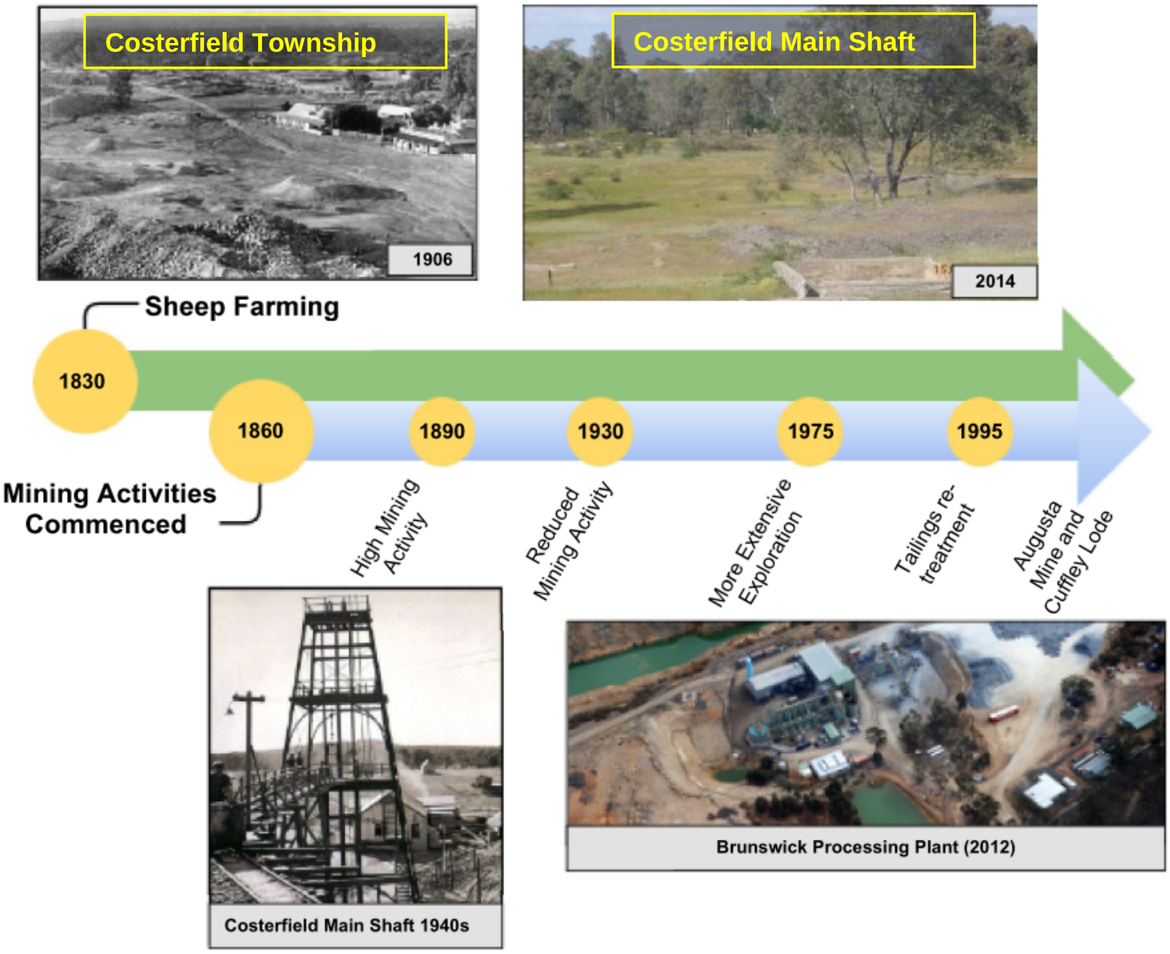

Figure 9: Timeline of historical activities in Costerfield

3.1 Settlement of Costerfield

A review of documents regarding settlement of Costerfield and historical activities within the area indicates the following:

- Prior to the 1840's low intensity farming occurred in the greater Costerfield region. Most of the land around Costerfield was licenced to a single farmer as part of the Campaspe Plains Sheep run, extending 45,000 acres (Context Pty Ltd, 2009). During the 1840's Campaspe Plains was subdivided into a series of smaller runs (Context Pty Ltd, 2009).
- The town of Costerfield was developed in the 1860's entirely based on the presence of mining activities (with the name of the town derived from Coster and Field, who first claimed the presence of stibnite and gold within the area).
- The population of Costerfield has been through periods of boom and bust associated with the mine activities, however even during high mining production periods, the population of miners within Costerfield was small (120 men were employed at the Costerfield mines during 1863) compared to the thousands of prospectors present in Heathcote and other gold mining centres, such as Bendigo

and Castlemaine (Whitelaw, 1926 and Bannear, 1998). The population of Costerfield and commercial development has decreased since the peak mining period in the early 20th Century.

- Residential and commercial infrastructure within the town has been limited, with the predominant buildings in the centre of the town comprising the "Antimony Hotel" (Figure 10), the town hall and the post office (built in 1863) (Context Pty Ltd, 2009). Historical maps of the town (as shown in Figure 19) show that a sports reserve, tennis courts, two churches, a state school, a potter and a piggery were present within Costerfield in 1926.
- The school in Costerfield was constructed in the 1870's and opened in 1875. Ten students were reported to attend the school in 1894 (The McIvor Times, Dec 1894). The school grew in the 1910-1920's with additional class rooms developed. However, as mining activities diminished following the 1940's and the town population decreased, the original school building was removed in 1963 (Context Pty Ltd, 2009).
- Residential development has remained low, with few new buildings present within the area post the 1970's.

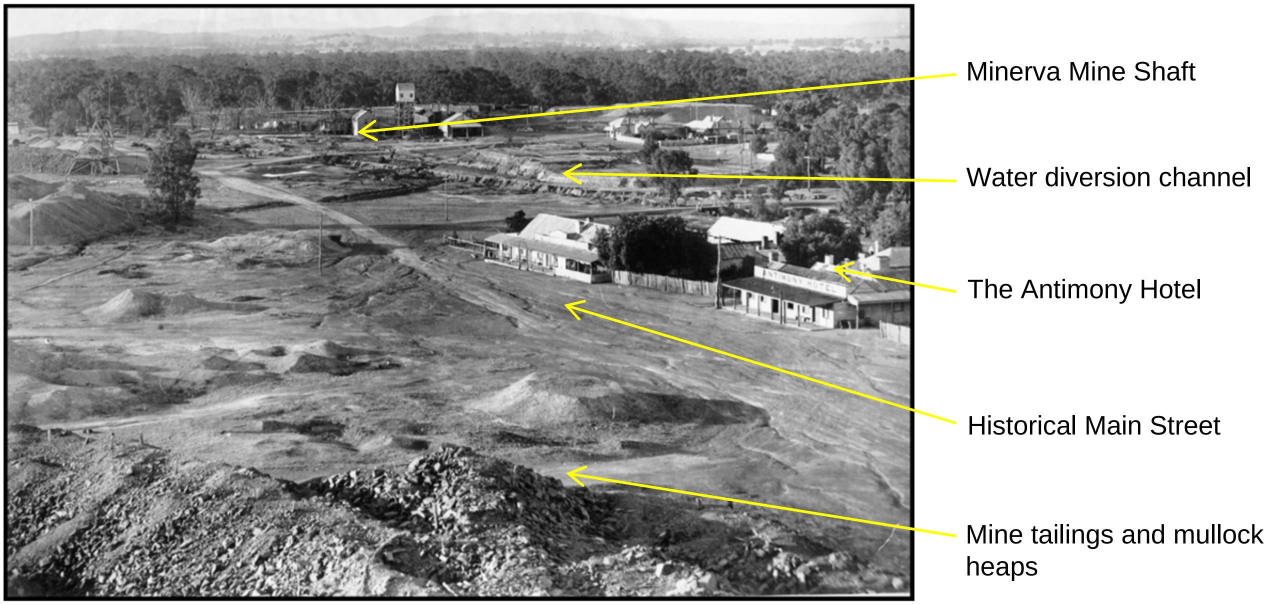

Figure 10: Costerfield Township, 1906[3]

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[3] Photo published by Anne Bradley, Pioneers of Costerfield 2009, looking South towards the Minerva Mine. Large stockpiles of tailings shown within the town centre. Photo taken from the Costerfield Main Mine.

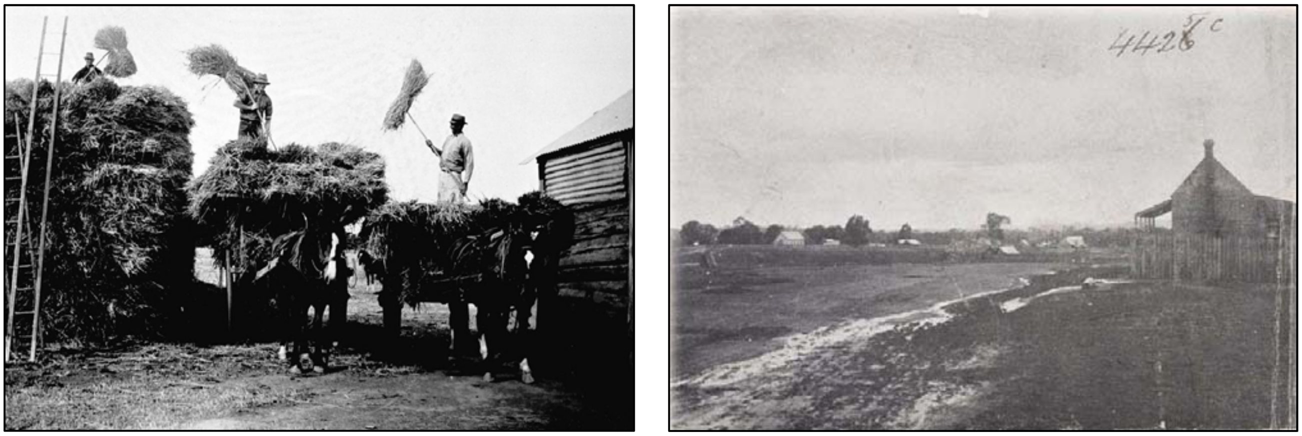

Figure 11: (a) Men creating hay bales in Costerfield, 1930[4]; (b) Residential development within the Costerfield Township (photo likely taken between 1900s and 1940s)

3.2 Regional Mining Activities

Mining within the regional area of Costerfield-Heathcote commenced in the 1850's. The discovery of alluvial gold near Heathcote attracted over 16,000 prospectors and miners to the town by 1852.

Gold mining activities initially commenced using pans, puddling machines, and sluicing (Figure 12). Mining activities in Heathcote were predominately for extraction of gold.

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[4] Photo sourced from Museum of Victoria

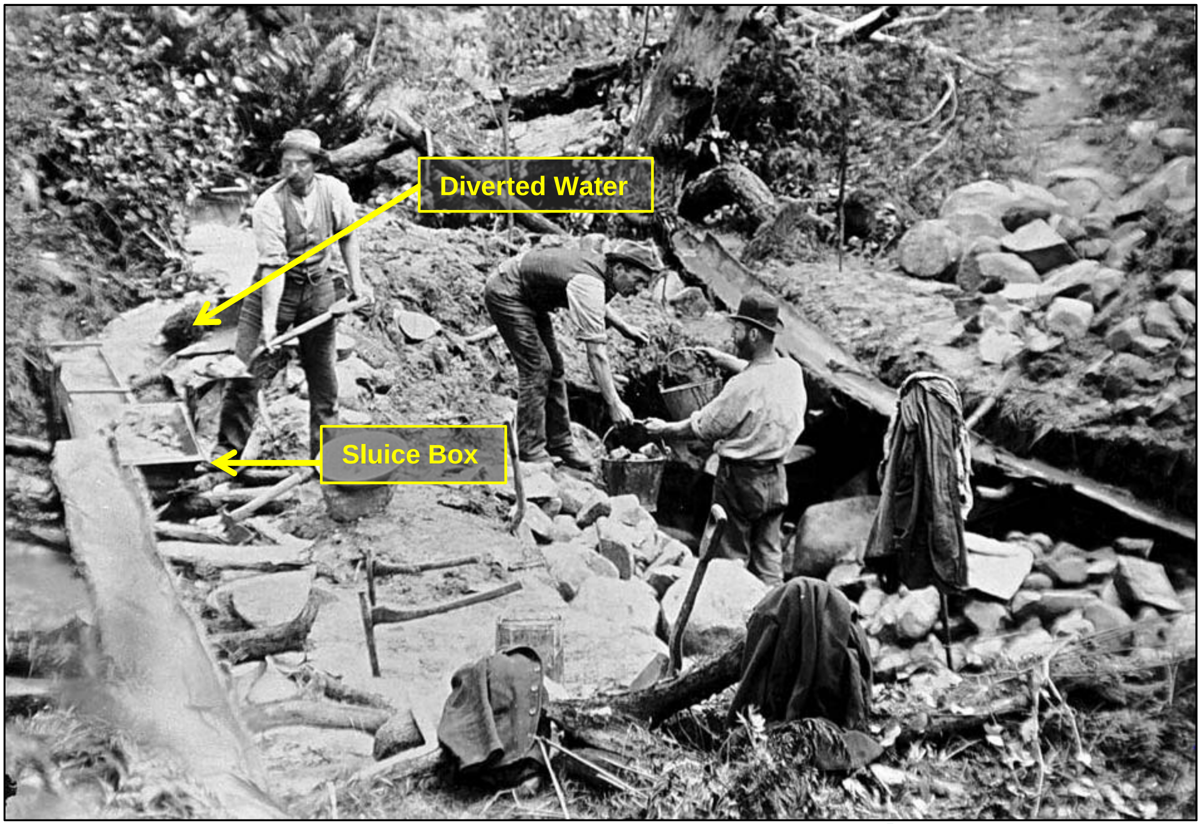

Figure 12: Example of miners sluicing for Gold at Tarnagulla, Central Victoria, 1880[5]

Sluicing methods typically comprised diversion of water through a sluice box, to separate heavy materials from fines. As such, historical mining activities resulted in excavation of multiple water channels, diversion of creeks and stockpiling/relocation of sluiced material.

3.2.1 Mining in Costerfield

Mineral ore deposits were first officially reported in the Costerfield area in 1860 (Whitelaw 1926) when a shepherd informed prospectors (Youle, Coster and Field) of a white surface outcrop projecting 4 feet out of the ground. The outcrop comprised an oxidised heavy lead-grey mass of stibnite (antimony sulphide), inside which gold was visible (Whitelaw, 1926). The outcrop was located at what is now known as the Costerfield Main Reef.

The discovery of the stibnite outcrop in the 1860's fuelled extensive exploration and mining of both gold and antimony within Costerfield, uncovering multiple ore enriched quartz veins.

Over 20 mine and shaft sites have been identified within the Costerfield area, many of which are located adjacent to the Costerfield anticline.

Historic mining occurred by both open cut and underground mining and was most productive during two periods, 1860 to 1883 and 1904 to 1925, with only intermittent small scale production during 1934 to 1950.

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[5] , photo Reg No. MM 001203, sourced from Museum of Victoria

Historic mining techniques had limited capacity to recover antimony. As mineral extraction techniques have improved, several attempts have been made to re-treat historical tailings in the area.

In 1926 a company “Costerfield Antox Company” purchased the Costerfield mine area. The Costerfield Antox Company extracted metals from tailings and manufactured antimony products including paints. The manufacture of paints is expected to have been undertaken near Minerva mine. During 1995, a processing plant was constructed for the re-treatment of tailings and the oxide portion of the mine wastes at the Brunswick open pit mine (Mandalay Resources, 2012).

Since 1970’s the Costerfield area has undergone more extensive exploration, including geochemical sampling and drilling, resulting in the discovery of the Augusta deposit in 1975 and the Cuffley Lode in 2011, located less than 500 metres north of the Augusta mine.

Remnants of the historical mine activities, including concrete footings, sheds, chimneys and tailings remain within the Costerfield Township (See Figure 13).

(a) Remnants of corrugated iron battery shed & iron chimneystack, at Bombay mine

(b) Remnant footings at Costerfield Main Shaft

(c) Remnants at the Costerfield Main Shaft

Figure 13: Remnants of historical mine infrastructure

3.2.2 Mining Processes

Mine processes for extraction of gold/antimony are summarised in Figure 14, below.

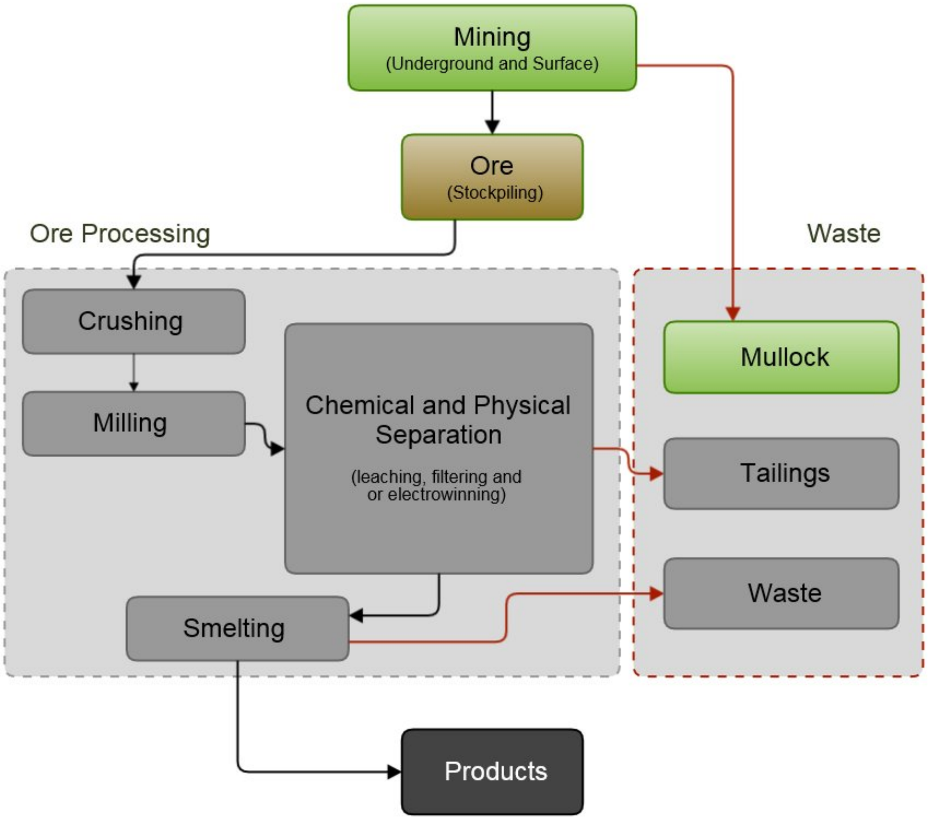

Figure 14: Typical Mine Processes and wastes generated

The mineral extraction processes recorded within the Costerfield area (as described by Bannear (1993)) are summarised in

Table 3. A summary of periods of use and extraction processes utilised at the main antimony mines within Costerfield is presented in Table C1, Appendix C. Additional processing facilities or processing methods may have been used, without being reported within the reviewed information.

Table 3: Summary of Historic Mining Processes within Costerfield

Summary of Process	Occurrence at Costerfield
Crushing: machines known as crushers, stamp mills, or stamp batteries, are used to pulverise the rock.	Battery crushers were used at many of the mine sites within Costerfield and were historically run by steam powered engines. The need to fuel steam engines lead to extensive felling of trees within regional Victoria. Diesel engines were typically used to generate crushing machinery following the 1930's. Water wheels were used to generate crushing machinery at Robinsons Reef.
Ball Milling: typically a rotating horizontal cylinder containing steel balls, referred to as a "Ball Mill" is used to further crush rock/sands, to create a fine powder or slurry.	Ball milling is likely to have occurred at several of the mine site. Two ball mills are currently used at the Brunswick processing facility.
Roasting: heating of material to oxidise sulphur and organic carbon.	Roasting is likely to have occurred at many of the mine sites in Costerfield, including the Costerfield Main Mine. Roasting was also historically used to burn off antimony (reducing antimony content assisted with the effectiveness of gold extraction).
Leaching: chemical solvents (commonly cyanide) are used to dissolve the gold and antimony.	Cyaniding has occurred at many of the mine sites in Costerfield. At the Bombay site there are records of cyaniding and precipitating gold, using zinc. Zinc powder has historically been used to combine with the cyanide, assisting the precipitation of gold. Lead nitrate may have been used to activate the zinc dust during this process or as an accelerator in the cyaniding process. The remnants of the cyanide works remain at the Bombay mine site and Tait's shaft.
Refining: removal of other metals, such as silver from gold (often via chlorination).	It is reported that chlorination plants were used for metal extraction at Taits shaft, Bombay mine, and Morning Star mines.
Filtering and or stripping	Amalgamation of gold with mercury (also referred to as quicksilver) was used unsuccessfully for a short period at the Minerva mine and Bombay mine due to "mercury loss" (Bannear, 1993).
Electrowinning: recovery of the gold/antimony from the leaching chemicals using electrical current.	Electrowinning processing facilities are currently present at the Brunswick processing plant.
Smelting: melting of the recovered metals, separation using flux chemicals and pouring of molten gold/antimony into solid bars or moulds.	Smelting occurred at multiple locations across the Costerfield mine fields including the Minerva and the Bombay mine.

3.3 Distribution of Mine Wastes

Mining processes produce wastes, comprising material of different particle size and chemical composition, including the following:

- Mullock and overburden rock generated during the excavation of the mine and physical separation of the ore from the host rock.

- Tailings comprising coarse to fine grained particles, generated from the crushing and milling of material, which may contain chemicals used for metal extraction.
- Liquid wastes and slurries comprising fine particles and potentially chemicals used during the extraction process.
- Atmospheric emissions comprising gases and fine particles associated with crushing, roasting, and or chemical processing of material.

The Costerfield Township was built in the center of the mining activities, with the historical main street running north to south, adjacent to many of the mine shafts and tailings stockpiles (Figure 15).

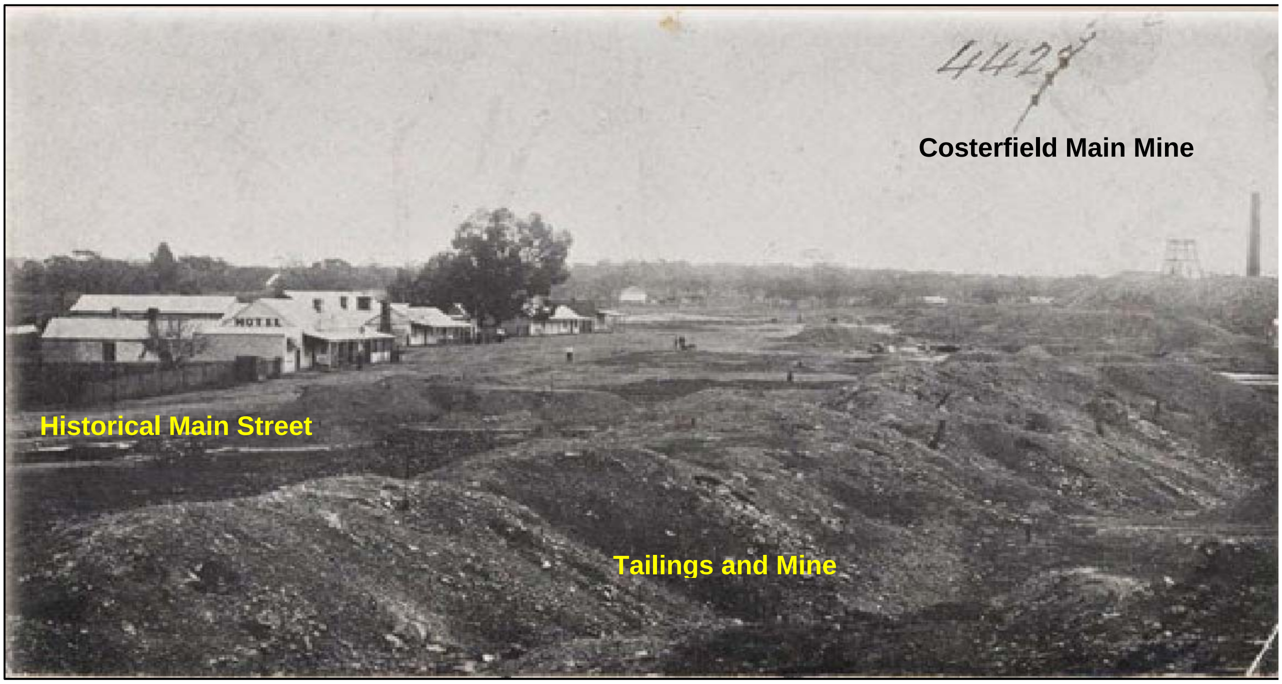

Figure 15: Costerfield township and mine tailings
Photo taken looking north towards the Costerfield Main Mine down the former main road, estimated within the 1900s to 1940s.

Mining processes within the Costerfield area have included hauling of mine material and extensive stockpiling of mine waste materials. A map showing the distribution of mine waste in 1926 is presented below.

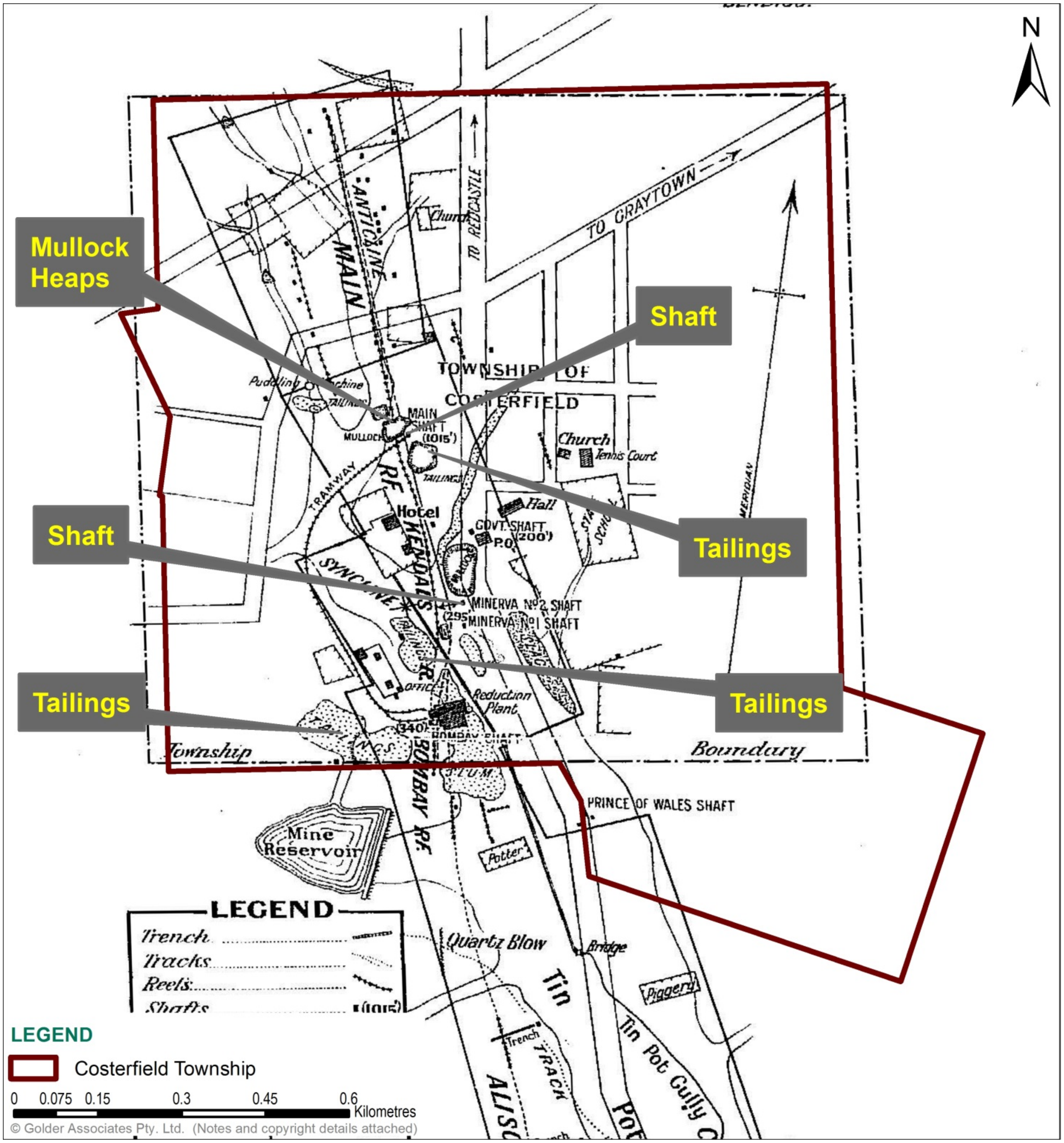

Figure 16: Location of Mine waste, including tailings, within the township of Costerfield during 1926

Many of the mine tailing stockpiles, present in 1926, are still present within the Costerfield Township. The current distribution of tailings is further described in Section 4.0.

3.4 Current Mining Activities

The Costerfield mine area has had a large number of different operators since 1860. Mine operations in the Costerfield area are currently owned by Mandalay Resources and are currently limited to the Augusta mine and Cuffley Lode as presented in Figure 17 below.

(a) Augusta Underground Mine

(b) Augusta Mine, aerial view

Figure 17 (a) Augusta Underground Mine [6]*(b) The Augusta Mine Site groundwater evaporation ponds shown in top of photo*[7]

Ore from the Augusta mine and Cuffley Lode is transported to the Brunswick Processing Plant, Figure 18, for processing. The processing plant produces gold and antimony sulphide concentrate, which is shipped offsite to external smelters (SRK Consulting, 2013).

Excess waste rock from the Augusta mine is stockpiled at the Augusta mine site, Brunswick tailings facility and the Bombay Tailings Facility. The waste rock is proposed to be used to fill the box cut and cap the tailing storage facility at the end of the mine's life (verbal communications, with Mandalay Resources, November 2014).

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[6] Sourced from http://adriancummins.com/projects.html

[7] Sourced from Mandalay (2012)

Figure 18: The Brunswick Processing Plant (Mandalay Resources, 2012)

The Brunswick Processing Plant comprises a two-stage crushing process, two milling stages in series, with closed circuit classification and gravity concentration. The flotation circuit produces antimony-gold flotation concentrate (SKR Consulting, 2013). The flotation tailings are sent to an onsite tailings storage facility. Flotation processes typically use chemical conditioning agents and intense agitation and/or sparging of the crushed ore slurry to produce mineral rich foam concentrate.

A facility for cyanide gold dissolution and adsorption followed by elution, electrowinning and smelting to produce bullion also exists within Brunswick Processing Plant, however this facility was decommissioned in 2011 (Snowden, 2012). Active mines within Costerfield area no longer use cyanide or have cyanide stored onsite, other than within tailings dam deposits from historical use (Snowden, 2012).

3.5 Water Management

Dewatering is currently undertaken at Augusta Mine and Cuffley Lode. The current rate of extraction of groundwater from around the Augusta mine is about 600 mega litres per year; removal of groundwater within the mine is undertaken at a rate of 19 litres per second (SRK Consulting, 2013 and Personal Communications with Mandalay Resources, November 2014).

Mine water is pumped from the underground Augusta mine to a disused open pit mine, the Brunswick Pit, and to evaporation ponds adjacent to the Augusta mine facilities. It is understood that Mandalay is not permitted to discharge untreated groundwater from the mine site.

In the past, emergency haulage of water to the Heathcote Mine Open Pit and an unsuccessful trial of reinjection of water to the deep aquifer via the Bombay shaft have been permitted for control of water levels. In addition, groundwater, town water and reverse osmosis treated water have been used for dust suppression. Groundwater is no longer used for dust suppression at Mandalay Resources’ mines, except within the Brunswick Processing Plant.

During August 2014, a reverse osmosis water treatment system was installed to treat groundwater prior to discharge to surrounding creeks. Also, construction is currently underway for additional evaporation ponds at an area of land known as Splitters Creek to increase the quantity of groundwater evaporated (Personal Communication with Mandalay Resources, November 2014).

4.0 WALKOVER OF THE COSTERFIELD AREA

A site walk over of the Costerfield area was undertaken to support the desktop review. The purpose of the site walkover was to assess the current condition of areas of historical mining, specifically the distribution of tailings and mine waste materials. The walkover was undertaken by an engineering geologist from Golder on 15 October 2014.

Selected field observations are provided in Appendix D. Historical mining waste was observed within the Costerfield area. Some revegetation has occurred, but in general vegetation is sparse and mining waste is visible at the ground surface. Some present day unsealed roads traverse through areas that were formerly (and likely are currently) underlain by mining waste. Locations at which fine grained materials, inferred to be historical mine tailings, are currently visible in some areas as presented in Figure 19. Many of the tailings locations observed are consistent with indications on the 1926 map of Costerfield (Figure 16). At some locations, mainly south of Costerfield, it appears that tailings may have been removed (possibly reprocessed), and some areas rehabilitated.

In addition to sites within the immediate vicinity of Costerfield, a field traverse was undertaken west from Costerfield towards Robinsons Reef and Brown’s Diggings. These are within sparsely vegetated areas. Evidence for mining activity remains including dams, inferred mine waste and channels. A traverse was also undertaken towards the west of Costerfield towards the West Costerfield Reef. This is a sparsely vegetated area, with similar evidence of historical mining as was observed to the east of Costerfield.

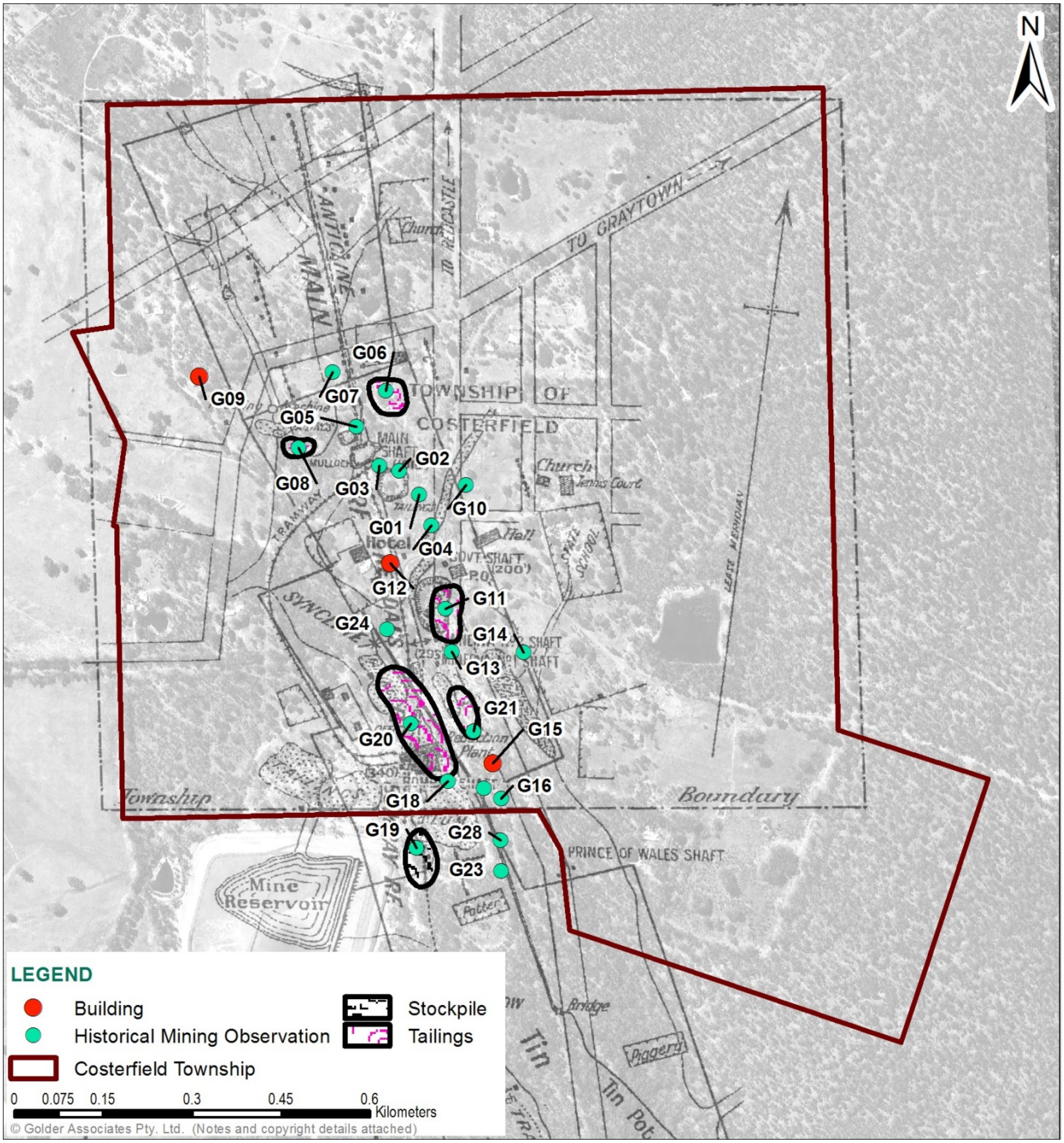

Figure 19: Site observations during walkover of the Costerfield area

Selected field observations (numbered G01 to G28) are described in Appendix D.

5.0 POTENTIAL SOURCES OF ANTIMONY AND RELATED CHEMICALS IN THE ENVIRONMENT

The purpose of this desktop review is to support the development of a comprehensive health risk assessment by providing an understanding of the nature, transport and distribution of antimony and related chemicals in the environment. Although focused on antimony, the human health risk assessment will aim to consider potential cumulative exposure to other potential chemicals of interest that may be present with antimony in the Costerfield area. The following sections describe the process undertaken to identify the potential chemicals of interest and associated sources of antimony and related chemicals to the environment.

5.1 Identification of Potential Chemicals of Interest

Based on the desktop review, Golder has reviewed related chemicals of interest, in addition to antimony, which may require consideration in a comprehensive human health risk assessment.

A limited environmental assessment of Mandalay's processes (undertaken by Snowden, 2012) reported that potential contaminants to the environment associated with the Costerfield mines may include antimony (from stibnite), arsenic from (arsenopyrite), cyanide (from historical processing) as well as lead (lead nitrate), caustic soda, acids and other flotation reagents used in the gold extraction process (Snowden, 2012). Current data on the composition of tailings is limited. Tailings from different areas and different mine periods are likely to vary in metal concentrations.

Golder has undertaken a process to identify which of the identified chemicals are of potential concern, in particular with regard to potential health risks to residents within the Costerfield area. This process is presented in Appendix E. In summary, based on the potential sources of chemicals in the environment and the reviewed soil and ore data (Section 2.2.2), antimony and to a lesser extent arsenic are considered the key chemicals of interest for the purposes of assessment of human health risks.

5.2 Identification of Sources of Antimony and Related Chemicals

The chemicals associated with each of the potential sources of antimony are presented in Figure 20. The extensive distribution of mine wastes (particularly tailings) within Costerfield is likely a significant source of antimony and associated chemicals in the environment.

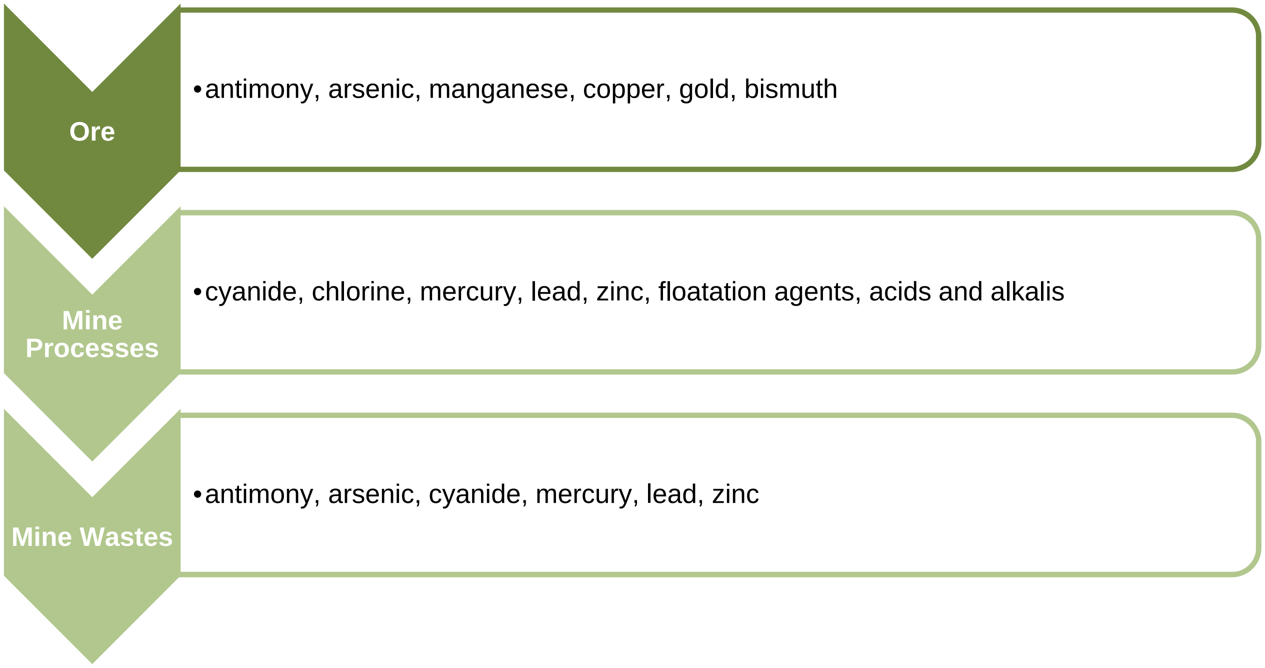

Figure 20: Source of potential contamination and associated chemicals of interest

Some materials used in a rural agricultural and residential setting may include antimony (such as lead shot from shooting and batteries). However, these sources of antimony are likely to be localised and/or sparsely distributed in the environment. Farming and residential development within the Costerfield area is unlikely to have significantly contributed to the antimony load within the local environment.

6.0 ANTIMONY BEHAVIOUR IN THE ENVIRONMENT

Typical antimony concentrations in the environment are low (Table F1, Appendix F), however they may be enriched in areas (i.e. mineral halos) associated with antimony mineralisation.

Antimony ore deposits in the Costerfield are have formed from the solidification of igneous intrusions (further described in Section 2.2.3) and are typically stable unless disturbed (i.e. change to the pH or redox of the environment).

Mine processes may alter the behaviour of antimony in the environment, including the mobility of antimony. The behaviour of antimony within the environment is summarised in the following sections and in Figure 21.

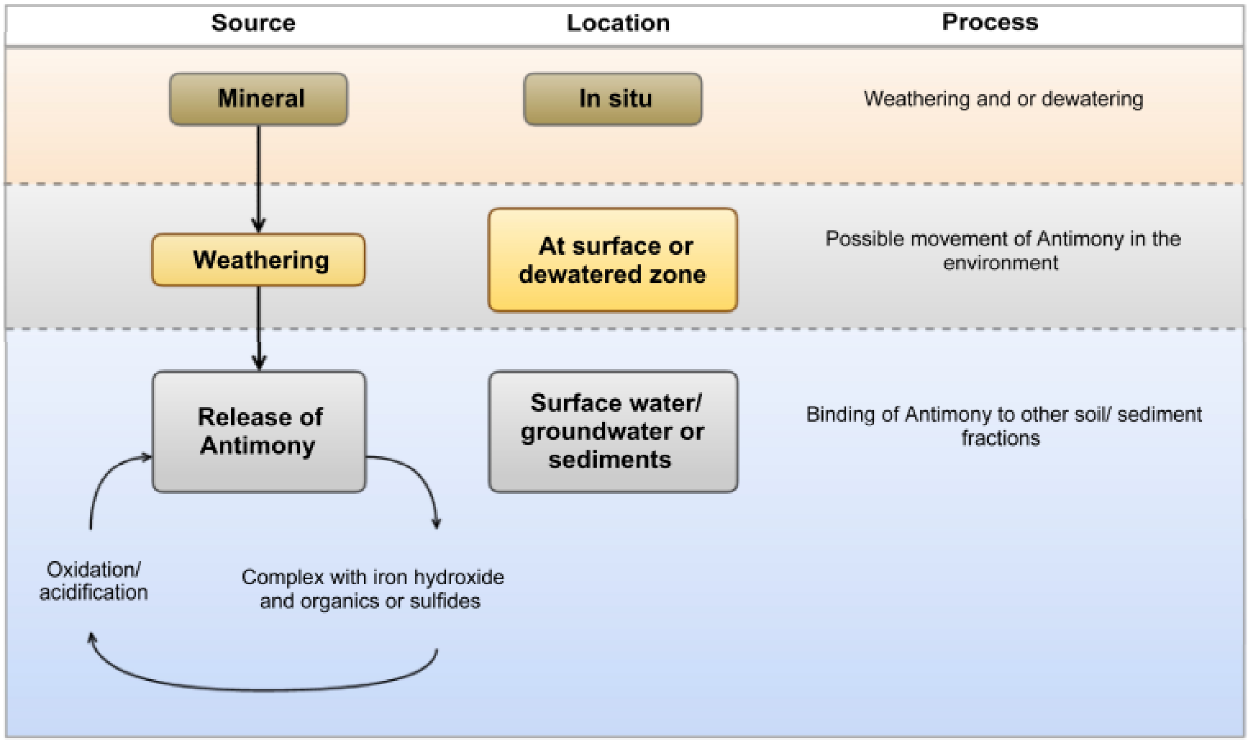

Figure 21: Simplified schematic of antimony behaviour within the environment

The chemical behaviour of antimony in the environment is described below.

In soils:

- Antimony forms strong bonds with iron oxides (in aerobic[8] conditions), and/or sulfides and organic ligands (in anoxic[9] conditions) (Filella et al.2002).
- Antimony typically has low mobility in the environment, except under highly oxidizing conditions (Wilson 2010).

Within mineral deposits:

- The weathering (oxidation[10]) of stibnite mineral deposits commonly results in the formation of antimony oxides and iron oxides, which have limited mobility within the environment (Wilson, 2010).
- Dewatering of insitu mineral deposits (i.e. during mine activities) may result in oxidation of metal sulphides. Oxidation of metal sulphides can cause generation of acidity and subsequent increase metal mobility. However, the presence of natural pH buffering chemicals, such as calcium, can mitigate soil/rock acidification.

In aquatic environments:

- Antimony is present as a result of rock weathering, soil runoff and anthropogenic activities.

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[8] Aerobic definition: requiring atmospheric oxygen in order to liver and grow.

[9] Anoxic definition: lacking oxygen.

[10] Oxidation definition: any chemical reaction that involves atoms or molecules losing electrons.

- Dissolved antimony in water commonly binds to iron oxides, reducing its mobility and transport.

Elevated antimony concentrations have been reported within streams and groundwater associated with antimony mines (Ashley et al., 2003).

Antimony concentration and mobility within mine wastes is likely to vary based on the mine processes undertaken, the grain size and a particle surface area, and environmental conditions. Limited data provided by Mandalay Resources (August 2014) reported typical antimony concentrations in the extracted ore (39,100 mg/kg), tailings (2,150 mg/kg) and waste rock (170 mg/kg).

Soil/rock naturally enriched in antimony is also commonly enriched with arsenic (Craw, 2004). Antimony and arsenic have similar chemical properties, where by the mobility of arsenic in the environment is driven by pH and redox potential (Wilson, 2010). Similar to antimony, arsenic (+3) is typically immobilised by sulfides, and arsenic (+5) is immobilised by binding to clays and forming bonds with iron oxides. Studies from surface water released from antimony mines in New South Wales, indicate that antimony is likely to precipitate[11] out of solution more readily than arsenic (Ashley et. al. 2003).

7.0 REVIEW OF SOURCE-PATHWAY-RECEIVING ENVIRONMENT

To assist in understanding the distribution of antimony and arsenic within the Costerfield area, Golder has identified the following:

- *Source Materials* - sources of antimony (and related chemicals) in the Costerfield area.
- *Transport pathways* - the potential pathways in which antimony (and related chemicals) may be re-distributed, moved or dispersed from the original source into the broader environment.
- *Receiving environment* – environmental media which have or may receive added antimony and associated chemicals.

Understanding potential linkages between sources of antimony and associated chemicals, pathways and the receiving environment can assist in assessing potential for exposure by occupiers or users of environment.

7.1 Source Materials

The key sources of antimony and associated chemicals in the Costerfield area are the result of antimony rich ore materials naturally present in soils and bedrock along with mine wastes that have redistributed within the landscape over the last 150 years.

The source materials can be present in many forms as described below:

- *Overburden (i.e mullock)* - material removed during excavation works (not significantly enriched in metals).
- *Ore* - is mined rock that contains sufficient mineralised zones that antimony can be economically extracted from the rock.
- *Tailings* - medium to fine grained materials remaining following ore extraction (may contain chemicals associated with mine processes).

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[11] Precipitate definition: a substance that has been chemically removed from solution by precipitation.

- Processing Wastes – includes;
  - *Mine slag* - coarse grained materials derived following smelting of material, likely chemically altered (i.e. oxidised) during mine processes.
  - *Dust and atmospheric emissions* - associated with mine processes (i.e. ventilation exhaust from material processing).
  - *Waste waters* - may contain elevated concentrations of metals and mine processing chemicals.

7.2 Transport Pathways

Current and historical mining activities, including the storage and transportation of mine waste materials have the potential to add chemicals, including antimony, to the environment. The reviewed historical information provides a summary of mineral extraction processes used within the Costerfield area. The locations of where many of the mine processes occurred are currently not confirmed.

The potential release mechanisms and transport/migration pathways for antimony and associated chemicals from the identified source materials include:

- *Dust* - generated from wind erosion of exposed material (i.e. tailings), crushing of mined materials, vehicle driving on unsealed roads or dirt bikes driving on mine waste stockpiles.
- *Airborne emissions* – generated from roasting, crushing and chemical processes, resulting in deposition on surface soils.
- *Surface runoff* - typically generated from rainfall on stockpiled mine materials
- *Infiltration* - typically by rainwater through mine wastes, into subsurface soils and the underlying the bedrock, and/or groundwater. In addition, potential infiltration through oxidised bedrock, associated with lowering of groundwater levels, resulting in chemical mobilisation of metals and infiltration into groundwater.
- *Transport through groundwater (advection / dispersion)* - into surface water bodies.
- *Use of groundwater or surface water* (including drinking, recreational use or irrigation).
- *Potential uptake in plants* and animals is possible; however antimony does not biomagnify through food chains.

7.3 Receiving Environment

Areas and environmental features which may experience added antimony concentrations due to migration of metals from mine wastes and or undisturbed mineralised material include:

- *Surrounding surface soils* - including agricultural, residential and forested areas.
- *Surface water features* - such as creeks, dams and rivers.
- *Groundwater* – shallow and deeper aquifers (perched alluvial aquifer and the deeper regional aquifer)

A schematic summarising the linkages between sources of antimony and the identified transport pathways and the potential receiving environment is presented in Figure 22.

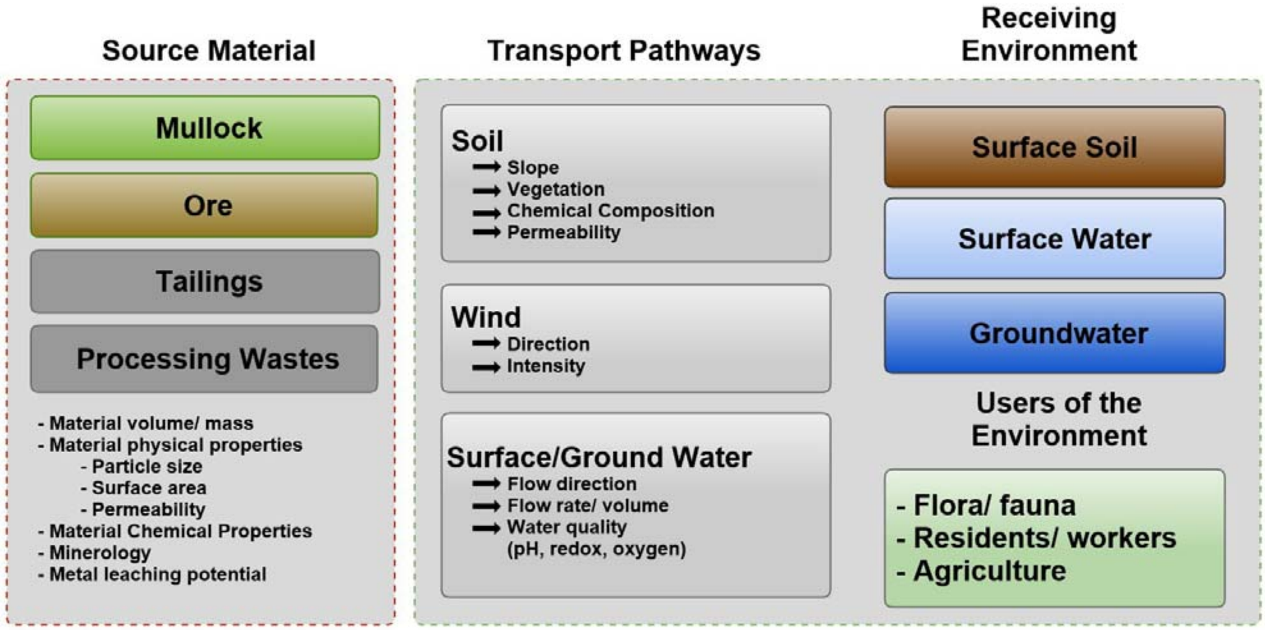

Figure 22: Schematic of linkages between sources and the receiving environment

7.4 Source, Pathway and Receiving Environment Linkages

Based on the reported metal concentrations and extensive history of soil disturbance in the Costerfield area, the key sources of antimony in excess of typical background conditions at the soil surface are mine wastes. Mine waste materials including tailings are distributed within the town; and much of this material has been exposed to weathering over the past 150 years. Mine wastes vary in metal content and particle size (from waste rock to slum, and particulates emitted from roasting of material and ventilation during processing). Weathering and dust generation is likely to be greater from fine grained mine wastes (such as tailings) compared to coarse large mine wastes (such as overburden).

The concentration of metals is typically greatest within the fine fractions of soils. Metal concentrations within dust generated from mine tailings may be proportionally greater than within the general tailings comprising a range of texture material classes.

In addition, added contaminants may be present within mine wastes due to mineral ore extraction processes.

Key pathways for movement of antimony (and related chemicals) in the environment which are likely to have influenced the distribution of antimony impacts include; direct movement of soil via trucking and hauling of ore and mine waste, and indirect secondary movement, via dust deposition, run off, or infiltration into surface water or groundwater. Other activities which generate dust (such as riding dirt bikes on tailings stockpiles) may increase migration of antimony.

Historic mine activities (by direct deposition and indirect run off) are likely to have resulted in release of antimony and related chemicals to surface water, which may have resulted in deposition of antimony hydraulically down gradient of the Costerfield area.

Current and historic dewatering activities may oxidise stibnite leading in the potential release of antimony and related chemicals to groundwater. Surface water and groundwater may act as a pathway for antimony movement beyond the Costerfield area. Golder has not undertaken chemical assessment of groundwater or surface water within the Costerfield area.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Golder was engaged by DEDJTR to undertake this desktop review of the nature, transport and distribution of antimony and related chemicals in the Costerfield area, as part of a series of staged environmental assessment to support the development of a comprehensive human health risk assessment. The results of this desk top review have provided an improved understanding of the likely sources and pathways of antimony distribution within the Costerfield area. The conclusions of this assessment are summarised by answering the following key questions defined for the review.

1. ***What are the sources of antimony in the Costerfield area?***

The main source of antimony in the Costerfield area is mineralised zones of sulphide minerals such as stibnite and adjacent altered host rocks of the Costerfield Formation. Mining activities have resulted in the relocation (and in some cases) concentration of antimony in the Costerfield environment.

2. ***What is the distribution of antimony and related chemicals within the Costerfield area?***

During historic mining activities, mine wastes have been distributed widely within the township and across the landscape. There may also be some local point sources of chemicals in the Costerfield environment primarily related with processing and/or extraction of antimony and gold. Early processing occurred around waterways leading to direct discharges without containment. Potential mining related chemicals include manganese, copper, gold, bismuth, lead, mercury, zinc, chlorine, floatation agents, acids, alkalis and cyanide. These chemicals may also be present within mining areas of Costerfield.

3. ***How do antimony and related chemicals behave in the environment?***

The concentration and mobility of antimony and related chemicals within mine wastes can be influenced by mine processing, the particle sizes within the wastes, and the prevailing environmental conditions. The weathering of antimony containing minerals commonly results in the formation of metal oxides which have limited mobility within the environment except under highly oxidised conditions. Therefore the physical size of antimony containing particles and land disturbance practices have a significant influence on its redistribution in the environment following the initial relocation of mine waste to the land surface.

Golder has not undertaken chemical assessment of groundwater or surface water within the Costerfield area, however, oxidation of mineralised rock, during dewatering activities, could potentially result in mobilisation of antimony into the environment.

4. ***What further assessment or information is required to assess risks to human health, associated with exposure to antimony and related chemicals?***

Further soil assessment should be considered to understand the distribution of antimony and related chemicals within the Costerfield area, specifically in those areas where mine wastes are present at the surface. Golder is currently undertaking soil assessment at selected residential properties and road reserves.

To assist in understanding the potential risk of antimony and related chemicals to human health and the environment, the following further information is considered important:

- Arsenic and antimony leachability (mobility) within different mine wastes (particularly tailings and dewatered mineralised zones).

- Arsenic and antimony impacts to groundwater and surface water. EPA has been commissioned to review the water (surface and groundwater) management issues. The EPA findings will also inform the HRA.
- Arsenic and antimony bioaccessability and bioavailability (for humans, flora and fauna). The bioaccessibility and bioavailability of antimony and related chemicals are typically limited in the environmental media. Investigations will inform the HRA.

9.0 LIMITATIONS

Your attention is drawn to the document - “Limitations”, which is included in Appendix A of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

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APPENDIX A

Limitations

LIMITATIONS

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APPENDIX B

Soil and Ore data

1.0 INTRODUCTION

An initial review of existing and publically available soil data was undertaken to support the desktop review of soil geochemistry in Costerfield. The initial review was limited to data for antimony, arsenic, and gold.

1.1 Data sets

Two sources of soil chemistry data were reviewed:

- Department of Primary Industries (DPI) dataset of geochemical results across central Victoria, containing 73,812 samples that were tested for the following metals: gold (Au), silver (Ag), arsenic (As), antimony (Sb), mercury (Hg), tungsten (W), aluminium (Al), calcium (Ca), iron (Fe) and manganese (Mn). It's noted that the DPI is now referred to as the Department of Economic Development, Jobs, Transport and Resources (DEDJTR).

- Mandalay ore data from August 2014, containing 20 samples (10 ore samples and 10 low grade samples) analysed for the following metals gold (Au), silver (Ag), aluminium (Al), arsenic (As), boron (B), barium (Ba), beryllium (Be), bismuth (Bi), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), potassium (K), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), phosphorus (P), lead (Pb), sulfur (S), antimony (Sb), selenium (Se), tin (Sn), strontium (Sr), titanium (Ti) (attached as Attachment A).

2.0 METHODOLOGY

2.1 DEPI Data

1. The DPI spreadsheet was imported into GIS software (ESRI ArcMap), and the samples were plotted using the coordinate fields (in datum GDA94, projection MGA zone 55), using:
    a. Easting = [GDA94_55_East]
    b. Northing = [GDA94_55_North]
2. The DPI samples that intersect the Costerfield Dome (presented as Figure 2.93 in VandenBerg et al. (2000) were export to a [.csv] file and import to R (code attached).
3. The dataset was prepared for analysis by:
    a. Converting zero results to 'NA'
    b. Removing negative symbols. It is assumed that negative symbols represent results reported as less than the laboratory limits of reporting (i.e. <). The negative results were converted to absolute values (e.g. -2 changed to 2).
4. The results were then grouped by into five sample depth classes:
    a. All samples (_a)
    b. Shallow samples: <= 30 cm depth (_s)
    c. Intermediate samples: >30 cm & < 600 cm depth (_i)
    d. Deep samples: >= 600 cm depth (_d)
    e. Samples without a recorded depth (_NA)
5. Summary statistics and density plots were generated for each depth class.

6. Inspection of the initial summary statistics and density plots indicated that the Sb, As and Au results were not normally distributed, and were skewed to the right. So to assist with the review, these parameters were log transformed and the statistics and plots were re-exported.

2.2 Mandalay Ore Data

Summary statistics were calculated for the Ore data using the following formula in Microsoft excel:

- #Results = Count( )
- Minimum = Min( )
- Maximum = Max()
- Median = Median()
- Mean = Average()
- SE.mean = [#Results]/Sqrt([std.dev])
- std.dev = STDEV()

No transformation or data cleaning was undertaken for the Mandalay ore data.

3.0 FINDINGS

3.1 DPI Data

Density histogram plots for the log transformed dataset are presented in Figure 1, and summary statistics are presented in Table 1.

It is noted that the plot for antimony (Log(Sb)) indicates that the distribution of intermediate results differs to the distribution of the shallow, and deep samples.

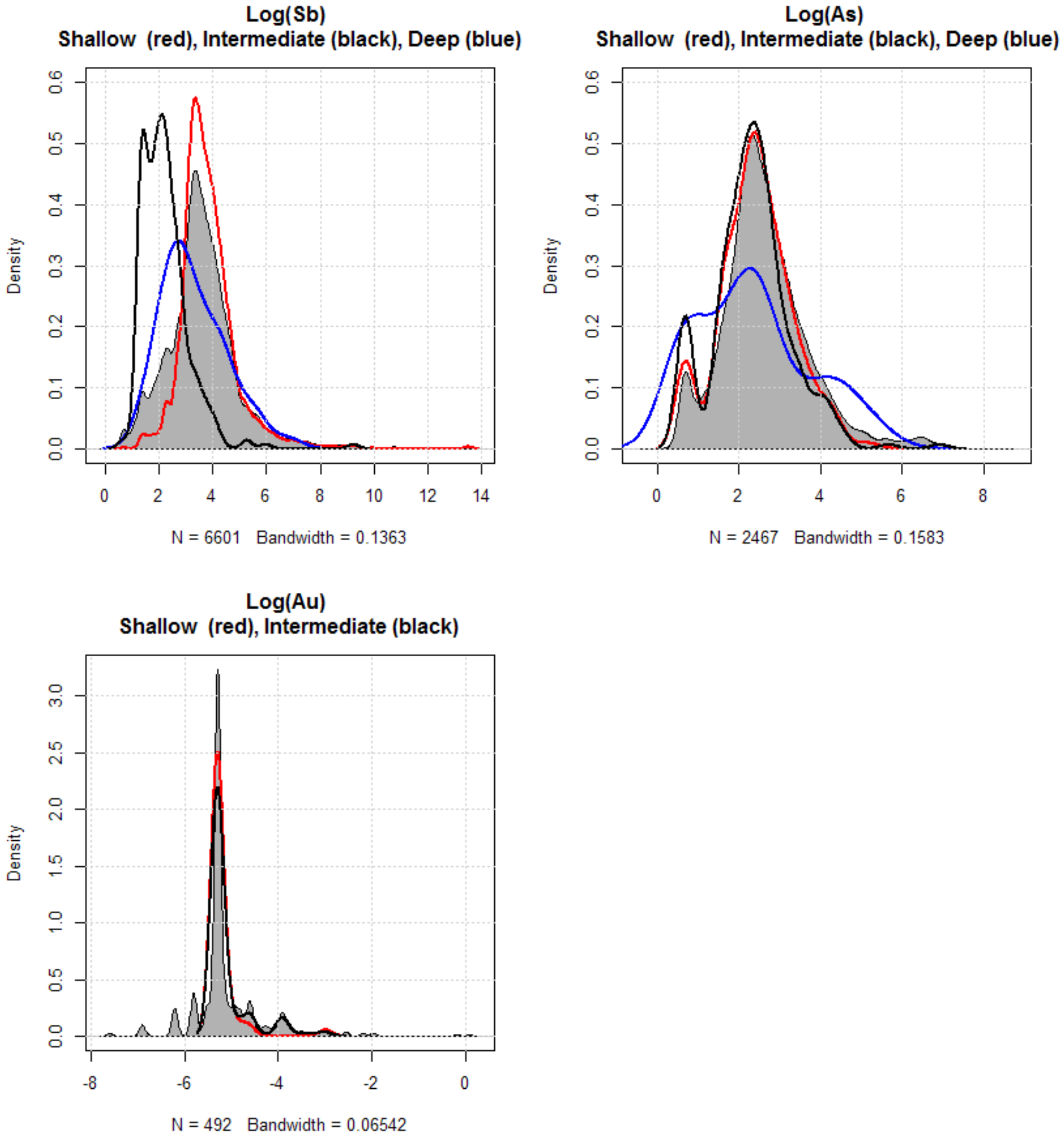

Figure 1: Density Histogram Plots for Log Transformed DPI data in the Costerfield Dome.

Table 1: Summary Statistics for DPI Data

Metal	Depth	#Results	Min	Max	Median	Mean	Standard Error of the mean	Confidence Interval for the mean (0.95)	Standard deviation	95%ile
As	All	2467	1	4100	12	35.7	2.63	5.15	130	93.85
As	Shallow	298	2	200	10	17.1	1.19	2.33	20.5	50.75
As	Int.	272	2	999	10	19.4	3.87	7.63	63.9	57.25
As	Deep	50	2	251	10	28	6.77	13.6	47.9	119.5
As	NA	1847	1	4100	13	41.3	3.44	6.75	148	116.7
As(log)	All	2467	0	8.32	2.48	2.66	0.0218	0.0427	1.08	4.542
As(log)	Shallow	298	0.693	5.3	2.3	2.43	0.0516	0.101	0.89	3.926
As(log)	Int.	272	0.693	6.91	2.3	2.32	0.0576	0.113	0.95	4.05
As(log)	Deep	50	0.693	5.53	2.3	2.34	0.194	0.39	1.37	4.8
As(log)	NA	1847	0	8.32	2.56	2.75	0.0257	0.0504	1.1	4.76
Au	All	492	0.0005	1.09	0.005	0.0124	0.00284	0.00558	0.063	0.023
Au	Shallow	51	0.005	0.05	0.005	0.00616	0.000887	0.00178	0.00634	0.008
Au	Int.	187	0.005	0.05	0.005	0.00713	0.000476	0.000939	0.00651	0.02
Au	NA	254	0.0005	1.09	0.005	0.0174	0.00547	0.0108	0.0872	0.029
Au(log)	All	492	-7.6	0.0862	-5.3	-5.12	0.035	0.0689	0.777	-3.772
Au(log)	Shallow	51	-5.3	-3	-5.3	-5.21	0.0485	0.0974	0.346	-4.836
Au(log)	Int.	187	-5.3	-3	-5.3	-5.11	0.0337	0.0666	0.461	-3.91
Au(log)	NA	254	-7.6	0.0862	-5.3	-5.11	0.0624	0.123	0.995	-3.54
Sb	All	6601	1.29	710000	35	831	244	478	19807	350
Sb	Shallow	4375	2	710000	40	944	363	711	23999	285
Sb	Int.	272	2	10000	8	51.2	36.8	72.4	606	40
Sb	Deep	50	4	950	20	67.6	20.5	41.3	145	233.8
Sb	NA	1904	1.29	182070	19	702	139	272	6060	945.55
Sb(log)	All	6601	0.255	13.5	3.56	3.61	0.0168	0.033	1.37	5.858
Sb(log)	Shallow	4375	0.693	13.5	3.69	3.84	0.016	0.0313	1.06	5.652
Sb(log)	Int.	272	0.693	9.21	2.08	2.24	0.0539	0.106	0.889	3.69
Sb(log)	Deep	50	1.39	6.86	3	3.32	0.171	0.344	1.21	5.5
Sb(log)	NA	1904	0.255	12.1	2.94	3.29	0.0415	0.0813	1.81	6.852

Table 2: Summary Statistics for Mandalay Ore Data

	#Results	min	max	median	mean	Standard Error of the mean	Standard deviation
Au (g/t)	20	1.55	19.9	4.82	6.16	1.1	4.918098
As (ppm)	20	132.36	954.49	480.27	533.13	47.97	214.5471
Sb (%)	20	0.24	10	2.14	2.57	0.46	2.065247

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Attachment A: Mandalay Ore Data (August 2014)

Attachment A: Mandalay Ore Data August 2014

Analyte	Limit of Reporting	Units	OREGrade 1	OREGrade 2	OREGrade 3	OREGrade 4	OREGrade 5	OREGrade 6	OREGrade 7	OREGrade 8	OREGrade 9	OREGrade 10	LOWGrade 1	LOWGrade 2	LOWGrade 3	LOWGrade 4	LOWGrade 5	LOWGrade 6	LOWGrade 7	LOWGrade 8	LOWGrade 9	LOWGrade 10
Au		g/t	2.65	2.45	9.90	7.30	7.25	5.60	19.90	2.08	5.13	1.55	6.35	5.80	6.23	3.90	18.40	3.23	2.13	4.43	4.35	4.50
Ag	0.5	ppm	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Al	0.01	%	0.16	0.16	0.19	0.18	0.19	0.14	0.18	0.15	0.16	0.17	0.18	0.18	0.19	0.14	0.19	0.14	0.18	0.17	0.18	0.13
As	1	ppm	783	954	440	724	536	410	324	736	443	293	379	274	583	630	454	479	760	482	132	846
B	5	ppm	18	15	16	15	17	16	16	20	21	25	14	12	13	20	16	15	14	11	8	10
Ba	10	ppm	49	47	57	49	45	48	51	43	48	45	48	41	48	44	53	50	54	41	41	36
Be	2	ppm	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Bi	0.2	ppm	3.9	3.5	4.3	4.0	2.8	3.9	4.9	3.1	5.5	2.5	4.7	4.2	3.2	1.9	5.9	5.4	2.7	3.6	3.9	4.1
Cd	2	ppm	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Co	2	ppm	12	12	12	13	14	13	14	10	12	11	13	13	13	13	13	12	14	15	14	14
Cr	5	ppm	6	8	8	7	7	6	7	8	7	6	7	8	7	6	7	6	6	5	9	5
Cu	1	ppm	33	35	31	35	32	34	35	28	32	34	33	33	35	35	41	31	36	32	30	32
Fe	0.01	%	4.52	4.58	4.45	4.80	4.61	4.75	4.76	4.21	4.38	4.14	4.79	4.96	4.88	4.73	4.63	4.75	4.70	4.67	4.76	4.64
Hg	2	ppm	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
K	0.01	%	3.18	3.10	2.71	2.72	3.16	2.41	2.92	2.24	2.25	2.59	3.01	3.06	3.05	2.56	3.60	2.86	2.89	3.38	2.84	3.16
Mg	0.01	%	0.52	0.52	0.53	0.53	0.52	0.52	0.52	0.52	0.52	0.52	0.53	0.53	0.52	0.51	0.52	0.53	0.51	0.51	0.53	0.53
Mn	1	ppm	537	392	516	506	502	497	529	489	615	499	627	645	772	747	794	537	795	720	550	561
Mo	1	ppm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Na	10	ppm	94	85	53	98	53	52	39	85	65	79	68	71	56	59	87	84	80	31	52	50
Ni	2	ppm	38	40	38	40	39	38	40	33	36	36	39	42	41	38	42	38	42	43	47	42
P	10	ppm	424	483	457	504	531	437	450	386	450	468	474	533	497	529	477	487	462	482	471	416
Pb	1	ppm	29	25	25	23	17	21	20	22	31	19	18	18	24	23	29	23	24	17	12	14
S	0.01	%	5.05	2.06	2.71	2.07	2.17	2.29	2.09	2.48	3.54	4.39	0.92	0.94	1.52	2.59	1.89	1.45	1.60	0.97	0.45	0.94
Sb	0.01	%	1.14	1.28	2.04	5.00	3.24	2.48	2.50	0.99	0.24	1.01	3.17	1.85	4.06	2.21	10.00	1.70	1.71	2.44	2.16	2.11
Se	5	ppm	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sn	5	ppm	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sr	1	ppm	96	96	94	106	68	90	95	112	108	75	80	80	131	137	78	107	82	59	51	68
Ti	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

APPENDIX C

Summary of Mine Processes

Table C1: Summary of key mine sites and ore extraction processes undertaken in Costerfield derived from Bannear 1993.

Mine	Summary of Processes
Costerfield mine	Mining commenced in 1860. Initial processing focussed on extraction of gold, using crushing and smelting. Works to retreat tailings to extract antimony and remaining gold commenced in 1869. Post 1894, improved chlorination methods were used to treat the mine tailings. During 1905, tailing ore extraction included roasting and cyanidation within above and underground tanks. In 1926 the “Costerfield Antox Company” purchased the Costerfield mine area and commenced processes to extract metals from tailings and manufacture antimony products including paints (understood to have been undertaken near Minerva mine). In 1934, mining resumed under the Gold Exploration and Finance Company at the Costerfield main shaft. In 1935 three diesel engines were purchased to power crushing and smelting machinery and assist dewatering machinery.
Bombay mine site	Mining had commenced by 1864 using battery crushers. During the late 1800’s the use of quicksilver (mercury) to extract gold was trailed, but was unsuccessful due to antimony interferences. In 1893 large boilers were installed to drive two engines, one for the battery and one for the pump, to support dewatering. In 1904 a milling and cyanide plant was erected to treat tailings, including use of furnace and many cyanide vats (comprising galvanized iron vats held in concrete cells). Zinc was used for metal precipitation. Post the 1920’s works at the Bombay mine site mainly comprising treatment of tailings using cyanide.
Minerva Mine	Mining had commenced by 1861. A crusher and furnace where on site. The furnace was used for calcining of tailings without mercury (mercury use was trialled, but was ceased due to excess loss of mercury). Costerfield Antox Mining Co. owned the site in 1926. It is thought to have included onsite use of antimony in the production of paint products. A galvanized shed expected to comprise historical paint manufacturing process remains at the site. Site was a rubbish disposal depot in 1993.
Alison Mine	Mining commenced in 1869. Processing works included crushing, smelting and chlorination. A large furnace was present within the mine area. Steam engines were used to power mine machinery.
South Costerfield/ Taits Shaft	Mining commenced in south Costerfield in 1870, including mining of Taits’ Shaft. Onsite processing included a 10 head battery and steam powered smelting furnaces, using chlorination processes. Post 1898 a cyanide plant was used to treat tailings from the battery. The remnants of the cyanide works remain at the Bombay mine site and Tait’s shaft.
Robinson’s reef mine	Robinson’s Reef was discovered in 1881. The reef was located approximately 2.5 Km east of Alison’s mine. Onsite processing included a crushing battery. A large dam was dug to hold water used for running the crushing/stamping machinery. Works at Robinsons reef stopped by 1990.
Brunswick open cut mine	Large scale gold mining was resumed in Costerfield in 1995, after a long period of inactivity over the preceding 30 years. The resumption in mining coincided with the opening of the Brunswick open cut mine in 1995, at the location of the former Brunswick shaft mine. Production at the Brunswick open cut mine was stopped in 2009. A processing plant remains active adjacent to the Brunswick open cut mine. The plant comprises a two stage crushing circuit, two ball mills in series, with classification and

Mine	Summary of Processes
	gravity concentration in closed circuit (Mandalay, 2012).
Augusta Mine	Ore at the Augusta mine was discovered in 1970. An underground mine was commenced at Augusta in 2006. Increased mining at depth and increased regional rainfall resulted in excess water being extracted from the Augusta mine. During 2012 two additional evaporation ponds were constructed to handle excess groundwater. Mining is currently underway at Augusta mine. Materials are currently processed at the Brunswick Processing plant circuit (Mandalay, 2012).
Cuffley Lode	In 2011 a new ore body was identified, less than 500 metres north of the Augusta mine, called the Cuffley lode. Mining of the ore of Cuffley lode has also commenced. Materials are processed at the Brunswick Processing plant circuit (Mandalay, 2012).

APPENDIX D

Photographs from Costerfield Walkover

Select photographs and field observations made during site walkover.

Locations	Notes	Photos
G01, G02, G03, G05	A number of mullock heaps surround the location of the former Costerfield main shaft. There appears to have been some disturbance to the mullock heaps and evidence of material having been removed. The mullock is a coarse, gravel to cobble sized material. Photo– Mullock heap near Costerfield Main Shaft.	 15/10/2014
G04	Former tailings area immediately south of the Costerfield main shaft. Low lying area, comprised of hummocky ground. Fine grained materials (possible tailings) visible at ground surface. Corresponds with area mapped as tailings on 1926 map. Photo – View south across former tailings area, taken from Costerfield Main Shaft.	 15/10/2014
G06	Area of sparse vegetation underlain by fine grained soil, immediately north of Costerfield main shaft. Soil appears to be fill and may be historical mine waste. Sparse vegetation growing in this area. Some trail bike tracks across area. Photo view north across inferred mine waste/tailings area.	 15/10/2014

Locations	Notes	Photos
G08	Heap of fine grained material inferred to be tailings. Heap about 2 m high and 30 m diameter with sparse vegetation. Corresponds with area mapped as tailings on 1926 map. Trail bike tracks present on heap and evidence of erosion. Photo – close up of inferred heaped tailings material.	
G12	The former main street of Costerfield is roughly aligned to a current road alignment. The road is unsealed and comprised of fine grained material. Historical photos show this area to be formerly underlain by mining waste. Photo – View north along former main street of Costerfield.	 15/10/2014
G13	Area to the south of the Minerva shaft is shown on the 1926 plan as underlain by tailings and other mine waste. This area is now revegetated with sparse vegetation. Fine grained soil exposed at surface, some of which appears to be tailings material and some of which appears to be a result of recent rehabilitation. Photo – View south with Minerva No 2 shaft in foreground.	 15/10/2014

Locations	Notes	Photos
G17	Diversion channel near former Bombay Mine. Fine grained material, inferred mining waste is exposed at various locations along the channel. Photo – View north along diversion channel.	 15/10/2014
G20	Area mapped as tailings on 1926 map. Appears to have been rehabilitated by placement of soil and revegetation. Photo – View to west across former tailings area near Bombay mine.	 15/10/2014
G25	Former tailings area to north of Bombay Mine. Fine grained material exposed at surface, no significant vegetation. Appears to be some recent fill placed over this area. Photo – view north over former tailings area.	 15/10/2014

APPENDIX E

Selection of Chemicals of Interest

1.0 IDENTIFICATION OF CHEMICALS OF INTEREST

The objective of the desktop review is to provide information to support the understanding of the nature, transport and distribution of antimony and related chemicals in the environment. This appendix provides a logical approach (decision framework) for identification of chemicals of interest (CoI).
The decision framework and data screening steps outlined in this document are site specific and were designed with regard to the evaluation methodology summarised by the US EPA in *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening* (1993).

Consistent with the desktop report the CoI evaluation focusses on antimony and related chemicals. The relevant considerations in selecting CoI include:

1. What is in the stibnite ore currently mined in Costerfield?
2. Is the element related to historical mining?
3. What common elements are suitable for assessing the potential for naturally occurring elevated concentrations of target compounds?
4. Which elements are potentially associated with materials used for roofs and tanks?

A tiered screening process was applied to define the list of CoI and is presented below:

1. **What is in the Ore:**

Information was provided by Mandalay Resources relating to elemental metal composition of the ore (referred to as crusher run data). The crusher run data contained compositional data for 28 elements which are listed in Table 1.

Table 1: Crusher Run Elements

1	Gold (Au)	8	Bismuth (Bi)	15	Potassium (K)	22	Lead (Pb)
2	Silver (Ag)	9	Cadmium (Cd)	16	Magnesium (Mg)	23	Sulfur (S)
3	Aluminium (Al)	10	Cobalt (Co)	17	Manganese (Mn)	24	Antimony (Sb)
4	Arsenic (As)	11	Chromium (Cr)	18	Molybdenum (Mo)	25	Selenium (Se)
5	Boron (B)	12	Copper (Cu)	19	Sodium (Na)	26	Tin (Sn)
6	Barium (Ba)	13	Iron (Fe)	20	Nickel (Ni)	27	Strontium (Sr)
7	Beryllium (Be)	14	Mercury (Hg)	21	Phosphorus (P)	28	Titanium (Ti)

The CoI within the ore were defined with the following steps:

- **Step 1 - Below the Limit of Detection**

  Those elements which are typically detected at concentration below or at the laboratory limit of detection (where the limit of detection is not greater than respective guideline value) are not considered CoI. These include; Ag, Be, Cd, Hg, Mo, Se, Sn, Ti. All other 20 elements are considered in Step 2.

- **Step 2 - Essential Elements**

  Elements essential to life which are natural constituents of biofluids (Fe, K, Mg, Na, P, S) are not considered as CoI given that humans have homeostatic mechanisms to process these substances and thus they are not of interest in human health risk assessments. Based on the Cramer decision tree for toxicants, all normal constituents of the body are considered a low priority for investigation (Cramer and Ford 1977; EC 2011; EFSA 2012).

- **Step 3 - Below HIL Guidelines**

  Elements present in the ore at concentrations above the Australian health investigation levels (HIL Residential A) for soil (NEPM 2013) are further considered in Step 4. Elements below the HIL that do not meet any of the other criteria for selection are not considered CoI (B, Cr, Cu, Mn, Ni, Pb).

- **Step 4 - Less than Average Crustal Abundance**

Elements present in the ore present at concentrations within or below the estimated crustal abundance ranges defined by Smith and Huyck (1999) and do not meet any of the other criteria for selection are not considered further (Al, Au[1], Ba, Co, Sr).

Mandalay Resources have advised that elements present in the ore do not concentrate in soil waste streams above typical ore concentrations. Therefore the concentrations, compared against HILs in Step 3 and crustal abundance in Step 4, are not expected to increase with processing.

- *CoI identified from the ore are antimony, arsenic and bismuth:Antimony - present in ore at concentrations elevated above crustal abundance range;*
- *Arsenic - present in ore at concentration greater than NEPM HIL; and*
- *Bismuth - present in ore at concentration elevated above crustal abundance range.*

2. **Is the metal related to historical mining?**

A preliminary desktop assessment of potential sources of contamination to the environment, associated with historical activities, within the assessment area has been undertaken. The CoI associated with ore processing are summarised in Table 2.

Table 2: Historical Activities and Additional CoI

Process	Occurrence at Costerfield	Resulting CoI
Precipitation of gold	Cyaniding has occurred at many of the mine sites in Costerfield. At the Bombay site there are records of cyaniding and precipitating gold with zinc. Zinc “dust” has historically been used to combine with the cyanide, assisting the precipitation of gold (Bannear 1993). Lead nitrate may have be used to activate the zinc dust during this process or as an accelerator in the cyaniding process.	Cyanide, lead and zinc
Amalgamation of gold with mercury	Whether mercury was used in a closed or open processing system at Costerfield, is not mentioned specifically within the reviewed documents, however it was reported that mercury was used unsuccessfully for a short period at Minerva mine and Bombay mine due to “mercury loss” (Bannear 1993).	Mercury

CoI based on findings of the preliminary desktop assessment are mercury, lead, cyanide and zinc.

3. **What common earth metals are suitable for assessing the potential for naturally occurring elevated concentrations of target metals?**

- Iron and manganese are common earth metals that may assist with the assessment of the spatial distribution of the source of antimony and arsenic in the environment.

CoI for assessing the potential for naturally occurring elevated concentrations of target metals are iron and manganese.

4. **Which metals are potentially associated with roofs and tanks?**

- Cadmium, copper, lead and zinc are metals that may be present in tank water due to roofing, guttering and pipework materials (CSIRO 2008; Enhealth 2010; Andra et al. 2014).

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[1] Gold is expected to be removed from the ore to within or below the crustal abundance range.

CoI associated with roofs and tanks are cadmium, copper, lead and zinc.

5. Metals relevant to health assessment due to their potential for accumulation in the food chain?

- In addition to mercury and cadmium (previously selected), nickel also has the ability to accumulate through the food chain and is considered potentially relevant to human health cumulative risk assessment.

CoI associated with accumulation potential are cadmium, mercury and nickel.

An additional screening step for CoI was included to ensure the chemicals are of relevance to human health.

Bismuth was further examined to determine if it was relevant to human health and thus relevant to further works.

A worldwide search of health based soil guidelines for bismuth did not identify any values indicating that it is not a priority soil contaminant.

Bismuth (as bismuth, oxide, hydroxide and sulphide forms) has been registered and assessed by a leading chemical evaluation agency - the European Chemicals Agency (ECHA). ECHA is the driving authority for implementation of chemicals legislation in the EU for the benefit of human health. A dossier dossiers providing information on potential human health hazards and risks posed by bismuth is available from ECHA. The following is a summary of relevant conclusions made by ECHA on bismuth:

- ECHA has classified bismuth (as bismuth, oxide, hydroxide and sulphide forms) as non-hazardous.
- The ECHA dossier describes a derived no effect level (DNEL i.e. dose at which no adverse health effects occurred) for chronic exposure to bismuth. The DNEL (systemic effects) for long term exposure via oral ingestion is 13.3 mg/kg body weight /day. Using a standard regulatory calculator for deriving soil health investigation levels in Australia (ASC NEPM Toolbox HIL calculator.) the soil screening value is 25,000 mg/kg. This concentration is four orders of magnitude greater than the maximum reported soil concentration (5.91 mg/kg).

On this basis bismuth was not considered as a CoI.

The final chemicals of interest and the relevant sampling media are listed in Table 3 below.

Table 3: CoI Identified for Next Phase of Works

Chemical of Interest		Recommended Analytical Schedule					
		Soil	Water	Sediment	Air	Eggs	Lamb
1	Antimony	✓	✓	✓	✓	✓	✓
2	Arsenic	✓	✓	✓	✓	✓	✓
4	Copper	✓	✓	✓	✓	✓	✓
5	Cyanide[1]	✓	✗	✗	✗	✗	✗
6	Iron	✓	✓	✓	✓	✓	✓
7	Lead	✓	✓	✓	✓	✓	✓
8	Manganese	✓	✓	✓	✓	✓	✓
9	Mercury	✓	✓	✓	✓	✓	✓

Chemical of Interest		Recommended Analytical Schedule					
		Soil	Water	Sediment	Air	Eggs	Lamb
10	Zinc	✓	✓	✓	✓	✓	✓
11	Cadmium	✓	✓	✓	✓	✓	✓
12	Nickel	✓	✓	✓	✓	✓	✓

✓- recommended for analysis ✗ - not recommended for analysis

[1] Cyanide is recommended for analysis in soils only as it is considered unlikely to be present in other matrices based on historical use and low potential for bioaccumulation.

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APPENDIX F

Antimony in the Environment

Typical Antimony Concentrations

Environment	Concentration	Reference
Dissolved Sb in unpolluted waters	<1 ug/L	Filella et al., 2002a
Mean crustal average	0.2 mg/kg	Onishi and Sandell, 1955
Aerosols over remote oceans	Typically <0.1 ngm^3	Fiella 2009
Aerosols over industrial areas	2-3 ngm^3	Fiella 2009
Basalt rock	015 mg/kg	Onishi and Sandell, 1955
Granitic rocks	0.2 mg/kg	Onishi and Sandell, 1955e
Shale	1-2 mg/kg	Onishi and Sandell, 1955
Australian Soils	4-44 mg/kg	ANZECC 1992 soils

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APPENDIX B

HRA - Introduction and Methodology

1.0 INTRODUCTION

In early 2014, the Costerfield community voiced concern with the former Department of State Development, Business and Innovation[1] that the mining operations in the Costerfield area may be a source of elevated antimony detected in biological samples collected from a local resident and water samples collected from local water tanks and nearby Tin Pot creek.

Golder Associates Pty Ltd (Golder) was engaged as an independent expert by the Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR) and Department of Health & Human Services (DHHS) to conduct an environmental monitoring program of soil, water, air and biota at Costerfield, and a human health risk assessment using the collected data.

The environmental site assessment at Costerfield was undertaken over three stages:

- Rapid Health Assessment, June 2014 – including ambient air monitoring and soil and tank water sampling. The rapid health assessment is discussed further in Section 2.0.
- Further Assessment to support the human health risk assessment (HRA), September 2014 to September 2015 - including stock sampling (lamb and eggs), air modelling, desktop study, tank water and soil sampling and ambient air monitoring.
- HRA, as documented in this report.

The rapid health assessment concluded that adverse health effects were unlikely due to antimony exposure estimated from a snapshot of environmental samples collected in June 2014. However it also concluded that further investigations and a risk assessment were warranted to inform ways to reduce antimony exposures to residents.

This report presents the data from the Further Assessment and the findings of the HRA. The outline of the report structure is provided in Table 1.

2.0 RAPID HEALTH ASSESSMENT SUMMARY

In order to respond to community concerns regarding antimony exposure in Costerfield, Golder was engaged as an independent expert to conduct an environmental monitoring program and a rapid health assessment. The rapid health assessment was based on data collected in a two week period during June 2014. Samples of shallow soils and tank water were collected, and ambient air monitoring was undertaken from one measuring station. The results of the rapid health assessment were reported in *Rapid Health Assessment and Preliminary Report on Monitoring Program Based on Information and Data Available to 15 June 2014*, Golder document number: 147613051-001-R-Rev3, dated 20 June 2014.

The key findings of the June 2014 environmental monitoring program were as follows:

- Regional levels of antimony in soil are naturally elevated. This is the reason antimony is mined in Costerfield.
- Antimony was the key metal measured above guideline levels. At 33 of 34 residential properties antimony concentrations in tank water were greater than the Australian Drinking Water Guideline. For soil, 13 of 34 residential properties reported an exceedance of the provisional antimony investigation level.
- The preliminary air monitoring results indicated low particulate levels (PM_{10} and $PM_{2.5}$). Antimony was measured within these particulates with a maximum ambient air concentration of 0.011 µg/m^3 [2].

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[1] Now Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR)

[2] This is lower than the human health risk screening level derived by Golder (refer Appendix F) of 1 µg/m^3.

Using conservative assumptions, the rapid health assessment found that adverse health effects were unlikely for both adults and children from the estimated antimony exposure. The assessment did conclude that further investigations and a comprehensive health risk assessment were warranted to inform ways to reduce antimony exposures to residents.

Although most residences within Costerfield are likely to result in low exposures, there are a small number of residences that, if children were present every day, there would be a need to reduce exposure levels. The rapid health assessment recommended implementation of mitigation measures in the interim between the rapid health assessment and completion of the HRA. The following measures were recommended to reduce exposure:

- Using drinking water that complies with the drinking water standard.
- Reducing indoor dust.
- Reducing soil exposures (e.g. replace soil in play areas and garden beds).

The rapid health assessment fulfilled the purpose of addressing the immediate health concerns of the Costerfield community. The outcomes and recommendations of the rapid health assessment are essentially superseded by the results of this HRA.

3.0 HRA PROJECT OBJECTIVES

The objective of the overall program was to develop a HRA for the metals of interest to:

1) Provide an understanding of the potential level of risk to human health in the area

2) Estimate how much of the risk to human health is attributed to mine activities.

4.0 STRUCTURE OF THE HRA TECHNICAL REPORT

The methodology and findings of the HRA are presented in a series of Appendices that detail the various components of the project, as outlined in Table 1.

Table 1: Report Structure

Appendix	Title	Content
A	Desktop Review - Antimony in the Costerfield Area	A copy of the Golder (2015) background report on the nature, transport and distribution of antimony in the environment, for the Costerfield area, Victoria.
B	Risk Assessment Methodology	An outline of the HRA approach, and summary of the document structure.
C	Problem Formulation	This is the first part of the issue identification stage. Includes the development of the Conceptual Site Model (CSM) to describe the sources, receptors and pathway(s) by which stressors (e.g., chemicals) can move from the source to the receptor, and identifies the complete pathways that have been assessed in further stages of the HRA.
D	Environmental Data Review & Selection of COPC	This is the second part of the issue identification stage and is often referred to as a Tier 1 risk assessment. The available environmental data is reviewed and screened against published environmental guidelines (relevant to the pathways and receptors to be assessed) to select the chemicals of potential concern (COPC) that have been assessed in further stages of the HRA.
E	Exposure Assessment	An outline of the equations and exposure parameters used to calculate the estimated daily intakes of the COPC for children and adults in Costerfield.
F	Toxicity Assessment and Interaction Profile	This appendix presents a review of toxicity information and an interaction profile for the COPC. This section is referred to as the ‘hazard assessment’ in the Australian Risk Assessment Framework.
G	Risk Characterisation	Details of the model used to calculate the estimated daily intakes and the hazard quotients, and a summary of the results.
H	Variability Assessment	An analysis of the uncertainties and sensitivities in the risk characterisation results.
I	Sources of Metals in the Environment	A review of various data sets to assist in understanding the key sources of the metals modelled in the HRA.

5.0 RISK ASSESSMENT FRAMEWORK

Risk assessment provides a systematic approach for characterising the nature and magnitude of the risks to health associated with environmental health hazards and is an important tool for decision-making (enHealth, 2012). It should be emphasised, however, that a health risk assessment (HRA) is only one of the tools used to gather and assess information which then feeds into the risk management process. Social, economic, political and technological factors are some of the other important considerations that contribute to the decision making process.

In addition to ongoing refinement of toxicological studies and modelling practices, the following represent the primary guidance in Australia:

- Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards. enHealth Council, September 2012.

- National Environment Protection (Assessment of Site Contamination) Measure 1999. The “ASC NEPM”. National Environment Protection Council / Standing Council on Environment and Water. The ASC NEPM was substantially revised and amended in 2013.

In addition to prevailing national guidance, consideration is also made of local direction from EPA Victoria and relevant Victorian State Environment Protection Policies.

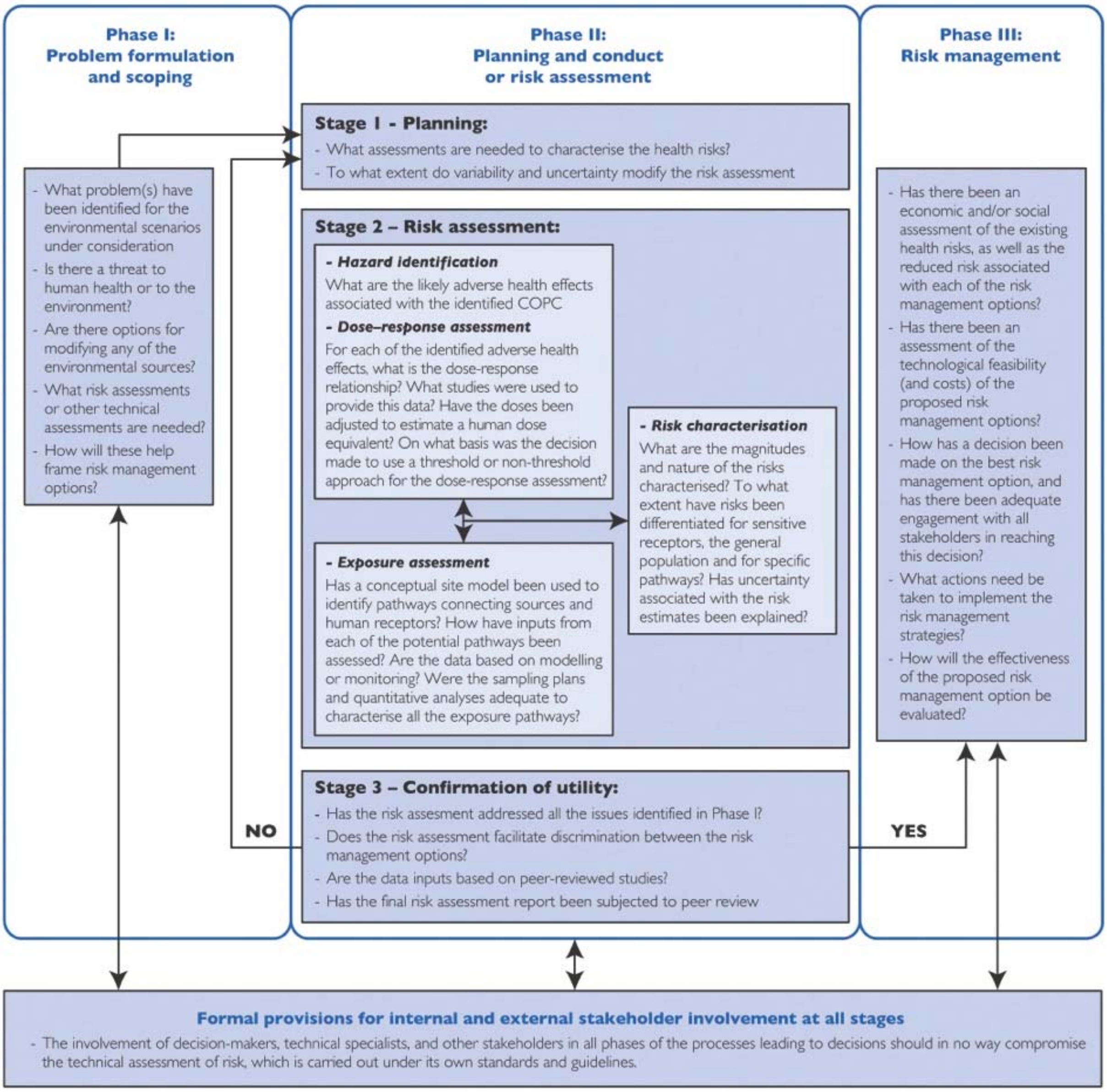
6.0 RISK ASSESSMENT APPROACH

The risk assessment framework adopted for the updated HRA is in general accordance with the Australian guidance (enHealth 2012) model for site-specific health risk assessment as presented in Table 2.

Table 2: Principal Steps Involved in Human Health Risk Assessment

Steps	Description
Problem Formulation (Issues Identification)	Identifies issues that can be assessed through a risk assessment and assists in establishing a context for the risk assessment. It includes assessing: ■ What is the concern? ■ What is causing the identified concern? ■ Why is the concern an issue? ■ How the concern was initially identified? ■ How the concerns were raised? ■ Whether the issue is amenable to risk assessment? ■ Whether risk assessment is appropriate? Issues have dimensions related to perception, science, economics and social factors that are important to establish the context of risk assessment and help in the process of risk management. There is a need to distinguish between “hazards” and “issues”.
Hazard Assessment (Toxicological Assessment)	The hazard assessment characterises the relationship between magnitude of exposure and adverse health effects and assesses the conditions under which the adverse effects may to occur.
Exposure Assessment	Assesses the amount, frequency, duration and routes of exposure to substances present in environmental media. In this assessment, exposure is estimated as the concentration of a compound to which a receptor may be exposed over long-term (i.e. chronic) exposure periods.
Risk Characterisation	Risk is a function of the hazard and the exposure or the dose i.e. the probability of the hazard being realised. A hazardous substance may pose a health risk at sufficiently high exposure. Conversely, a highly hazardous substance may not pose a health risk if exposure is very low. Risk characterisation combines the information from the exposure and hazard assessment steps to estimate the potential health risks associated with length of exposure.
Uncertainty and Variability Assessment	Identifies potential sources of uncertainty and qualitative discussion of the magnitude of uncertainty and expected effects on risk estimates.

Figure 1 displays the relationship between the HRA process and other aspects of environmental contaminant investigation.



Phase I: Problem formulation and scoping

- What problem(s) have been identified for the environmental scenarios under consideration
- Is there a threat to human health or to the environment?
- Are there options for modifying any of the environmental sources?
- What risk assessments or other technical assessments are needed?
- How will these help frame risk management options?

Stage 1 - Planning:

- What assessments are needed to characterise the health risks?
- To what extent do variability and uncertainty modify the risk assessment

Stage 2 – Risk assessment:

- Hazard identification

What are the likely adverse health effects associated with the identified COPC

- Dose–response assessment

For each of the identified adverse health effects, what is the dose-response relationship? What studies were used to provide this data? Have the doses been adjusted to estimate a human dose equivalent? On what basis was the decision made to use a threshold or non-threshold approach for the dose-response assessment?

- Exposure assessment

Has a conceptual site model been used to identify pathways connecting sources and human receptors? How have inputs from each of the potential pathways been assessed? Are the data based on modelling or monitoring? Were the sampling plans and quantitative analyses adequate to characterise all the exposure pathways?

- Risk characterisation

What are the magnitudes and nature of the risks characterised? To what extent have risks been differentiated for sensitive receptors, the general population and for specific pathways? Has uncertainty associated with the risk estimates been explained?

Stage 3 – Confirmation of utility:

- Has the risk assesment addressed all the issues identified in Phase I?
- Does the risk assessment facilitate discrimination between the risk management options?
- Are the data inputs based on peer-reviewed studies?
- Has the final risk assessment report been subjected to peer review

Phase III: Risk management

- Has there been an economic and/or social assessment of the existing health risks, as well as the reduced risk associated with each of the risk management options?
- Has there been an assessment of the technological feasibility (and costs) of the proposed risk management options?
- How has a decision been made on the best risk management option, and has there been adequate engagement with all stakeholders in reaching this decision?
- What actions need be taken to implement the risk management strategies?
- How will the effectiveness of the proposed risk management option be evaluated?

Formal provisions for internal and external stakeholder involvement at all stages

- The involvement of decision-makers, technical specialists, and other stakeholders in all phases of the processes leading to decisions should in no way compromise the technical assessment of risk, which is carried out under its own standards and guidelines.

Figure 1: Australian Frameworks for Human Health Risk Assessment (from enHealth 2012)

Figure 2: Risk Assessment Fundamentals

In the issue identification (problem formulation) step, the issues relevant to the risk assessment are assessed. This includes the development of a preliminary risk assessment conceptual site model (CSM). The CSM describes three elements: sources, receptors and pathway(s) by which stressors (e.g., chemicals) can move from the source to the receptor. These three elements need to be integrated to characterise the risk, as described in Figure 2.

The CSM for the Costerfield HRA is presented in Appendix C. This CSM considers the potential sources of antimony and associated metals in the environment and the pathways of exposure for the residents of Costerfield.

7.0 WHAT IS AN ACCEPTABLE RISK?

To assess whether or not an estimated or measured concentration indicates that a population may be at risk, a tolerable daily intake (TDI)[3] or an acceptable risk against which the exposure information can be compared, needs to be established for each chemical under consideration. Typically, TDI and acceptable risk levels are derived by regulatory agencies (such as the World Health Organization or the United States Environmental Protection Agency) and are based on scientific evidence available at the time.

The term "*acceptable risk*" can be an emotive one, since "*acceptable*" may mean different things to different people and in different circumstances. In this report, acceptable risk means a level of risk established by a regulatory agency.

For community members who may be unintentionally exposed to chemicals, the most important question is "is it safe?" The concept, as well as the perception, of safety or risk are subjective and will vary between individuals and circumstances. Safety does not necessarily mean the absence of risk, nor does risk mean the absence of safety. HRA is a measure of the possible effects of a substance expressed in a consistent and verifiable way that reflects a judgement based on the available information at the time. It provides a tool for comparing the estimates of safety or risk between substances and circumstances and assigning priorities when developing management options.

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[3] Reference values are named variably by different jurisdictions as Toxicity Reference Values (TRV), Tolerable Concentration (TC), Reference Concentration (RfC), Minimum Risk Levels (MRL), and also as probabilistic estimates of impacts, such as Unit Risk (UR, the impact associated with exposure to a unit concentration, such as 1 µg/m^3). TRVs are not thresholds of effect and typically include several safety factors or uncertainty factors in their derivation.

8.0 ESTIMATES OF RISK

8.1 Individual Chemicals

In HRA, the ratio of the TDI[4] to an estimated the exposure concentration (or dose) of a chemical is known as the hazard quotient (HQ), and provides a verifiable measure of the safety or risk under a particular set of conditions.

The HQ is a measure of the margin of safety, which is reflected in the size of the HQ - the smaller the HQ the larger the margin of safety.

- If the HQ is less than or equal to one, the estimated exposure concentration (or dose) is less than equal to the TDI, suggesting that the chemical is unlikely cause adverse health effects.
- If the HQ value is greater than one, the exposure concentration is greater than the TDI. This may be interpreted to present an “unacceptable risk”. However, a breach of the TDI does not necessarily mean that adverse health effects are imminent or that there is a high potential for adverse effects.

In cases where the HQ is greater than one, the underlying reasons for the result requires further consideration. Pertinent data will include the mode of action of the COPC, and the degree of conservatism introduced in the exposure assessment and the TDI. A judgement can then be made as to whether or not the exposure may lead to adverse effects. For example, in cases where conservative assumptions have been made about exposure, the exposure assessment may then be refined to a more realistic scenario or additional site data may be obtained to remove conservative assumptions made in the modelling process.

The numerical value generated in calculating HQ is a useful tool for assigning priorities to risks and assessing the need for more in depth investigations and assessment. Generally, further action is not warranted for HQ values that only marginally exceed (scenario specific, nominally by less than 50%) the target a value of 1 because of the degree of conservatism in the TDI and the HRA (enHealth, 2012).

The equations used and details of the HQ values for the chemicals modelled in this HRA, as well as discussion of the risks outcomes are presented in Appendix G of this report.

8.2 Cumulative Risks

The estimates of risk discussed above (section 8.0) consider exposure to only a single chemical. However, to understand the potential health risks to the Costerfield community, the HRA needs to consider potential impacts from multiple chemicals exposure routes. The approach adopted in this HRA to assess cumulative risk is the summation of risk estimates.

In this approach, the HQ values for the individual chemicals and exposure pathways are summed for each receptor, to give a hazard index (HI) value.

enHealth (2012) notes that this is a conservative approach to providing an estimate of cumulative risk, as the toxicological reference values (TRV) estimates include safety factors of between 100 and 10,000, therefore the effects of the chemical combinations would need to significantly erode this 100–10,000-fold margin between the TDI and the level where toxic effects begin to occur. Further, this approach assumes a common Mode of Action (i.e the way a chemical affects parts of the body) for the individual chemicals, which may or may not be the case. Discussion on the toxicology of the chemicals modelled in this HRA is presented in the toxicological profiles in Appendix F.

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[4] TDIs for the COPC in a risk assessment are derived in the Hazard Assessment step of a HRA. Refer **Table 2**.

For this HRA, a target HI value of one was adopted. The calculated HI was compared to the target HI of one to provide an overall estimate of risk as described by enHealth (2012):

- Where the overall HI is less than one, it is generally assumed that cumulative risk is within reasonable bounds and that there is no need to undertake a more refined risk assessment.
- Where the HI is greater than 1, it does not imply that risks are unacceptable, although there is clearly some erosion of the conservatism built into each of the processes of determining components of the HQ calculation (exposure and TDI).
- When the HI is greater than 10 there is more reason to undertake further investigation of the risks, including an assessment of whether addition of HQs is justified and/or whether the risk contribution of some of the components is independent.

EnHeatlh (2012) note that this summation of risks is a common approach in the professional practice in Australia, and that further refinement of the risk estimates including consideration of the overestimation of risks is undertaken when the HI exceeds 1.

The details of the HI values for the chemicals modelled in this HRA, and discussion of the risks outcomes are presented in Appendix G.

9.0 REFERENCES

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APPENDIX C

Problem Formulation

1.0 INTRODUCTION

1.1 Background

The purpose of The Problem Formulation stage of HRA is to formulate the problems to be considered by the risk assessment; to identify the issues that can be assessed through a risk assessment and to assist in establishing a context for the risk assessment.

A preliminary Conceptual Site Model (CSM) was developed as part of the Desktop Review (Golder 2015, Appendix A). The CSM summarised the potential linkages (via transport pathways) between sources of antimony and receptors in the receiving environment.

The preliminary CSM found that the main source of antimony in the Costerfield area is mineralised zones of sulphide minerals such as stibnite and adjacent altered host rocks[1] of the Costerfield Formation. Mining activities have resulted in the relocation and (in some cases) concentration of antimony and other metals in the Costerfield environment. Based on the potential sources of chemicals in the Costerfield environment and the reviewed soil and ore data, the preliminary CSM found antimony and, to a lesser extent, arsenic are considered the key chemicals of interest (COI) for the purposes of the assessment of human health risks.

The preliminary CSM described the key pathways for movement of antimony (and related chemicals) in the environment as: direct movement of soil via trucking and hauling of ore and mine waste, and indirect secondary movement, via dust deposition, run off, or infiltration into surface water or groundwater. Other activities which generate dust (such as riding dirt bikes on tailings stockpiles) may increase migration of antimony.

This problem formulation will refine the preliminary CSM to define the chemicals of potential concern (COPC), the pathways of exposures and the receptors that will be considered in the health risk assessment (HRA).

1.2 Study Area

Costerfield is located in rural Victoria, approximately 100 km north-west of Melbourne and 50 km south-east of Bendigo. The largest township within close proximity of Costerfield is Heathcote. The population of the Heathcote District (including the Costerfield area), during 2011, was less than 4000 residents.

The desktop review considered a study area including the broader Costerfield area with particular focus on geological conditions and related mining activities. For the purposes of the HRA, the study area is considered to be the area within the Costerfield Dome, as shown in Figure 1.

Details on the geology are presented in the Desktop Review (Golder 2015, Appendix A). In summary, the Costerfield Township is located within the Costerfield Dome anticline, which is truncated in the east by the Moormbool Fault, resulting in an asymmetric dome like structure (Figure 2). The eroded peak of the Costerfield Dome (comprising Costerfield Siltstone) is exposed approximately 1 km west of the Costerfield Township. Mining activities have occurred extensively within the Costerfield area, predominantly along the Costerfield Anticline shown in Figure 2).

Mineral ore deposits were first officially reported in the Costerfield area in 1860 (Whitelaw 1926). Historic mining occurred by both open cut and underground mining and was most productive during two periods, 1860 to 1883 and 1904 to 1925, with only intermittent small scale production during 1934 to 1950.

The Costerfield mine area has had a large number of different operators since 1860. Mine operations in the Costerfield area are currently owned by Mandalay Resources and are limited to the Augusta mine and

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[1] A body of rock serving as a host for other rocks or for mineral deposits, further details of the Costerfield geology is presented in Appendix A (section 2.2).

Cuffley Lode. Further details on the historical and current mining activities are presented in the Desktop Review (Golder 2015, Appendix A).

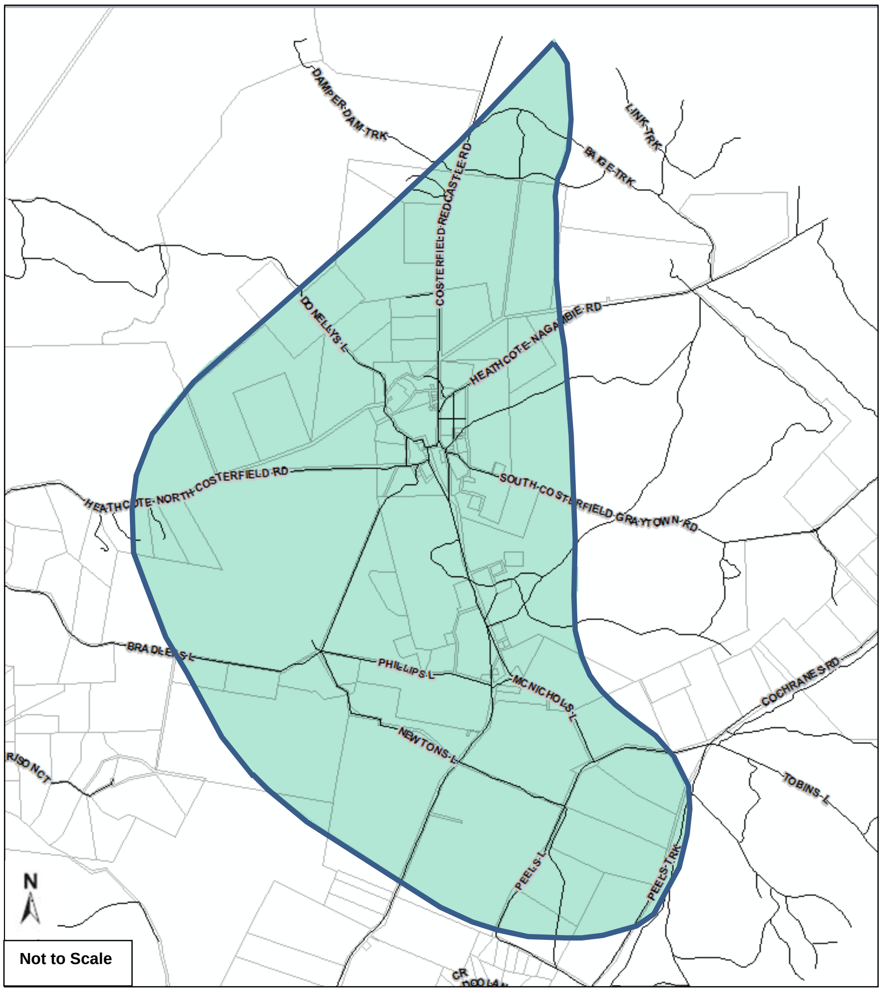

Figure 1: Costerfield Township, showing Costerfield Dome (HRA Study Area)

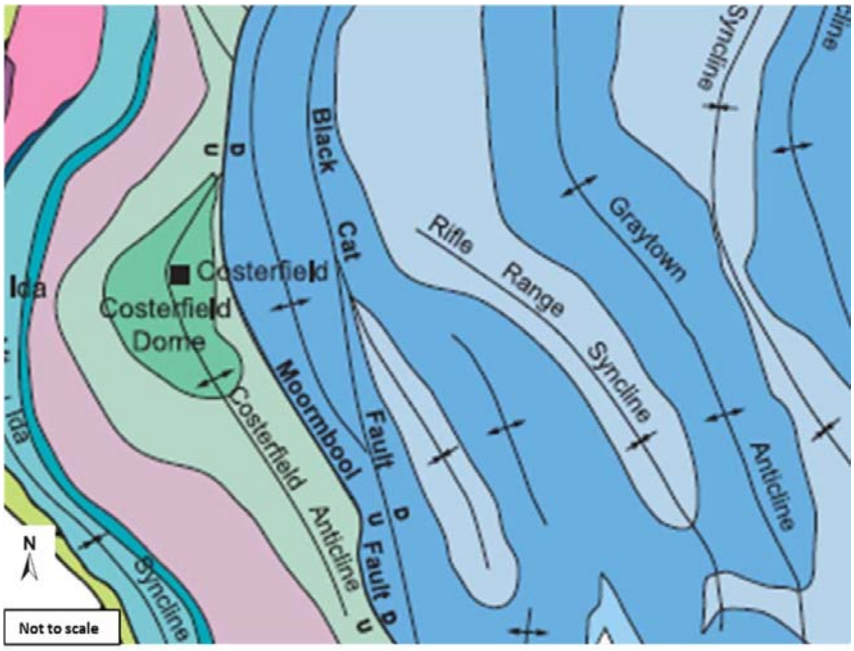

Figure 2: Regional Geology, showing Costerfield Dome
(extracted from SRK Consulting 2013 and created by Vandenberg et. al 2000)

2.0 CONCEPTUAL SITE MODEL

The CSM describes the source(s) of contamination, the pathway(s) by which contaminants may migrate through the various environmental media, and the receptors (human or ecological) that may potentially be exposed. This section presents a summary of the potential sources, potential receptors and the potential pathways of exposure.

2.1 Sources

Metals such as antimony are naturally present within the environment. The concentration of metals naturally present in the environment is highly variable and is influenced by many factors including the underlying geology from which the soil has formed and the extent of weathering. Human activities, including industrialisation, mining, agricultural and domestic activities has resulted in the re-distribution of metals within the environment.

The Desktop Review (Golder 2015, Appendix A) found that, based on the reported metal concentrations and extensive history of soil disturbance in the Costerfield area, the key sources of antimony at the soil surface in excess of typical background conditions are mine wastes. Mine waste materials including tailings are distributed within the town; and much of this material has been exposed to weathering over the past 150 years. Mine wastes vary in metal content and particle size (from waste rock to slum, and particulates emitted from roasting of material and ventilation during processing). Weathering and dust generation is likely to be greater from fine grained mine wastes (such as tailings) compared to coarse large mine wastes (such as overburden). The concentration of metals is typically greatest within the fine fractions of soils. Metal concentrations within dust generated from mine tailings may be proportionally greater than within the general tailings comprising a range of texture material classes. In addition, added contaminants may be present within mine wastes due to mineral ore extraction processes.

In summary, the sources of metals in the environment in and around Costerfield can be described as:

1) Background concentrations – present due to the naturally occurring underlying geology.

2) Historic mining operations – largely mine waste materials including tailings that have historically been distributed within the area.

3) Current mining operations – largely dust and deposited dust from the current mining activities, including traffic movements.

As part of the preliminary CSM, COI were selected to inform the analytical schedule for the environmental sampling. In the absence of environmental data, the preliminary CSM considered the following in selecting the COI:

1) What is in the stibnite ore currently mined in Costerfield?

2) Is the element related to historical mining?

3) What common elements are suitable for assessing the potential for naturally occurring elevated concentrations of target compounds?

4) Which elements are potentially associated with materials used for roofs and tanks?

A tiered screening process was applied to define the list of COI; the details of which are presented in the Desktop Review (Golder 2015, Appendix A). The COI informed the analytical schedule for the environmental data collected in during the data collection phase of the project (June 2014 to September 2015).

The COI selected were:

- Antimony
- Arsenic
- Copper
- Cyanide (only for soil)
- Iron
- Lead
- Manganese
- Mercury
- Zinc
- Cadmium
- Nickel

2.1.1 Environmental Data

A data collection program was conducted by Golder from June 2014 to September 2015. The aim of this program was to support the HRA. The environmental data collection forms part of the Exposure Assessment step of the HRA (refer Table 2 in Appendix B of this HRA).

The details of the environmental media sampled, including sample collection methodology, and a summary and analysis of the chemical results is presented in a series of appendices as shown in Table 1.

Table 1: Summary of Environmental Data

Media	Samples Collected	Appendix Reference
Soil	Surface samples: 242 samples (228 within study area, 14 outside study area) Subsurface samples: 28 samples (21 within the study area, 7 outside study area) Roadway samples: 15 samples (not included in HRA, discussion provided in Appendix D1)	D1
Tank Water	Sampling prior to Tank Cleaning, June – October 2014: 95 samples (81 within study area, 14 outside study area). Sampling post Tank Cleaning, October 2014 – May 2015: 88 samples (86 within study area, 2 outside study area).	D2
Sediment	Base of rainwater tanks: 17 samples (not included in HRA, discussion provided in Appendix D2)	D2
Bottled Water	One sample (collected by Mandalay)	D2

Media	Samples Collected	Appendix Reference
Air Quality	Two monitoring stations, where a 24 hours sample was collected at the following frequency: Oct 2014, Jul 2015 – Aug 2015: one every six days. Nov 2014 – Jun 2015: one every three days.	D3
Locally Grown Produce	Eggs: 20 samples (4 eggs collected at 5 properties) Lamb: 15 samples (5 tissues samples from 10 sheep)	D4
Surface Dust	Surface dust swab samples from four properties and one silage bag (not included in HRA, discussion provided in Appendix D5)	D5

Surface Water and Groundwater

As discussed in the Desktop Review (Golder 2015, Appendix A), surface water and groundwater may act as a pathway for antimony movement within and beyond the Costerfield area but was not identified as a significant human health pathway (Monash University (2014)). Golder has not undertaken a chemical assessment of groundwater or surface water within the Costerfield area. EPA Victoria is responsible for the regulation of discharges to surface water bodies and Goulburn – Murray Water is responsible for management of groundwater resources.

2.1.2 Selection of Chemical of Potential Concern

For the HRA, the COI list has been refined to key chemicals, referred to as the chemicals of potential concern (COPC). A screening process has been applied to the data set for each environmental media to determine the COPC.

The screening process for each data set is described in the individual appendices as listed in Table 1. The general approach is as follows:

1) Select published Australian guideline values, applicable to a residential use scenario (considers adult and child exposures) for use as screening criteria.
    a. Where Australian guidelines are not available, consider the applicability of international guidelines for use as screening criteria.
2) Review of individual data results from the collected samples against relevant screening criteria.
3) Where greater than 5%[2] of the individual results are greater than the screening criteria, the chemical is considered a COPC and should be considered further in the HRA.

The results of the screening identified three COPC:

- Antimony
- Arsenic
- Lead

2.2 Receptors

Land uses within the township of Costerfield comprise mining, agriculture, low density residential development, and limited commercial and recreational activities. The population of Costerfield includes adults and children who are permanent residents in the area, as well and families and individuals who stay in the area intermittently, such as over weekends or during school holidays. For the purposes of the HRA, the following receptors have been considered:

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[2] For small data sets, it may be appropriate to consider any one result above the screening criteria. The review and justification of COPC for each media is presented in the individual Appendices as listed in Table 1.

- Permanent residents (living in Costerfield 365 days per year):
  1) Adult - > 18 years
  2) Child - 10 years old
  3) Child - 2 years old
  4) Child - 1 year old
- Weekend Resident (living in Costerfield 2 days/week, or 104 days/year):
  1) Adult - > 18 years
  2) Child - 10 years old
  3) Child - 2 years old
  4) Child - 1 year old

The age brackets have been selected to reflect the different stages of development and different activity patterns of infants, toddlers and young children. Older children (i.e. 11 – 18 years) are likely to have similar behaviour patterns as adults and as such for the purposes of the HRA are not considered to require a separate model. Potential differences in the toxicological effects for different age groups are discussed further in the toxicity assessment (Appendix F).

There may also be a number of sensitive or susceptible sub-populations within the residents of Costerfield. These could include adults or children with chronic illness, pregnant women or lactating mothers. Although these groups may have different exposure characteristics, it is considered that the adoption of ‘average’ and ‘upper estimates’ for the input exposure parameters (refer Appendix E) and adoption of conservative toxicity reference values (refer Appendix F) will be sufficiently conservative to estimate exposures to these populations.

2.3 Pathways

The fundamental requirement for a risk to occur is that there should be an exposure pathway linking the source of contamination and the exposed population. Where this linkage exists, an assessment of the nature and significance of the exposure pathway is required to assess the level of risk NEPM (2013). The pathways of exposure potentially relevant to the residents of Costerfield are as follows:

- Soil – incidental ingestion during outside activities (e.g. gardening, children playing)
- Soil – dermal contact during outside activities (e.g. gardening, children playing)
- Dust – inhalation outdoors and indoors
- Water – ingestion via drinking tank water or bottled water
- Water – dermal contact and ingestion whilst showering or bathing in tank water
- Water – dermal contact and ingestion whilst swimming in local dams or swimming pools
- Locally grown foods – ingestion of locally produced eggs and lamb

The above exposure pathways were all considered to be potential complete linkages, relevant to the study area.

All pathways with the exception of swimming in local dams or swimming pools have been modelled in the HRA. The exposure risks due to dermal contact and ingestion of water whilst swimming in local dams or swimming pools has not been included in the modelling as there is insufficient information regarding the concentrations of COPC in dams or swimming pools to support the calculation of an estimated daily intake.

Monitoring of water in a pool located within the study area was undertaken approximately monthly from October 2014 until May 2015 (excluding November). The results of this are discussed in Appendix D2. The results suggest that there are potential risks to health if the pool is left uncovered, so allowing dust deposition over a period of time. This risk can be managed though regular cleaning or covering the pool whilst not in use. If the pool is covered or cleaned regularly, swimming in a local swimming pool risks are considered to be acceptable.

The assessment of locally grown foods has considered the intakes of COPC due to the consumption of locally produced eggs and lamb. The assessment has not included intakes from other locally produced foods such as vegetables or poultry. Whilst this is a limitation, the data on typical background food intakes of the selected COPC suggests that this pathway is unlikely to be a significant contributor to the estimated daily intake as root uptake into plants is likely to be low. Further discussion on the food intakes for the COPC is presented in the toxicological profiles for each chemical included in Appendix F.

2.4 Summary

The exposure model describing the possible mechanisms of exposure is also presented in Figure 3. The CSM showing the possible sources of metal contamination, the relevant environmental media, exposure pathways and receptors modelled in the quantitative HRA is summarised in a flow diagram in Figure 4.

With respect to the sources of metals, this CSM (Figure 3) considered the environmental media the source. A detailed review of how these metals come to be present in the environment and their behaviour and movement in the environment is beyond the scope of this HRA, however review of the available data and consideration of the available historical information is considered in Appendix I.

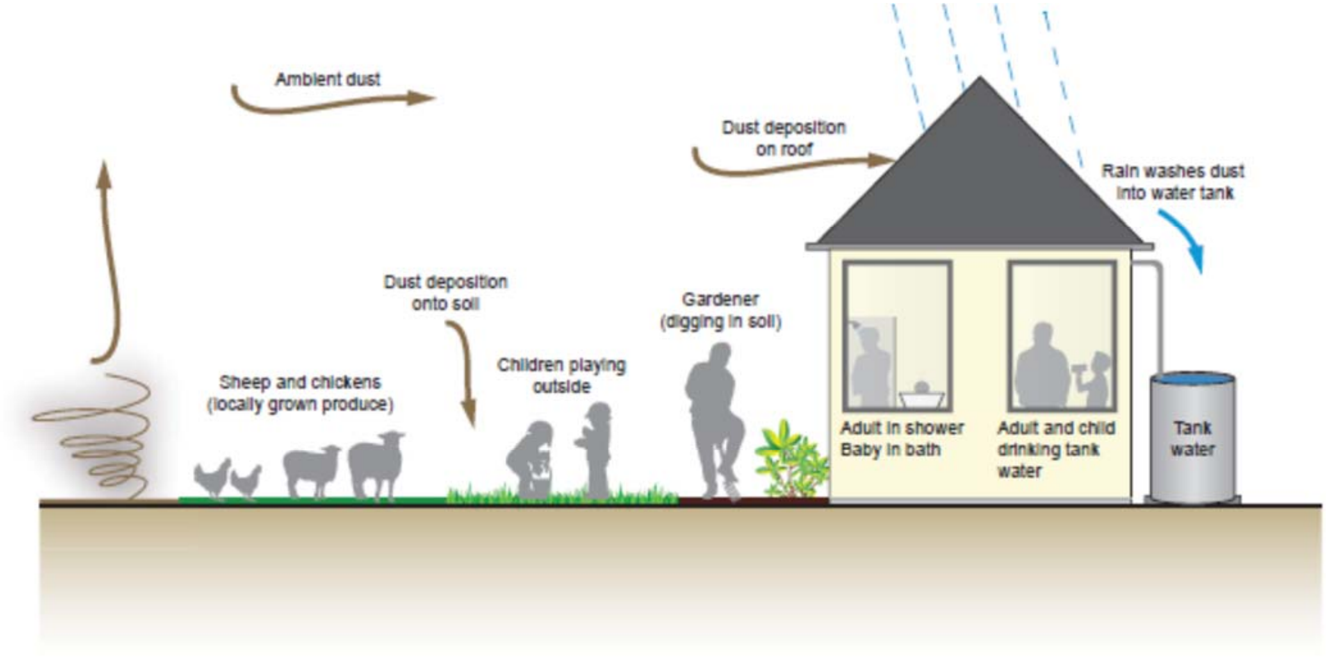

Figure 3: Conceptual Exposure Model

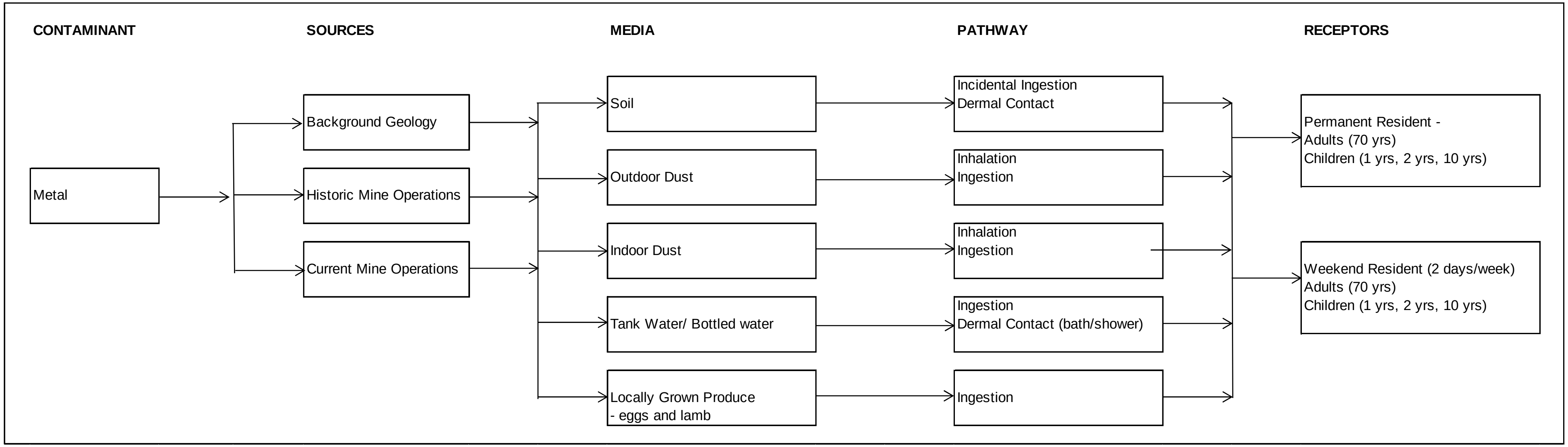

Figure 4: Conceptual Site Model

3.0 REFERENCES

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APPENDIX D

Environmental Data Review
(Soil, Water, Air, Food, Surface Dust, Bioaccessibility in soil, Soil Isotope Analysis)

1.0 INTRODUCTION

Appendix D1 presents a summary of the soil assessment programs conducted by Golder in the Costerfield region. The soil data will be used in the HRA exposure assessment (Appendix E), to calculate the estimated daily intakes of selected chemicals due to their presence in soil. This Appendix describes the following:

- summary of the sampling approach and methodology;
- summary of the results and statistical analysis of the data;
- comparison of the data to published assessment criteria to establish the chemicals of potential concern (COPC) which is the list of chemicals to be modelled it the HRA; and
- establishment of the 'average' and 'upper estimate' soil concentrations of COPC for input into the HRA exposure model.

The following tables are referred to throughout and attached to this appendix:

- Table D1.1: Soil Analytical Results
- Table D1.2: Soil QA/QC results
- Table D1.3: Field blanks, rinsate and laboratory blank results

A statistical review of the soil data has also been undertaken with respect to understanding the potential sources of chemicals in the environment and the potential contribution of the mining activities to the concentrations reported. This assessment is presented separately in Appendix I.

2.0 SOIL ASSESSMENT METHODOLOGY

Soil sampling and analysis was conducted by Golder in June and October 2014 to assess concentrations of selected metals, including antimony, in shallow surface soils and along roadways. A summary of the methodology is provided in Table 1.

Table D1-1 at the end of this Appendix presents the results of the individual soil samples that have been considered in the risk assessment. The table highlights the results that are higher than the adopted assessment criteria as described in Table 1.

Table 1: Soil Sampling Methodology

Item	Description
Adopted Sampling Guidelines	■ **Australian/New Zealand Standard 4482.1 (2005) Guide to the investigation and sampling of sites with potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds.** This standard was prepared as part of a series on the identification, analytical methods and investigation procedures for the assessment of soil. The objective of this standard is to derive the information which may be required to satisfy regulatory authorities, although additional detail may be required in some locations. ■ **National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No.1).** This guidance is recognised as the primary national guidance document for the assessment of site contamination in Australia. The purpose of the guideline is to '*establish a nationally consistent approach to the assessment of site contamination to ensure sound environmental management practices by the community which includes regulators, site assessors, environmental auditors, landowners, developers and*

Item	Description
	industry'.
Sample Points	■ **Surface samples:** Exposed soil near main residential dwellings, in particular from within vegetable gardens and lawns. ■ **Subsurface samples:** Subsurface soil within the assessment area. Samples collected 20 cm below the ground surface with one exception where sample was collected 10 cm below the ground surface (a deeper sample was not able to be collected due to hard ground conditions). ■ **Roadway samples:** Exposed soil on dirt roadways within the assessment area.
Number of Primary Soil Samples Collected	■ **Surface samples:** 204 samples (190 samples from properties within study area, 14 samples from properties outside study area) ■ **Subsurface samples:** 29 samples (22 samples from properties within the study area, 7 samples from properties outside study area) ■ **Roadway samples:** 15 samples
Soil collection methodology	■ **Surface samples**: To represent exposed soil, the ground surface was gently scraped with a gloved hand or clean trowel to collect surface soil. ■ **Subsurface samples**: A hand auger was used to dig to the required sample depth. A sample was collected using gloved hands. ■ Hand augers and trowels were decontaminated between each soil sampling location by first removing any soil adhered to the tool, washing the equipment in a bucket with phosphate-free detergent using brushes, rinsing in a bucket of tap water then rinsing again in a bucket of laboratory supplied de-ionised water. ■ Nitrile gloves were replaced between each soil sampling location.
Record of Sample Location	Sampling locations were recorded with hand-held GPS with +/- 10 m accuracy.
Sample Storage	Soil samples were placed in new jars supplied by the laboratory. Jars were labelled with a unique identifier.
Sample Delivery	The samples were transferred into chilled, insulated containers and delivered to the analytical laboratory under Chain of Custody (CoC) procedures.
Laboratory for Soil Analysis	The laboratory engaged as the primary laboratory for the analysis was ALS Environmental Pty Ltd. The secondary laboratory selected for quality assurance testing was Eurofins MGT. Both laboratories are registered by the National Association of Testing Authority (NATA) for the analyses performed.
Laboratory Analytical Schedule	Samples were designated for analysis of soil pH and metals (including antimony, arsenic and manganese). Selected samples were analysed for additional metals (including aluminium, boron, beryllium, barium, cadmium, copper, cobalt, iron, lead, mercury, nickel, selenium, vanadium and zinc), cyanide, sulphur, sulphate, total organic carbon, cation exchange capacity and electrical conductivity.
Adopted Assessment	■ **National Environment Protection (Assessment of Site Contamination) Measure (NEPM), 2013 Health Investigation Levels - Residential A Soil (HIL**

Item	Description
Criteria	**A).** ‘Residential A’ represents low density residential land. - The soil assessment criteria were selected based on the objectives of the State Environment Protection Policy (Prevention and Management of Contamination of Land) (Land SEPP).The soil assessment criteria adopted for the protected beneficial use of ‘Human Health’ in low density residential areas is the NEPM 2013 HIL A. Other beneficial uses of land were not considered in this assessment. - Antimony - Victorian Department of Human Services Personal Correspondence Tuesday 10 June 2014 detailed a residential soil guideline of 100-300 mg/kg for antimony when people are exposed via soil and drinking water. The recently adopted NEPM (2013) includes a calculator for estimating HIL values for substances. Using the tolerable daily intake of 0.006 mg/kg for antimony, the calculated value is 200 mg/kg. - Aluminium, barium and vanadium – the NEPM (2013) does not include a HIL for these compounds, therefore the US EPA (2015) risk-based screening levels for residential soil was adopted for these compounds.

3.0 SELECTION OF CHEMICAL OF POTENTIAL CONCERN

As part of the Desktop Review (Golder, 2015), Golder identified related chemicals of interest (COI), in addition to antimony, which may require consideration in a comprehensive human health risk assessment (HRA). Based on the potential sources of chemicals in the environment and the reviewed background soil and ore data, the COI for the soil analysis included antimony and other compounds as listed in Table 2.

Following the identification of the COI, soil sampling was undertaken by Golder as outlined in Table 1. The results of this sampling and analysis was reviewed as described below to establish the list of chemicals of potential concern (COPC) that were carried through in the HRA.

The soil risk assessment considered the chemicals of interest in soil. To select the COPC in soil, the data was first screened against publish Australian guidelines (adopted assessment criteria) developed to assess potential exposures of residents (children and adults) to chemicals in soil. In general, where a chemical result is above the generic screening guideline, the chemical was retained for further consideration in the risk assessment. When a chemical concentration is below the screening guideline, the concentrations were considered to be acceptable in the residential setting and as such they were not considered further in the risk assessment. Discussion on the guidelines adopted and the screening results is presented in the sections below.

3.1 Soil Data Assessment

3.1.1 Assessment Criteria

As outlined in Table 1, the adopted assessment criteria are the NEMP 2013 HIL A. The HILs are applicable for assessing human health risk via direct contact (dermal contact, ingestion and inhalation of dusts) pathways of exposure. These criteria have been used to screen the data to identify the COPC that will be carried through into the HRA. NEPM HIL A have not been published for antimony, aluminium, barium and vanadium, however screening criteria for other jurisdictions have been adopted (refer Table 1).

The NEPM (2013) has considered the proportion of intake of the individual chemical that is typically provided by sources other than soil (e.g. food, water and consumer products). This background concentration has been considered for each threshold chemical based on available data from Australia and, where limited data is available, from other countries. Therefore the assessment criteria are considered appropriate to use for Tier 1 screening for selection of COPC for the HRA.

3.1.2 Data Sets

The soil data set used is the results from those samples collected from within the properties of the study area within the Costerfield Dome area[1].

The data collected from roads was excluded from the risk assessment calculations as this data is not considered representative of on-going long-term exposures to residents when they are undertaking activities outside (e.g. gardening, playing with children in the backyard). To assess the impact of this approach, the summary statistics for both data sets are presented in Table 2. This summary indicates that there is little difference between the two data sets (soil from properties and soil from roads). The chemicals with results above the screening criteria were the same in both data sets, and the average concentration varies by up to ±5%. It is therefore considered reasonable to exclude the road samples for the assessment of risks to residents.

3.1.3 Selection of COPC

The adopted assessment criteria and a summary of the number of individual results above the criteria are presented in Table 2. The table highlights that reported concentrations of antimony, arsenic, cadmium, lead and zinc were above the relevant criterion.

For cadmium and zinc, there is one individual result each above the guideline, from a total of 248 individual results (0.4%). For cadmium, the maximum concentration is 24 mg/kg, compared to an assessment criterion of 20 mg/kg, and the average concentration is 0.78 mg/kg. For zinc, the maximum concentration is 13,200 mg/kg and the average concentration is 249 mg/kg, compared to an assessment criterion of 7,400 mg/kg. Given the infrequent nature of concentrations above the assessment criteria, it is considered that cadmium and zinc are not COPC for the HRA.

As discussed in the Desktop Review (Golder, 2015, included in Appendix A), iron is a common earth metal and was included as a COI to potentially assist with the assessment of the spatial distribution of the source of antimony and arsenic in the environment. Iron is an element which is essential to life, as a natural constituent of biofluids. Iron is not commonly considered a COI in human health risk assessments, as humans have homeostatic mechanisms to process iron. Based on the Cramer decision tree for toxicants, all normal constituents of the body are considered a low priority for investigation (Cramer and Ford 1977; EC 2011; EFSA 2012). Therefore, iron is not considered a COPC for the purpose of HRA.

In summary, the COPC in soil that will be considered in the HRA are:

- Antimony
- Arsenic
- Lead.

3.1.4 HRA Input Concentrations

The HRA has been developed to assess the regional risks to residents in Costerfield, therefore the input concentrations used in the HRA should reflect a typical or average concentration across the study area. Both surface (0-0.1 m depth) and sub-surface (0.2-0.3 m depth) results were considered for the HRA input as although residents may be exposed to surface soils more frequently, activities such as gardening, or children digging and playing in the backyard may result in exposure to deeper soils, noting that the deeper soil are only 20-30 cm below the ground surface. Given the number of deeper samples (22) compared to the surface samples (190) the inclusion of the data for the deeper soils does not significantly influence the statistical

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[1] The area was defined based on the geological boundary of the Costerfield Dome presented as discussed in the Desktop Review and shown in Figures 3 and 4 of that report (Refer Appendix A).

analysis of the data. Further discussion on the variation between surface and sub-surface concentrations is presented in Appendix I.

The statistics presented in Table 2 consider the study area data set for properties within the Costerfield Dome. The data was collected across 43 properties; however the number of samples collected at each property varied from 2 to 20 samples.

An average concentration of all the data will be skewed towards the concentrations present at those properties with a larger number of samples. Typically a larger number of samples were collected from properties with higher concentrations. To remove this potential bias, the data was assessed on a per property basis (excluding road samples). The calculation of an average and maximum concentration from the statistics *per property* reduces the influence of the number of samples collected per property. The distribution of the average concentrations per property for antimony, arsenic and lead are shown in Figures 1, 2 and 3 respectively.

An assessment of the soil property data for selected chemicals has also been made with respect to the 95% Upper Confidence Limit on the arithmetic mean (95% $\text{UCL}_{\text{average}}$). The calculated 95% $\text{UCL}_{\text{average}}$ concentration for a given analyte indicates that, with 95% certainty, the average concentration will not exceed the calculated 95% $\text{UCL}_{\text{average}}$ concentration.

For comparison, the summary statistics per property for antimony, arsenic and lead are presented in Table 3 alongside the average, geometric mean, 95% UCL and 95th percentile concentration for the data set (shaded cells).

The HRA requires two concentration inputs: an average exposure concentration and an upper estimate.

To represent the average concentration the following was considered:

- Arithmetic mean (average) of the full data set for properties within the Costerfield Dome
- Geometric mean of the full data set for properties within the Costerfield Dome
- Median Concentration of the full data set for properties within the Costerfield Dome
- Arithmetic mean (average) of the average concentrations at each property

The input selected for the HRA is the average of the average concentrations at each property, as discussed above this approach reduces the influence of the number of samples collected from individual properties, and provides an indication of the average soil concentrations across the Costerfield Dome.

For antimony, arsenic and lead, the average of property averages is lower than the average of the entire data set (due to the influence of selected properties where a larger number of samples were collected and higher results reported, see Figure1), but it is higher than the geometric mean or the median.

For the upper estimate, the input selected was the 95th percentile concentration for full data set. Typically in a contaminated land assessment, the 95% UCL would be selected for this purpose, however given the large range of concentrations of the COPC and the limited spatial extent of the sampling program, the higher 95th percentile concentration was adopted. This is considered to represent a reasonable upper concentration to which average Costerfield residents may be exposed.

Further statistical analysis of the soil data set is presented in Appendix I.

The input concentrations for the HRA are highlighted bold in Table 3.

Table 2: Summary of Soil Data

	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Vanadium	Zinc
Screening Criteria	*77000*	*200*	*100*	*15000*	*60*	*4500*	*20*	*100**	*100*	*6000*		*300*	*3800*	*40*	*400*	*200*	*390*	*7400*
ALL PROPERTIES INCLUDING ROAD SAMPLES																		
Number of Results Above Criteria	0	**66**	**20**	0	0	0	**1**	0	0	0	0	**19**	0	0	0	0	0	**1**
Number of Results	91	248	248	45	45	45	248	45	45	248	203	248	248	157	248	45	45	248
Number of Detects	91	212	206	44	13	0	14	45	32	219	203	227	247	52	236	0	45	241
Minimum Concentration (mg/kg)	1280	<5	<5	<10	<1	<50	<1	3	<2	<5	2680	<5	<5	<0.1	<2	<5	6	<5
Maximum Concentration (mg/kg)	22300	8670	367	200	2	<50	24	46	24	1140	330,000	3760	1650	6.8	84	<5	68	13200
Average Concentration (mg/kg)	6362	328	31	57	0.71	25	0.76	20	6.8	23	28790	113	217	0.21	18	2.5	21	236
Median Concentration (mg/kg)	5690	76	12	40	0.5	25	0.5	19	5	15	25400	22	142.5	0.05	14	2.5	19	67
Standard Deviation (mg/kg)	3125	854	51	46	0.41	0	2	13	6	74	27316	396	233	0.59	15	0	12	928
INSIDE THE DOME EXCLUDING ROAD SAMPLES																		
Number of Results Above Criteria	0	**63**	**20**	0	0	0	**1**	0	0	0	0	**19**	0	0	0	0	0	**1**
Number of Results	75	211	211	32	32	32	211	32	32	211	179	211	211	136	211	32	32	211
Number of Detects	75	211	211	32	32	32	211	32	32	211	179	211	211	136	211	32	32	211
Minimum Concentration (mg/kg)	1280	5	5	10	1	50	1	3	2	5	2680	5	5	0.1	2	5	7	5
Maximum Concentration (mg/kg)	22300	8670	367	200	2	50	24	46	24	1140	330000	3760	1650	6.8	73	5	68	13200
Average Concentration (mg/kg)	6613	359	35	63	1.1	50	1.3	23	7.8	25	29382	132	223	0.26	16	5	23	263
Median Concentration (mg/kg)	6000	95	14	50	1	50	1	25.5	6	15	24900	27	151	0.1	14	5	22.5	78
Standard Deviation (mg/kg)	3251	887	54	49	0.3	0	2.1	13	6	80	28537	427	237	0.62	11	0	13	995
Geometric Mean (mg/kg)	5959	85	18	48	1	50	1	19	6	15	22189	38	147	0	13	5	20	92
95% Upper Confidence Limit (mg/kg)	-	738.7	50.66	-	-	-	1.53	-	-	-	-	259.4	-	-	-	-	-	565.7
95th Percentile (mg/kg)	11590	1210	125	164	2	50	1	43	20	48	63880	477	657	0.9	38	5	43	772

- Not calculated, * Cr VI

Table 3: Summary of Soil Results for COPC – Inside the Dome

	Antimony	Arsenic	Lead
Screening Criteria	*200*	*100*	*300*
Number of Properties	43	43	43
Average Minimum Property Concentration (mg/kg)	55	10	29
Average of Average Property Concentration (mg/kg)	**275**	**30**	**96**
Average of Maximum Property Concentration (mg/kg)	740	76	358
Average Concentration (mg/kg)	359	35	132
Median Concentration (mg/kg)	95	14	27
Geometric Mean (mg/kg)	85	18	38
95% Upper Confidence Limit (mg/kg)	738.7	50.66	259.4
95th Percentile (mg/kg)	**1210**	**125**	**477**

Bold values adopted as input into HRA.

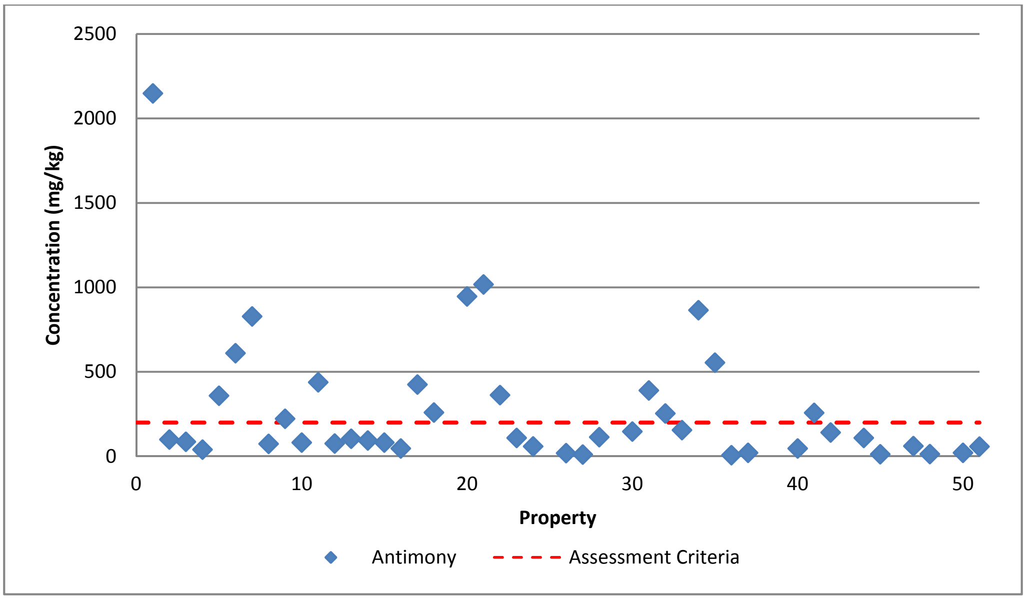

Figure 1: Antimony Average Concentration per Property

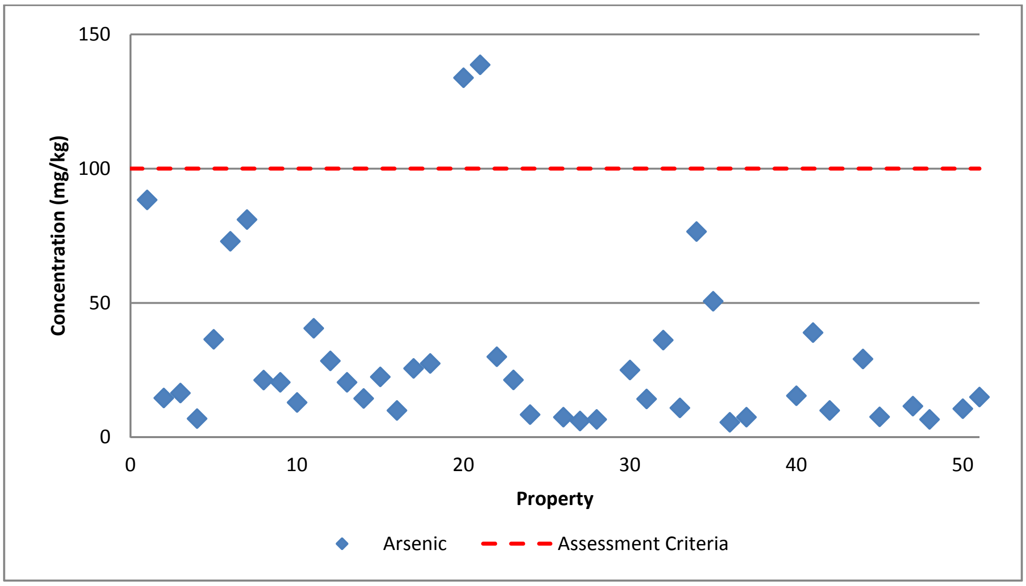

Figure 2: Arsenic Average Concentration per Property

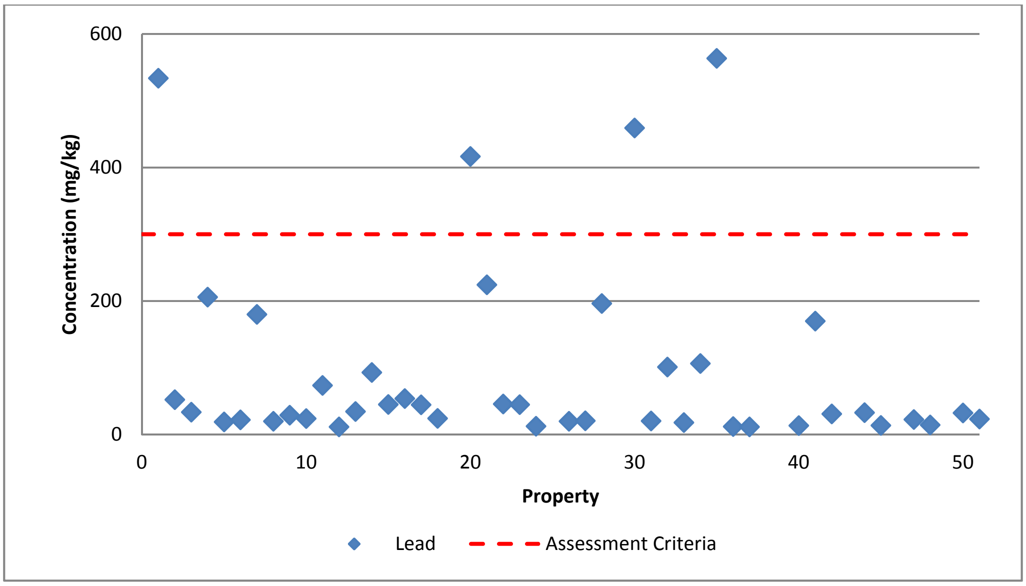

Figure 3: Lead Average Concentration per Property

4.0 QUALITY ASSURANCE AND QUALITY CONTROL

4.1 Data quality objectives and indicators

The data quality review has been conducted utilising the Data Quality Objectives (DQOs) and Data Quality Indicators (DQIs) as outlined by NEPM (NEPC, 2013) and the NSW EPA Auditor guidelines (NSW EPA, 2006), which include:

- Representativeness; the confidence (expressed qualitatively) that data are representative of each media present on the site.
- Comparability; the confidence (expressed qualitatively) that data may be considered to be equivalent for each sampling and analytical event.
- Precision; a quantitative measure of the variability or reproducibility of data.
- Accuracy (or bias); a quantitative measure of the closeness of reported data to the true value.
- Completeness; a measure of the amount of usable data (expressed as %) from a data collection activity.

For each DQO an assessment of various DQIs is required with respect to the field and laboratory programs. Acceptance limits set to assess DQIs are outlined in Table 4, below.

Table 4: Summary of Project Quality Acceptance Limits

DQO	DQI	Acceptance Limit
Representativeness	-	Environmental sampling to be conducted in general accordance with national guidance - NEPM (2013)
Comparability	LORs	Preferably below acceptance criteria
Precision	Field Duplicates	Duplicates are to be collected at a rate of 10% of all samples of which 50% are to be analysed by the primary laboratory and 50% are to be analysed by the secondary laboratory. Relative Percent Difference (RPD) to be less than 50% for field duplicates analysed by the primary and secondary laboratories. Where duplicate results exceeded the primary result, the duplicate result would be adopted as a conservative value.
	Internal Laboratory Duplicates	Duplicates to be analysed at a rate of at least 10%. RPDs to be less than 30% for laboratory duplicates.
Accuracy	Field Blanks	Collected for each day of sampling per sampling team during the additional assessment to assess for potential cross contamination during sampling. Sample containers filled with laboratory supplied deionised water were left open during the collection of the primary sample. These were analysed for the same suite of metals as the primary sample. Results should be below LORs.
	Rinsate Blanks	Collected for each piece of plastic equipment, in general per day of sampling. Rinsates also collected at a rate of 1 per set of reusable sampling equipment per sampling team per day. One rinsate collected off disposable gloves during the additional assessment. Analysed for metals as per the primary samples. Results should be below LORs.

DQO	DQI	Acceptance Limit
Accuracy	Laboratory Bottle Blanks	Preparation and analysis within the primary and secondary laboratory of plastic bottle blanks at two pH levels, pH 4 and pH 7, to assess for potential contamination of samples from plastic laboratory bottles. Analysed for metals of interest. Results should be below LORs.
	Laboratory Method Blanks	Results should be below LORs.
	Laboratory Control Sample Spikes (LCS)	Analysed at a frequency of 10% of total samples analysed by the laboratory. Recoveries for most analytes should generally be within the range of 70% to 130%. This spike refers to a certified reference material or an independently prepared interference free matrix spiked with target analytes. Organic LCS' are almost exclusively blank water spiked with target analytes.
	Matrix Spikes	Analysed at a frequency of 10% of total samples analysed by the laboratory. Recoveries for most analytes should generally be within the range of 70% to 130%. Different matrix effects can affect the recoveries of some analytes and therefore recoveries that fall outside this range may still be acceptable. Matrix spikes refer to an intra-laboratory split sample, spiked with a representative set of target analytes. This spike monitors potential matrix effects on analyte recoveries.
	Surrogates	For every sample analysed by gas chromatography or gas chromatography-mass spectroscopy techniques, at least one surrogate is required to be added to the sample during sample preparation. Surrogates are added or analysed with each batch of samples and recoveries should be within acceptable laboratory limits.
	Overall Completeness	95%
Completeness	Calibration	Calibration of equipment required in accordance with manufactures instructions.
	LORs	LORs adopted by primary and secondary laboratories should be below the adopted assessment criteria.
	Documentation	Laboratory and field documentation in accordance with NEMP (2013).

The Primary (intra-laboratory) and Secondary (inter-laboratory) Duplicates are duplicate samples of the primary sample collected during sampling. The Primary Duplicates are labelled differently to the Primary Sample and both are submitted to the primary laboratory for analysis. The Secondary Duplicate is sent to the quality control laboratory (secondary or 'check' laboratory) for analysis to compare the results obtained between the two laboratories.

The Primary and Secondary Duplicate results are compared with primary sample results using Relative Percent Difference (RPDs). RPDs are calculated according to the following formula where A is the concentration of the primary laboratory result per analyte, B is the corresponding duplicate result and ABS is the absolute number:

$$\%RPD = ABS\left\{\left[\frac{A-B}{A+B}\right]*200\right\}$$

RPD values can range from 0% (indicating perfect correlation between results) to 200% (indicating complete divergence in results).

4.2 QA/QC Results

A summary of the QA/QC completeness for soil samples, including sediment, is presented in Table 5 and Table 6.

Table 5: Summary of Data Quality Indicators

DQO	Field & Laboratory DQI Considerations
Representativeness	Soil and sediment were sampled in general accordance with NEPM (2013) guidelines. Samples were analysed using the same laboratory procedures and within appropriate holding times. Appropriate collection, handling, storage and preservation used.
Comparability	Standard procedures were used for the collection of samples, use of qualified samplers, same types of instruments used, same types of samples collected, same analytical methods used, same sample limits of reporting (LORs), same laboratories, same units, same laboratory methods and appropriate sample integrity. The laboratories used were NATA registered and the methods used were to be NATA endorsed for the majority of the analyses undertaken.
Precision	Assessed through the collection of field duplicates, analysis of primary and secondary laboratory field duplicates and analysis of laboratory duplicates. Details are provided in Table 6.
Accuracy	This was assessed through compliance with standard procedures and analysis of field blanks, rinsates, reagent blanks, method blanks, matrix spikes, surrogate spikes, reference materials, laboratory control samples and laboratory prepared spiked control samples. Different matrix effects can affect the recoveries of some analytes and therefore recoveries that fall outside this range may still be acceptable. Accuracy is assessed by measuring the extent to which an analytical result reflects the known concentration as measured by the recovery obtained from internal laboratory spikes. Details are provided in Table 6.
Completeness	Locations sampled were selected to meet the objective of the project. Field and laboratory documentation was collected and assessed to be correct. Appropriate standard procedures were used and complied with. Samples were analysed for analytes in accordance with the proposal and variations to meet the objectives of the assessment. Laboratory methods and LORs were appropriate. Sample documentation including CoCs is complete and sample holding times in compliance. Acceptable data are obtained when samples are collected and analysed in accordance with the quality control procedures and the DQIs.

Table 6: Summary of Soil QA/QC Completeness

QC Sample Type	No. Results (individual analytes) NOT Meeting DQI	Total No. Results (individual analytes)	Percentage Results Meeting DQI
Sample Receipt Notifications-Primary Lab	0	4,916	100.0%
Holding Time Exceedances-Primary Lab	0	4,916	100.0%
Field Primary Duplicates-Primary Lab	17	311	94.5 %
Field Rinsates-Primary Lab	17	213	92.0 %
Internal Primary Lab Duplicates	19	1,016	98.1 %
Internal Primary Lab Method Blanks	0	579	100.0 %
Internal Primary Lab Control Spikes	0	553	100.0 %
Internal Primary Lab Matrix Spikes	5	354	98.6 %
Internal Primary Lab Surrogate Spikes	0	44	100.0 %
Sample Receipt Notifications-Secondary Lab	0	498	100.0 %
Holding Time Exceedances-Secondary Lab	7	498	98.6 %
Field Secondary Duplicates-Secondary Lab	45	266	83.1 %
Internal Secondary Lab Duplicates	0	69	100.0 %
Internal Secondary Lab Method Blanks	0	69	100.0 %
Internal Secondary Lab Control Spikes	0	47	100.0 %
Internal Secondary Lab Matrix Spikes	0	48	100.0 %
Internal Secondary Lab Surrogate Spikes	0	36	100.0 %
Overall Soil Completeness	**110**	**14,433**	**99.2** %

4.3 Discussion of Soil QA/QC Completeness

- 20 primary and 20 secondary duplicates were analysed during the assessment with a total of 249 primary soil samples analysed. This equates to a frequency of 16% for the collection of field duplicates of which 8% were intra-laboratory duplicates and 8% were inter-laboratory duplicates. This complies with the minimum collection frequency of 5%. Soil primary and secondary analytical results are presented in Table D1-2, attached.
- Of the 311 primary duplicate analytes, 17 returned RPDs above 50%, representing a conformance level of 95%. RPDs greater than 50% were reported for heavy metals (Al, Sb, As, Zn, Fe, Pb, Mn, Hg), moisture content, conductivity, sulphate and total organic carbon. Primary results were generally greater than duplicate results. Where duplicate results were greater than primary sample results, all duplicate results were below adopted acceptance criteria.
- Of the 266 secondary duplicate analytes, 45 returned RPDs above 50%, representing a conformance level of 83%. High RPDs were reported for metals (Sb, As, Zn, Fe, Pb, Mn, Hg, Cr, B, Ba, Co, Ni, Mg, Ti, V, Be), moisture content, electrical conductivity, sulphate, total organic carbon, potassium and calcium. A comparison of the primary and duplicate result against each other and against adopted acceptance criteria was conducted. The following was noted:

  - In general, duplicate results were less than the primary sample result.
  - Where duplicate results were greater than the primary sample result, the duplicate results were generally below adopted acceptance criteria. The exception to this was one antimony result, where the duplicate result has been adopted in the HRA as a conservative measure.
- 17 of the 213 rinsate analytes were reported with detections greater than the laboratory limit of reporting, primarily for metals (Sb, As, Cd, Cu, Pb, Mn, Ni and Zn). A review of the primary results indicates that these have not been impacted, due to the low levels of detection reported in the rinsates. Rinsate results are presented in Table D1-3 attached.
- A review of the Primary and Secondary Laboratory internal QA/QC procedures, including laboratory duplicates, matrix spikes, method blanks and laboratory control samples, indicates that the conformance level was greater than the 95%, providing confidence in the accuracy and precision of the results.
- The LORs adopted by primary and secondary laboratories were below criteria and considered suitable for the assessment. The exception to this was the LOR for some metals, including antimony, adopted by the secondary laboratory, however based on discussions with the laboratory indicated that analysis for a lower LOR was not possible. The LORs adopted by the secondary laboratory are considered sufficient for the purposes of assessing duplicate samples and internal QA/QC procedures of the secondary laboratory.

The achieved QA/QC completeness of 97% is above the overall completeness objective of 95%. Based on this, it is considered that the overall data quality generated during the assessment of soil is sufficient for the purposes of the HRA.

5.0 REFERENCES

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NEPC (2013). National Environment Protection (Assessment of Site Contamination) Measure, 1999. National Environment Protection Council, Australia, amendment date 11 April 2013.

US EPA (2015) Regional Screening Levels for Chemical Contaminants at Superfund Sites June 2015, accessed at: http://www2.epa.gov/risk/regional-screening-table

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APPENDIX D1
Soil Data Summary

Attachments

1. **Table D1.1 Soil Analytical Results**
2. **Table D1.2: Soil QA/QC results**
3. **Table D1.3: Field blanks, rinsate and laboratory blank results**

					Exchangable Cations				Heavy Metals																		Other	Sample Quality Parameters					
					Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Vanadium	Zinc	CEC	Electrical Conductivity @ 25°C	Sulphate (as SO4)	Cyanide (free)	Sulphur (as S)	Total Organic Carbon	Moisture
					%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/kg	uS/cm	mg/kg	mg/kg	mg/kg	mg/kg	%
	EQL				0.1	0.1	0.1	0.1	50	5	5	10	1	50	1	2	2	5	50	5	5	0.1	2	5	5	5	1	1	50	1	50	200	1
	Assessment Criteria - Residential Soil				NA	NA	NA	NA	*77,000*	200	100	*15,000*	60	4500	20	100	100	6000	NA	300	3800	40	400	200	*390*	7400	NA	NA	NA	250	NA	NA	NA
Property ID	**Sample ID**	**Depth**	**Date**	**Within/Outside Costerfield Dome**																													
19	19_BH1/4001_20141008	0-0.05	8/10/2014	Outside	-	-	-	-	-	18	<5	-	-	-	<1	-	-	<5	3400	<5	101	<0.1	<2	-	-	9	-	-	-	<1	-	-	23.7
19	19_BH2/4001_20141008	0-0.05	8/10/2014	Outside	-	-	-	-	-	10	<5	20	<1	<50	<1	4	<2	<5	-	<5	32	<0.1	<2	<5	7	17	-	36	<50	<1	300	32,500	23.1
19	19_BH2/4002_20141008	0.2-0.3	8/10/2014	Outside	-	-	-	-	-	<5	<5	20	<1	<50	<1	4	<2	<5	-	<5	59	<0.1	<2	<5	7	<5	-	10	<50	<1	<100	900	10.3
29	29_BH01/4001_20141007	0-0.05	7/10/2014	Outside	-	-	-	-	-	27	6	-	-	-	<1	-	-	9	13,400	11	75	0.1	8	-	-	22	-	-	-	<1	-	-	16.6
29	29_BH02/4001_20141007	0-0.05	7/10/2014	Outside	-	-	-	-	-	<5	6	120	<1	<50	<1	14	6	15	-	10	874	<0.1	10	<5	14	87	-	1280	200	2	600	47,600	33.6
29	29_BH02/4002_20141007	0.2-0.3	7/10/2014	Outside	-	-	-	-	-	<5	6	90	<1	<50	<1	18	12	10	-	12	1010	<0.1	11	<5	21	24	-	176	<50	<1	200	4700	15.2
38	38_BH01/4001_20141006	0-0.05	6/10/2014	Outside	-	-	-	-	-	19	<5	30	<1	<50	<1	4	<2	<5	-	<5	69	<0.1	<2	<5	6	8	-	180	<50	2	300	26,800	14.8
38	38_BH01/4002_20141006	0.2-0.3	6/10/2014	Outside	-	-	-	-	-	22	<5	<10	<1	<50	<1	4	<2	<5	-	<5	7	<0.1	3	<5	6	<5	-	6	<50	<1	<100	2000	6.8
38	38_BH02/4001_20141006	0-0.05	6/10/2014	Outside	-	-	-	-	-	9	<5	-	-	-	<1	-	-	<5	4050	<5	62	<0.1	<2	-	-	7	-	-	-	1	-	-	1.5
39	39_BH01/4001_20141007	0-0.05	7/10/2014	Outside	-	-	-	-	-	<5	7	50	<1	<50	<1	30	15	12	-	10	72	<0.1	41	<5	23	86	-	324	<50	<1	200	14,600	8.3
39	39_BH01/4002_20141007	0.2-0.3	7/10/2014	Outside	-	-	-	-	-	<5	7	-	-	-	<1	-	-	16	30,500	12	57	<0.1	44	-	-	75	-	-	-	<1	-	-	9
39	39_BH02/4001_20141007	0-0.05	7/10/2014	Outside	-	-	-	-	-	<5	<5	40	<1	<50	<1	17	4	15	-	8	49	<0.1	16	<5	16	43	-	582	90	<1	300	25,300	8.5
46	46_BH01/4001_20141007	0-0.05	7/10/2014	Outside	-	-	-	-	-	<5	<5	-	-	-	<1	-	-	<5	4950	<5	129	<0.1	2	-	-	15	-	-	-	1	-	-	18.6
46	46_BH02/4001_20141007	0-0.05	7/10/2014	Outside	-	-	-	-	-	<5	<5	-	-	-	<1	-	-	9	32,400	40	183	<0.1	10	-	-	1900	-	-	-	<1	-	-	17.9
46	46_BH02/4002_20141007	0.2-0.3	7/10/2014	Outside	-	-	-	-	-	<5	<5	30	<1	<50	<1	5	<2	<5	-	<5	128	<0.1	<2	<5	8	11	-	26	<50	-	200	1100	11.7
52	52_BH01/4001_20141007	0-0.05	7/10/2014	Outside	-	-	-	-	-	6	7	50	<1	<50	<1	20	7	15	-	10	119	<0.1	19	<5	23	38	-	112	<50	<1	200	15,000	14.4
52	52_BH01/4002_20141007	0.2-0.3	7/10/2014	Outside	-	-	-	-	-	<5	7	30	1	<50	<1	25	10	19	-	11	58	<0.1	33	<5	21	62	-	13	<50	<1	200	5200	9.5
52	52_BH02/4001_20141007	0-0.05	7/10/2014	Outside	-	-	-	-	-	<5	5	-	-	-	<1	-	-	6	27,200	9	62	<0.1	10	-	-	21	-	-	-	<1	-	-	11.1
53	53_BH01/4001_20141006	0-0.05	6/10/2014	Outside	-	-	-	-	-	<5	<5	-	-	-	<1	-	-	50	4870	22	223	<0.1	5	-	-	193	-	-	-	<1	-	-	5.8
53	53_BH02/4001_20141006	0-0.05	6/10/2014	Outside	-	-	-	-	-	<5	15	20	<1	<50	<1	13	<2	5	-	7	23	<0.1	5	<5	16	20	-	23	<50	<1	200	9900	1.6
53	53_BH02/4002_20141006	0.2-0.3	6/10/2014	Outside	-	-	-	-	-	<5	6	20	<1	<50	<1	12	<2	<5	-	5	20	<0.1	4	<5	16	11	-	18	<50	<1	300	33,800	7.6
1	1/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	9680	697	126	-	-	-	20	-	-	95	82,500	3760	533	-	25	-	-	13,200	-	19	-	-	-	-	41.7
1	1/4002_20140603	0-0.05	3/06/2014	Within	-	-	-	-	6780	4230	186	-	-	-	9	-	-	30	34,700	3740	189	-	25	-	-	4430	-	90	-	-	-	-	38.2
1	1_BH01/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	814	121	-	-	-	<1	-	-	20	56,500	44	142	0.1	29	-	-	71	-	-	-	<1	-	-	3.4
1	1_BH02/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	223	50	-	-	-	<1	-	-	19	42,500	42	137	<0.1	27	-	-	67	-	-	-	<1	-	-	4.7
1	1_BH03/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	103	19	-	-	-	<1	-	-	20	42,600	31	543	<0.1	44	-	-	81	-	-	-	<1	-	-	15.7
1	1_BH04/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	650	27	130	1	<50	<1	19	24	25	-	38	239	<0.1	41	<5	18	84	-	110	<50	<1	300	4200	5
1	1_BH05/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	94	65	-	-	-	2	-	-	23	71,100	653	94	<0.1	26	-	-	230	-	-	-	<1	-	-	5.4
1	1_BH06/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	6590	325	-	-	-	<1	-	-	24	28,200	317	151	0.8	15	-	-	404	-	-	-	<1	-	-	8.1
1	1_BH07/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	1370	58	-	-	-	<1	-	-	41	32,400	222	427	0.5	28	-	-	154	-	-	-	<1	-	-	28
1	1_BH08/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	8670	51	-	-	-	<1	-	-	12	21,300	42	122	6.8	12	-	-	130	-	-	-	<1	-	-	12.3
1	1_BH09/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	114	40	-	-	-	-	-	-	-	-	418	-	-	-	-	-	-	-	-	-	-	-	-	10.8
1	1_BH10/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	6540	278	-	-	-	-	-	-	-	-	306	-	-	-	-	-	-	-	-	-	-	-	-	8.8
1	1_BH11/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	3110	60	-	-	-	-	-	-	-	-	102	-	-	-	-	-	-	-	-	-	-	-	-	6.2
1	1_BH12/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	7460	31	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-	6.2
1	1_BH13/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	1420	124	-	-	-	-	-	-	-	-	717	-	-	-	-	-	-	-	-	-	-	-	-	10
1	1_BH14/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	59	28	-	-	-	-	-	-	-	-	63	-	-	-	-	-	-	-	-	-	-	-	-	3.3
1	1_BH15/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	17	17	-	-	-	-	-	-	-	-	22	-	-	-	-	-	-	-	-	-	-	-	-	5.4
1	1_BH16/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	103	26	-	-	-	-	-	-	-	-	28	-	-	-	-	-	-	-	-	-	-	-	-	3.9
1	1_BH17/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	729	76	-	-	-	-	-	-	-	-	51	-	-	-	-	-	-	-	-	-	-	-	-	5.6
1	1_BH18/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	538	60	-	-	-	-	-	-	-	-	69	-	-	-	-	-	-	-	-	-	-	-	-	7.5
2	2/4001_20140604	0-0.05	4/06/2014	Within	-	-	-	-	10,800	126	16	-	-	-	<1	-	-	19	59,900	47	76	-	18	-	-	80	-	428	-	-	-	-	17.2
2	2/4002_20140604	0-0.05	4/06/2014	Within	4.6	2	0.6	<0.1	14,300	168	22	-	-	-	<1	-	-	24	63,700	91	157	-	25	-	-	168	72	36	<50	-	-	32,800	26.4
2	2/4003_20140604	0.2-0.3	4/06/2014	Within	1.2	2.6	0.2	<0.1	22,300	<5	6	-	-	-	<1	-	-	26	40,000	19	42	-	35	-	-	54	40	14	60	-	-	4200	24.3
3	3/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	9720	97	18	-	-	-	<1	-	-	10	36,800	26	110	-	13	-	-	42	-	36	-	-	-	-	17.6
3	3/4002_20140603	0-0.05	3/06/2014	Within	-	-	-	-	8170	76	15	-	-	-	<1	-	-	21	33,800	41	261	-	12	-	-	170	-	53	-	-	-	-	20.1
4	4/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	4480	8	<5	-	-	-	<1	-	-	114	7980	5	714	-	11	-	-	525	-	1390	-	-	-	-	49.4
4	4/4002_20140603	0-0.05	3/06/2014	Within	-	-	-	-	3900	72	9	-	-	-	<1	-	-	13	6590	407	128	-	4	-	-	777	-	7	-	-	-	-	15.1
5	5/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	7100	592	68	-	-	-	<1	-	-	16	19,800	24	132	-	10	-	-	62	-	16	-	-	-	-	27.6
5	5/4002_20140603	0-0.05	3/06/2014	Within	-	-	-	-	2640	125	<5	-	-	-	<1	-	-	12	4240	14	438	-	6	-	-	82	-	31	-	-	-	-	48.7
6	6/4001_20140604	0-0.05	4/06/2014	Within	-	-	-	-	7660	1040	115	-	-	-	<1	-	-	15	32,000	19	184	-	17	-	-	166	-	12	-	-	-	-	22.6
6	6/4002_20140604	0-0.05	4/06/2014	Within	-	-	-	-	10,700	181	31	-	-	-	<1	-	-	13	50,700	25	302	-	23	-	-	134	-	13	-	-	-	-	29
7	7/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	8610	908	124	-	-	-	<1	-	-	18	69,600	401	131	-	21	-	-	127	-	20	-	-	-	-	17.3
7	7/4002_20140603	0-0.05	3/06/2014	Within	-	-	-	-	11,500	10	<5	-	-	-	<1	-	-	<5	14,600	6	91	-	4	-	-	38	-	20	-	-	-	-	8.8
7	7_BH01/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	1890	82	-	-	-	-	-	-	-	-	160	-	-	-	-	-	-	-	-	-	-	-	-	3.9
7	7_BH02/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	41	26	-	-	-	-	-	-	-	-	49	-	-	-	-	-	-	-	-	-	-	-	-	4.6
7	7_BH03/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	909	265	-	-	-	-	-	-	-	-	61	-	-	-	-	-	-	-	-	-	-	-	-	5
7	7_BH04/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	23	<5	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	2.9
7	7_BH05/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	339	34	-	-	-	-	-	-	-	-	40	-	-	-	-	-	-	-	-	-	-	-	-	10.7
7	7_BH06/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	1250	81	-	-	-	-	-	-	-	-	266	-	-	-	-	-	-	-	-	-	-	-	-	10.2
7	7_BH07/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	1690	155	-	-	-	-	-	-	-	-	710	-	-	-	-	-	-	-	-	-	-	-	-	3.7
7	7_BH08/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	337	58	-	-	-	-	-	-	-	-	66	-	-	-	-	-	-	-	-	-	-	-	-	5.4
7	7_BH09/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	1050	76	-	-	-	-	-	-	-	-	188	-	-	-	-	-	-	-	-	-	-	-	-	3.6
7	7_BH10/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	1490	62	-	-	-	-	-	-	-	-	203	-	-	-	-	-	-	-	-	-	-	-	-	5.9
8	8/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	11,800	<5	7	-	-	-	<1	-	-	12	22,500	17	1170	-	14	-	-	37	-	24	-	-	-	-	19.9
8	8/4002_20140603	0-0.05	3/06/2014	Within	5	3.8	0.3	<0.1	7740	28	12	-	-	-	<1	-	-	12	17,500	16	697	-	29	-	-	46	92	176	<50	-	-	17,000	14.8
8	8/4003_20140603	0.2-0.3	3/06/2014	Within	5.7	4.9	0.1	0.4	7000	189	45	-	-	-	<1	-	-	20	20,000	27	452	-	31	-	-	36	111	376	250	-	-	5700	10.2
9	9/4001_20140602	0-0.05	2/06/2014	Within	-	-	-	-	7140	244	27	-	-	-	2	-	-	65	19,000	36	318	-	22	-	-	347	-	48	-	-	-	-	49.9
9	9/4003_20140602	0-0.05	2/06/2014	Within	2.2	1.2	0.4	<0.1	9020	200	14	-	-	-	<1	-	-	10	44,800	22	141	-	16	-	-	48	38	29	<50	-	-	46,700	23.8
10	10/4001_20140604	0-0.05	4/06/2014	Within	-	-	-	-	6540	190	11	-	-	-	<1	-	-	18	15,800	28	77	-	7	-	-	74	-	14	-	-	-	-	21.6
10	10/4002_20140604	0-0.05	4/06/2014	Within	-	-	-	-	6250	44	6	-	-	-	<1	-	-	82	11,800	26	299	-	8	-	-	277	-	12	-	-	-	-	23.6
10	10/4003_20140604	0.2-0.3	4/06/2014	Within	-	-	-	-	6100	10	22	-	-	-	<1	-	-	<5	67,300	18	16	-	6	-	-	7	-	21	-	-	-	-	9
11	11/4001_20140605	0-0.05	5/06/2014	Within	-	-	-	-	3740	3140	236	-	-	-	<1	-	-	16	8860	51	125	-	5	-	-	390	-	25	-	-	-	-	23.9
11	11/4002_20140605	0-0.05	5/06/2014	Within	-	-	-	-	1280	89	<5	-	-	-	<1	-	-	7	3770	15	351	-	5	-	-	100	-	53	-	-	-	-	43.7
11	11_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	106	11	40	<1	<50	<1	12	3	6	-	28	218	<0.1	7	<5	16	50	-	20	<50	<1	300	49,400	21.7
11	11_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	73	7	-	-	-	<1	-	-	<5	13,600	10	81	<0.1	5	-	-	16	-	-	-	<1	-	-	15
11	11_BH03/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	153	12	-	-	-	<1	-	-	12	10,300	208	136	0.5	6	-	-	215	-	-	-	1	-	-	29.1
11	11_BH04/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	123	17	-	-	-	<1	-	-	14	13,000	57	230	<0.1	6	-	-	150	-	-	-	1	-	-	25.7
11	11_BH05/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	463	64	-	-	-	<1	-	-	49	18,400	293	289	1.1	10	-	-	357	-	-	-	1	-	-	28.8
11	11_BH06/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	105	12	-	-	-	<1	-	-	9	30,900	33	128	<0.1	9	-	-	81	-	-	-	<1	-	-	7.3
11	11_BH07/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	41	5	-	-	-	<1	-	-	<5	13,100	11	74	<0.1	6	-	-	22	-	-	-	<1	-	-	13.5

Notes: Assessment criteria from NEPM (2013) HIL A, with the exception of:
italics - Residential soil US EPA Regions 3, 6, and 9 Regional Screening Levels for Chemical Contaminants at Superfund Sites

Table D1.1: Soil Analytical Results

					Exchangable Cations				Heavy Metals																		Other	Sample Quality Parameters					
					Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Vanadium	Zinc	CEC	Electrical Conductivity @ 25°C	Sulphate (as SO4)	Cyanide (free)	Sulphur (as S)	Total Organic Carbon	Moisture
					%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/kg	uS/cm	mg/kg	mg/kg	mg/kg	mg/kg	%
	EQL				0.1	0.1	0.1	0.1	50	5	5	10	1	50	1	2	2	5	50	5	5	0.1	2	5	5	5	1	1	50	1	50	200	1
	Assessment Criteria - Residential Soil				NA	NA	NA	NA	*77,000*	200	100	*15,000*	60	4500	20	100	100	6000	NA	300	3800	40	400	200	*390*	7400	NA	NA	NA	250	NA	NA	NA
Property ID	**Sample ID**	**Depth**	**Date**	**Within/Outside Costerfield Dome**																													
11	11_BH08/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	90	37	-	-	-	<1	-	-	10	69,500	30	183	<0.1	15	-	-	44	-	-	-	<1	-	-	6.8
12	12/4001_20140604	0-0.05	4/06/2014	Within	-	-	-	-	3770	35	23	-	-	-	<1	-	-	26	7340	10	140	-	5	-	-	119	-	142	-	-	-	-	15.5
12	12/4002_20140604	0-0.05	4/06/2014	Within	-	-	-	-	5650	116	34	-	-	-	<1	-	-	25	32,400	13	380	-	73	-	-	62	-	44	-	-	-	-	12.6
13	13/4001_20140603	0-0.05	3/06/2014	Within	9.6	3	0.8	<0.1	5060	182	16	-	-	-	<1	-	-	21	8260	45	436	-	6	-	-	239	134	36	<50	-	-	73,300	37.8
13	13/4002_20140603	0-0.05	3/06/2014	Within	-	-	-	-	4320	26	25	-	-	-	<1	-	-	10	37,600	24	1180	-	5	-	-	78	-	114	-	-	-	-	33.8
14	14/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	13,400	114	10	-	-	-	<1	-	-	37	21,500	128	610	-	11	-	-	240	-	141	-	-	-	-	44.7
14	14/4002_20140603	0-0.05	3/06/2014	Within	-	-	-	-	6870	73	19	-	-	-	<1	-	-	12	16,100	58	128	-	8	-	-	216	-	50	-	-	-	-	31.4
15	15/4001_20140604	0-0.05	4/06/2014	Within	-	-	-	-	5660	50	12	-	-	-	<1	-	-	45	13,300	16	298	-	11	-	-	213	-	164	-	-	-	-	29.6
15	15/4002_20140604	0-0.05	4/06/2014	Within	-	-	-	-	6780	112	33	-	-	-	<1	-	-	42	36,700	74	328	-	26	-	-	1000	-	41	-	-	-	-	35.7
16	16/4001_20140602	0-0.05	2/06/2014	Within	-	-	-	-	5680	26	9	-	-	-	<1	-	-	15	17,400	28	329	-	12	-	-	90	-	50	<50	-	-	-	26.5
16	16/4001_20140602	0-0.05	2/06/2014	Within	9.2	1.8	0.6	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	115	-	-	-	-	31,800	-
16	16/4002_20140602	0-0.05	2/06/2014	Within	-	-	-	-	4850	67	11	-	-	-	<1	-	-	15	22,100	80	235	-	12	-	-	75	-	13	-	-	-	-	22.7
17	17_BH01/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	130	11	-	-	-	<1	-	-	16	36,300	62	536	<0.1	19	-	-	79	-	-	-	2	-	-	24.2
17	17_BH02/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	1110	59	50	<1	<50	<1	43	7	11	-	53	116	0.2	21	<5	41	65	-	21	<50	<1	300	17,900	9.1
17	17_BH02/4002_20141008	0.2-0.3	8/10/2014	Within	-	-	-	-	-	34	7	30	1	<50	<1	32	9	19	-	19	31	0.2	23	<5	26	36	-	10	<50	<1	200	6500	14.9
18	18/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	6000	613	72	-	-	-	<1	-	-	16	27,900	26	264	-	13	-	-	366	-	14	-	-	-	-	27.6
18	18/4002_20140603	0-0.05	3/06/2014	Within	18.2	4.6	0.5	<0.1	5490	195	20	-	-	-	<1	-	-	15	23,500	26	299	-	11	-	-	130	232	58	<50	-	-	140,000	28.6
18	18/4003_20140603	0.2-0.3	3/06/2014	Within	2.1	1.3	0.3	<0.1	7430	10	14	-	-	-	<1	-	-	8	31,400	15	100	-	18	-	-	37	38	22	<50	-	-	4800	8.3
18	18_BH01/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	776	54	40	<1	<50	<1	22	6	12	-	19	107	<0.1	17	<5	19	66	-	23	<50	<1	300	37,500	11.8
18	18_BH02/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	181	16	-	-	-	<1	-	-	7	27,200	42	77	<0.1	10	-	-	52	-	-	-	<1	-	-	14.3
18	18_BH03/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	19	10	-	-	-	<1	-	-	16	28,600	16	164	<0.1	26	-	-	56	-	-	-	<1	-	-	7.7
18	18_BH04/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	9	<5	-	-	-	<1	-	-	<5	2680	<5	12	<0.1	3	-	-	18	-	-	-	<1	-	-	7.1
18	18_BH05/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	304	17	-	-	-	<1	-	-	16	19,800	27	354	0.1	14	-	-	325	-	-	-	<1	-	-	40.3
18	18_BH06/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	517	69	-	-	-	<1	-	-	25	45,100	39	285	<0.1	32	-	-	131	-	-	-	<1	-	-	9.6
18	18_BH07/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	44	9	-	-	-	<1	-	-	10	27,000	30	54	<0.1	13	-	-	24	-	-	-	<1	-	-	4.5
18	18_BH08/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	189	17	-	-	-	<1	-	-	8	26,200	21	94	<0.1	14	-	-	27	-	-	-	<1	-	-	6.1
20	20/4001_20140604	0-0.05	4/06/2014	Within	-	-	-	-	6100	930	106	-	-	-	1	-	-	29	24,000	468	228	-	14	-	-	614	-	57	-	-	-	-	37
20	20/4002_20140604	0-0.05	4/06/2014	Within	-	-	-	-	3910	600	37	-	-	-	<1	-	-	46	10,200	206	323	-	11	-	-	851	-	136	-	-	-	-	13.5
20	20/4003_20140604	0.2-0.3	4/06/2014	Within	-	-	-	-	7310	791	79	-	-	-	<1	-	-	17	55,500	52	42	-	10	-	-	118	-	28	-	-	-	-	17
20	20_BH01/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	769	30	30	<1	<50	<1	44	8	16	-	32	143	0.4	24	<5	45	60	-	476	<50	<1	200	9200	5
20	20_BH02/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	2080	208	-	-	-	3	-	-	35	50,200	669	530	0.5	21	-	-	1980	-	-	-	<1	-	-	13.1
20	20_BH03/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	1510	136	-	-	-	<1	-	-	16	40,600	78	187	0.4	16	-	-	131	-	-	-	<1	-	-	35.3
20	20_BH04/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	1390	100	-	-	-	1	-	-	32	45,300	216	260	0.9	21	-	-	782	-	-	-	<1	-	-	18.7
20	20_BH05/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	1100	138	-	-	-	<1	-	-	65	35,800	2130	837	0.4	26	-	-	710	-	-	-	2	-	-	28.4
20	20_BH06/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	516	318	-	-	-	<1	-	-	28	74,200	56	176	<0.1	21	-	-	91	-	-	-	<1	-	-	5.2
20	20_BH07/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	196	14	-	-	-	1	-	-	13	11,400	84	215	<0.1	8	-	-	259	-	-	-	<1	-	-	17.9
20	20_BH08/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	832	104	-	-	-	<1	-	-	138	35,300	629	485	0.3	18	-	-	641	-	-	-	<1	-	-	24.3
20	20_BH09/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	1140	113	-	-	-	-	-	-	-	-	156	-	-	-	-	-	-	-	-	-	-	-	-	3.9
20	20_BH10/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	1350	417	-	-	-	-	-	-	-	-	292	-	-	-	-	-	-	-	-	-	-	-	-	2.6
20	20_BH11/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	716	117	-	-	-	-	-	-	-	-	291	-	-	-	-	-	-	-	-	-	-	-	-	3.9
20	20_BH12/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	860	194	-	-	-	-	-	-	-	-	405	-	-	-	-	-	-	-	-	-	-	-	-	3.2
20	20_BH13/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	365	31	-	-	-	-	-	-	-	-	901	-	-	-	-	-	-	-	-	-	-	-	-	3.7
21	21/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	4120	331	28	-	-	-	<1	-	-	130	25,400	130	197	-	8	-	-	390	-	108	-	-	-	-	31.9
21	21/4002_20140603	0-0.05	3/06/2014	Within	18.9	5.2	1.3	<0.1	4450	410	21	-	-	-	<1	-	-	113	8640	48	493	-	8	-	-	365	254	179	<50	-	-	123,000	44.5
21	21/4003_20140603	0.2-0.3	3/06/2014	Within	7.2	4.2	0.4	<0.1	7330	2310	367	-	-	-	2	-	-	35	23,600	495	236	-	15	-	-	1840	119	89	<50	-	-	16,600	15.5
22	22/4001_20140603	0-0.05	3/06/2014	Within	8.5	2.2	0.2	<0.1	2700	11	5	-	-	-	<1	-	-	27	3030	15	95	-	2	-	-	80	109	24	<50	-	-	70,900	47.3
22	22/4002_20140603	0-0.05	3/06/2014	Within	-	-	-	-	3540	212	13	-	-	-	<1	-	-	5	6810	25	160	-	4	-	-	32	-	19	-	-	-	-	33.8
22	22_BH01/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	728	69	-	-	-	<1	-	-	6	25,200	18	121	0.2	8	-	-	19	-	-	-	<1	-	-	6.7
22	22_BH02/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	422	29	-	-	-	<1	-	-	6	13,600	19	114	0.2	5	-	-	19	-	-	-	<1	-	-	9.2
22	22_BH03/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	147	8	-	-	-	<1	-	-	9	8780	35	146	0.6	10	-	-	58	-	-	-	1	-	-	13
22	22_BH04/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	609	38	-	-	-	<1	-	-	8	12,600	159	168	0.4	6	-	-	105	-	-	-	1	-	-	13.6
22	22_BH05/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	542	44	-	-	-	<1	-	-	5	22,700	112	36	0.3	5	-	-	20	-	-	-	<1	-	-	5.2
22	22_BH06/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	345	23	-	-	-	<1	-	-	7	14,700	41	52	0.2	5	-	-	36	-	-	-	1	-	-	19.5
22	22_BH07/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	12	15	-	-	-	<1	-	-	13	36,500	20	24	<0.1	13	-	-	20	-	-	-	<1	-	-	7.3
22	22_BH08/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	593	56	30	<1	<50	<1	9	2	6	-	14	48	0.2	5	<5	13	22	-	25	<50	<1	300	19,000	10.4
23	23/4001_20140605	0-0.05	5/06/2014	Within	-	-	-	-	4750	92	12	-	-	-	<1	-	-	7	24,000	20	77	-	6	-	-	24	-	16	-	-	-	-	37
23	23/4002_20140605	0-0.05	5/06/2014	Within	-	-	-	-	5090	60	7	-	-	-	<1	-	-	6	12,300	15	124	-	5	-	-	26	-	22	-	-	-	-	28.2
23	23_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	62	13	50	<1	<50	<1	12	2	7	-	75	51	<0.1	6	<5	19	17	-	39	<50	<1	200	23,100	17
23	23_BH01/4002_20141007	0.2-0.3	7/10/2014	Within	-	-	-	-	-	34	11	30	<1	<50	<1	13	<2	<5	-	13	27	<0.1	4	<5	25	<5	-	126	<50	<1	200	9400	4
23	23_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	7	36	-	-	-	<1	-	-	11	68,200	22	39	<0.1	13	-	-	23	-	-	-	<1	-	-	6.5
23	23_BH03/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	95	11	-	-	-	<1	-	-	6	19,900	15	117	<0.1	6	-	-	20	-	-	-	<1	-	-	14.5
23	23_BH04/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	19	6	-	-	-	<1	-	-	<5	3700	<5	25	<0.1	<2	-	-	<5	-	-	-	<1	-	-	9.3
23	23_BH05/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	76	8	-	-	-	<1	-	-	6	12,800	15	177	<0.1	4	-	-	17	-	-	-	<1	-	-	15.6
23	23_BH06/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	471	91	-	-	-	<1	-	-	37	40,300	242	112	0.2	14	-	-	279	-	-	-	<1	-	-	16.4
23	23_BH07/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	140	11	-	-	-	<1	-	-	7	12,600	30	230	0.1	4	-	-	78	-	-	-	<1	-	-	8.9
23	23_BH08/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	145	29	-	-	-	<1	-	-	12	16,000	41	74	<0.1	4	-	-	59	-	-	-	<1	-	-	16.5
24	24/4001_20140605	0-0.05	5/06/2014	Within	-	-	-	-	8340	104	9	-	-	-	<1	-	-	9	32,900	12	42	-	16	-	-	41	-	30	-	-	-	-	15
24	24/4002_20140605	0-0.05	5/06/2014	Within	-	-	-	-	9330	14	8	-	-	-	<1	-	-	12	34,300	13	42	-	16	-	-	311	-	21	-	-	-	-	16.5
26	26/4001_20140603	0-0.05	3/06/2014	Within	-	-	-	-	9970	18	7	-	-	-	<1	-	-	10	31,200	26	304	-	22	-	-	49	-	10	-	-	-	-	12.7
26	26/4002_20140603	0-0.05	3/06/2014	Within	-	-	-	-	8690	20	8	-	-	-	<1	-	-	8	33,200	14	60	-	15	-	-	30	-	4	-	-	-	-	12.9
27	27/4001_20140604	0-0.05	4/06/2014	Within	-	-	-	-	3230	9	<5	-	-	-	<1	-	-	<5	5250	9	40	-	2	-	-	22	-	22	-	-	-	-	23.8
27	27/4002_20140604	0.2-0.3	4/06/2014	Within	-	-	-	-	11,000	<5	7	-	-	-	<1	-	-	6	18,300	19	72	-	9	-	-	45	-	44	-	-	-	-	18.4
27	27/4003_20140604	0-0.05	4/06/2014	Within	-	-	-	-	4110	30	5	-	-	-	<1	-	-	11	7510	11	277	-	4	-	-	159	-	104	-	-	-	-	35.9
27	27/4004_20140604	0.2-0.3	4/06/2014	Within	-	-	-	-	4760	16	7	-	-	-	<1	-	-	16	9500	117	157	-	6	-	-	221	-	84	-	-	-	-	15.4
27	27_BH10/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	<5	13	-	-	-	<1	-	-	8	24,900	29	82	<0.1	9	-	-	56	-	-	-	<1	-	-	25.4
27	27_BH3/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	6	<5	-	-	-	<1	-	-	<5	3670	5	120	<0.1	<2	-	-	19	-	-	-	1	-	-	6.8
27	27_BH4/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	21	<5	-	-	-	<1	-	-	7	6250	10	180	<0.1	3	-	-	71	-	-	-	1	-	-	12.1
27	27_BH5/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	7	<5	-	-	-	<1	-	-	7	10,500	19	99	<0.1	4	-	-	62	-	-	-	1	-	-	22.8
27	27_BH6/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	<5	<5	-	-	-	<1	-	-	10	5950	<5	91	<0.1	11	-	-	31	-	-	-	<1	-	-	3.4
27	27_BH7/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	11	6	-	-	-	<1	-	-	6	7540	9	143	<0.1	4	-	-	432	-	-	-	<1	-	-	36.7
27	27_BH8/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	<5	<5	-	-	-	<1	-	-	<5	3460	<5	32	<0.1	<2	-	-	15	-	-	-	<1	-	-	9.1

Notes: Assessment criteria from NEPM (2013) HIL A, with the exception of:
italics - Residential soil US EPA Regions 3, 6, and 9 Regional Screening Levels for Chemical Contaminants at Superfund Sites

Table D1.1: Soil Analytical Results

					Exchangable Cations				Heavy Metals																		Other	Sample Quality Parameters					
					Exchangeable Calcium	**Exchangeable Magnesium**	**Exchangeable Potassium**	**Exchangeable Sodium**	**Aluminium**	**Antimony**	**Arsenic**	**Barium**	**Beryllium**	**Boron**	**Cadmium**	**Chromium**	**Cobalt**	**Copper**	**Iron**	**Lead**	**Manganese**	**Mercury**	**Nickel**	**Selenium**	**Vanadium**	**Zinc**	**CEC**	**Electrical Conductivity @ 25°C**	**Sulphate (as SO4)**	**Cyanide (free)**	**Sulphur (as S)**	**Total Organic Carbon**	**Moisture**
					%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/kg	uS/cm	mg/kg	mg/kg	mg/kg	mg/kg	%
	EQL				0.1	0.1	0.1	0.1	50	5	5	10	1	50	1	2	2	5	50	5	5	0.1	2	5	5	5	1	1	50	1	50	200	1
	Assessment Criteria - Residential Soil				NA	NA	NA	NA	*77,000*	200	100	*15,000*	60	4500	20	100	100	6000	NA	300	3800	40	400	200	*390*	7400	NA	NA	NA	250	NA	NA	NA
Property ID	**Sample ID**	**Depth**	**Date**	**Within/Outside Costerfield Dome**																													
27	27_BH9/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	16	<5	-	-	-	<1	-	-	<5	9,800	9	16	<0.1	2	-	-	560	-	-	-	<1	-	-	13.2

Notes: Assessment criteria from NEPM (2013) HIL A, with the exception of:
italics - Residential soil US EPA Regions 3, 6, and 9 Regional Screening Levels for Chemical Contaminants at Superfund Sites

					Exchangable Cations				Heavy Metals																			Other	Sample Quality Parameters					
					Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Vanadium	Zinc	CEC	Electrical Conductivity @ 25°C	Sulphate (as SO4)	Cyanide (free)	Sulphur (as S)	Total Organic Carbon	Moisture
					%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/kg	uS/cm	mg/kg	mg/kg	mg/kg	mg/kg	%
	EQL				0.1	0.1	0.1	0.1	50	5	5	10	1	50	1	2	2	5	50	5	5	0.1	2	5	5	5	1	1	50	1	50	200	1
	Assessment Criteria - Residential Soil				NA	NA	NA	NA	*77,000*	200	100	*15,000*	60	4500	20	100	100	6000	NA	300	3800	40	400	200	*390*	7400	NA	NA	NA	250	NA	NA	NA
Property ID	**Sample ID**	**Depth**	**Date**	**Within/Outside Costerfield Dome**																													
28	28/4001_20140604	0-0.05	4/06/2014	Within	-	-	-	-	4730	199	9	-	-	-	<1	-	-	23	9140	199	229	-	6	-	-	767	-	53	-	-	-	-	37.9
28	28/4002_20140604	0-0.05	4/06/2014	Within	11.6	3.5	0.9	<0.1	3720	51	<5	-	-	-	1	-	-	78	6790	133	335	-	19	-	-	278	160	140	<50	-	-	164,000	35.7
28	28/4003_20140604	0.2-0.3	4/06/2014	Within	3.5	0.9	0.4	<0.1	4190	90	6	-	-	-	<1	-	-	16	7740	257	216	-	5	-	-	148	48	121	<50	-	-	47,600	11.3
30	30/4001_20140605	0-0.05	5/06/2014	Within	-	-	-	-	3050	15	<5	-	-	-	<1	-	-	15	7450	63	205	-	6	-	-	106	-	323	-	-	-	-	19.3
30	30/4002_20140605	0-0.05	5/06/2014	Within	-	-	-	-	3470	80	8	-	-	-	<1	-	-	17	17,700	363	183	-	13	-	-	303	-	202	-	-	-	-	35.8
30	30_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	15	8	80	2	<50	<1	35	12	16	-	18	104	<0.1	37	<5	26	62	-	29	<50	<1	200	46,500	9
30	30_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	118	21	-	-	-	<1	-	-	44	48,700	485	276	<0.1	32	-	-	149	-	-	-	<1	-	-	12
30	30_BH03/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	298	25	-	-	-	<1	-	-	21	36,200	119	308	0.3	25	-	-	310	-	-	-	<1	-	-	26.3
30	30_BH04/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	173	15	-	-	-	<1	-	-	16	20,900	39	652	0.2	21	-	-	82	-	-	-	1	-	-	29.2
30	30_BH05/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	172	19	-	-	-	<1	-	-	19	34,500	67	429	0.2	29	-	-	99	-	-	-	<1	-	-	22.8
30	30_BH06/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	264	115	-	-	-	<1	-	-	22	27,700	2140	334	0.2	20	-	-	299	-	-	-	<1	-	-	6
30	30_BH07/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	84	11	-	-	-	<1	-	-	24	20,900	95	443	0.1	28	-	-	180	-	-	-	<1	-	-	32.3
30	30_BH08/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	100	18	-	-	-	<1	-	-	27	330,000	103	535	0.2	25	-	-	237	-	-	-	<1	-	-	25.4
30	30_BH09/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	238	16	-	-	-	-	-	-	-	-	491	-	-	-	-	-	-	-	-	-	-	-	-	11.6
30	30_BH10/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	292	77	-	-	-	-	-	-	-	-	3920	-	-	-	-	-	-	-	-	-	-	-	-	5
30	30_BH11/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	149	32	-	-	-	-	-	-	-	-	435	-	-	-	-	-	-	-	-	-	-	-	-	7.7
30	30_BH12/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	137	18	-	-	-	-	-	-	-	-	378	-	-	-	-	-	-	-	-	-	-	-	-	15.9
30	30_BH13/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	218	19	-	-	-	-	-	-	-	-	77	-	-	-	-	-	-	-	-	-	-	-	-	8.1
30	30_BH14/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	161	36	-	-	-	-	-	-	-	-	156	-	-	-	-	-	-	-	-	-	-	-	-	7.1
30	30_BH15/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	98	17	-	-	-	-	-	-	-	-	48	-	-	-	-	-	-	-	-	-	-	-	-	8.6
30	30_BH16/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	92	17	-	-	-	-	-	-	-	-	58	-	-	-	-	-	-	-	-	-	-	-	-	5.9
30	30_BH17/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	94	11	-	-	-	-	-	-	-	-	94	-	-	-	-	-	-	-	-	-	-	-	-	9.2
30	30_BH18/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-		142	14	-	-	-	-	-	-	-	-	36	-	-	-	-	-	-	-	-	-	-	-	-	9.8
31	31_BH01/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	807	31	-	-	-	<1	-	-	13	18,200	45	195	0.3	13	-	-	102	-	-	-	<1	-	-	16
31	31_BH02/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	322	7	20	<1	<50	<1	5	<2	<5	-	11	43	0.4	3	<5	8	26	-	2270	870	<1	600	11,800	11.6
31	31_BH02/4002_20141008	0.2-0.3	8/10/2014	Within	-	-	-	-	-	40	<5	10	<1	<50	<1	3	<2	<5	-	<5	<5	<0.1	<2	<5	8	<5	-	570	140	<1	200	3800	5.3
32	32/4001_20140605	0-0.05	5/06/2014	Within	-	-	-	-	4570	1920	148	-	-	-	<1	-	-	17	30,100	230	86	-	13	-	-	158	-	8	-	-	-	-	22.8
32	32/4002_20140605	0-0.05	5/06/2014	Within	-	-	-	-	6360	62	18	-	-	-	<1	-	-	20	46,500	58	154	-	40	-	-	100	-	19	-	-	-	-	15.5
32	32/4003_20140605	0.1-0.1	5/06/2014	Within	-	-	-	-	6230	<5	10	-	-	-	<1	-	-	13	36,200	12	34	-	23	-	-	34	-	38	-	-	-	-	8.2
32	32_BH01/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	11	16	50	1	<50	<1	35	6	15	-	20	33	<0.1	17	<5	38	73	-	86	<50	<1	300	7800	5.7
32	32_BH02/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	118	24	-	-	-	<1	-	-	23	49,200	39	121	<0.1	36	-	-	96	-	-	-	<1	-	-	7.5
32	32_BH03/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	647	66	-	-	-	<1	-	-	26	34,900	315	121	0.1	24	-	-	336	-	-	-	<1	-	-	15.8
32	32_BH04/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	251	69	-	-	-	<1	-	-	13	37,500	205	86	0.1	17	-	-	77	-	-	-	<1	-	-	5.5
32	32_BH05/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	23	20	-	-	-	<1	-	-	12	40,300	36	50	<0.1	19	-	-	68	-	-	-	<1	-	-	4.1
32	32_BH06/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	79	22	-	-	-	<1	-	-	12	46,400	100	79	<0.1	22	-	-	92	-	-	-	<1	-	-	6.2
32	32_BH07/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	27	17	-	-	-	<1	-	-	16	44,900	24	49	<0.1	29	-	-	66	-	-	-	<1	-	-	4.4
32	32_BH08/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	47	21	-	-	-	<1	-	-	19	54,600	81	97	<0.1	31	-	-	110	-	-	-	<1	-	-	3.7
32	32_BH09/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	79	26	-	-	-	-	-	-	-	-	139	-	-	-	-	-	-		-	-	-	-	-	3.7
32	32_BH10/4001_20151208	0-0.1	8/12/2015	Within	-	-	-	-	-	24	14	-	-	-	-	-	-	-	-	58	-	-	-	-	-	-		-	-	-	-	-	<1
33	33_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	285	19	30	<1	<50	<1	7	<2	6	-	38	48	0.4	3	<5	10	44	-	19	<50	<1	400	28,100	7
33	33_BH01/4002_20141007	0.2-0.3	7/10/2014	Within	-	-	-	-	-	58	<5	10	<1	<50	<1	4	<2	<5	-	<5	9	<0.1	<2	<5	8	<5	-	9	<50	<1	200	4400	4
33	33_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	122	9	-	-	-	<1	-	-	5	12,400	11	93	<0.1	6	-	-	32	-	-	-	<1	-	-	3.2
34	34/4001_20140605	0-0.05	5/06/2014	Within	-	-	-	-	4380	1190	93	-	-	-	<1	-	-	17	26,200	68	142	-	20	-	-	70	-	22	-	-	-	-	20.4
34	34/4002_20140605	0-0.05	5/06/2014	Within	-	-	-	-	5580	1060	59	-	-	-	<1	-	-	40	16,700	348	212	-	12	-	-	2860	-	26	-	-	-	-	36.8
34	34_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	201	8	20	<1	<50	<1	5	<2	<5	-	10	121	<0.1	4	<5	7	16	-	10	<50	<1	200	4900	7.8
34	34_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	1130	114	-	-	-	<1	-	-	42	63,100	50	239	0.6	34	-	-	136	-	-	-	<1	-	-	10.7
34	34_BH03/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	914	93	-	-	-	<1	-	-	23	32,000	89	218	0.6	24	-	-	105	-	-	-	<1	-	-	11
34	34_BH04/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	1080	101	-	-	-	<1	-	-	22	21,000	95	210	1.8	12	-	-	96	-	-	-	<1	-	-	8.8
34	34_BH05/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	407	53	-	-	-	<1	-	-	17	23,900	49	228	1.1	16	-	-	89	-	-	-	<1	-	-	11.8
34	34_BH06/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	1210	86	-	-	-	2	-	-	31	29,800	197	217	1.2	15	-	-	1560	-	-	-	<1	-	-	15.3
34	34_BH07/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	923	108	-	-	-	<1	-	-	14	32,100	104	71	1	13	-	-	84	-	-	-	<1	-	-	6.9
34	34_BH08/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	537	51	-	-	-	<1	-	-	12	24,200	54	156	0.1	17	-	-	47	-	-	-	<1	-	-	3.1
35	35_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	1210	84	-	-	-	24	-	-	1140	57,900	752	169	0.4	12	-	-	1010	-	-	-	<1	-	-	5.6
35	35_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	310	34	200	<1	<50	1	23	4	47	-	505	524	<0.1	11	<5	33	348	-	240	<50	<1	700	100,000	19.1
35	35_BH02/4002_20141007	0.2-0.3	7/10/2014	Within	-	-	-	-	-	144	34	150	1	<50	<1	46	5	34	-	433	384	<0.1	15	<5	68	197	-	29	<50	<1	300	52,000	12.4
36	36/4001_20140602	0-0.05	2/06/2014	Within	-	-	-	-	9080	<5	5	-	-	-	<1	-	-	19	15,700	18	1650	-	20	-	-	115	-	60	-	-	-	-	27.5
36	36/4002_20140602	0-0.05	2/06/2014	Within	-	-	-	-	4250	10	<5	-	-	-	<1	-	-	10	8590	9	1150	-	9	-	-	83	-	32	-	-	-	-	42
36	36_BH10/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	<5	7	-	-	-	<1	-	-	<5	25,000	10	116	<0.1	15	-	-	26	-	-	-	<1	-	-	4.4
36	36_BH3/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	<5	6	-	-	-	<1	-	-	11	14,000	13	995	<0.1	17	-	-	67	-	-	-	1	-	-	2.8
36	36_BH4/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	<5	5	-	-	-	<1	-	-	25	13,700	16	1260	<0.1	18	-	-	174	-	-	-	1	-	-	27
36	36_BH5/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	8	<5	100	<1	<50	<1	16	8	8	-	14	662	<0.1	16	<5	13	65	-	40	<50	<1	200	17,500	19.1
36	36_BH5/4002_20141006	0.2-0.3	6/10/2014	Within	-	-	-	-	-	<5	<5	-	-	-	<1	-	-	6	12,700	10	440	<0.1	11	-	-	36	-	-	-	<1	-	-	13.8
36	36_BH6/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	12	5	100	<1	<50	<1	12	5	9	-	10	776	<0.1	11	<5	13	58	-	76	<50	1	400	68,200	3.5
36	36_BH7/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	6	5	-	-	-	<1	-	-	5	17,800	8	198	<0.1	8	-	-	30	-	-	-	<1	-	-	4
36	36_BH8/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	6	8	-	-	-	<1	-	-	11	39,600	13	310	<0.1	16	-	-	38	-	-	-	<1	-	-	4.3
36	36_BH9/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	6	6	-	-	-	<1	-	-	12	14,100	11	577	<0.1	12	-	-	42	-	-	-	2	-	-	6.2
37	37/4001_20140605	0-0.05	5/06/2014	Within	-	-	-	-	4340	22	8	-	-	-	<1	-	-	8	21,800	13	44	-	11	-	-	37	-	43	-	-	-	-	14.1
37	37/4002_20140605	0-0.05	5/06/2014	Within	-	-	-	-	4680	19	7	-	-	-	<1	-	-	7	15,400	10	130	-	9	-	-	58	-	24	-	-	-	-	18.2
40	40/4001_20140602	0-0.05	2/06/2014	Within	-	-	-	-	9820	87	10	-	-	-	<1	-	-	10	33,600	12	162	-	25	-	-	47	-	14	-	-	-	-	13.8
40	40/4002_20140602	0-0.05	2/06/2014	Within	-	-	-	-	4680	<5	21	-	-	-	<1	-	-	26	12,700	15	162	-	14	-	-	110	-	63	-	-	-	-	20.2
41	41/4001_20140604	0-0.05	4/06/2014	Within	-	-	-	-	5710	126	22	-	-	-	3	-	-	31	21,500	294	132	-	23	-	-	215	-	55	-	-	-	-	38.9
41	41/4002_20140604	0-0.05	4/06/2014	Within	-	-	-	-	9420	389	56	-	-	-	<1	-	-	22	48,100	46	119	-	38	-	-	127	-	20	-	-	-	-	16.9
42	42/4001_20140605	0-0.05	5/06/2014	Within	-	-	-	-	3100	141	10	-	-	-	<1	-	-	12	7420	31	235	-	4	-	-	131	-	99	-	-	-	-	37.9

Notes: Assessment criteria from NEPM (2013) HIL A, with the exception of:
italics - Residential soil US EPA Regions 3, 6, and 9 Regional Screening Levels for Chemical Contaminants at Superfund Sites

Table D1.1: Soil Analytical Results

					Exchangable Cations				Heavy Metals																		Other	Sample Quality Parameters					
					Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Vanadium	Zinc	CEC	Electrical Conductivity @ 25°C	Sulphate (as SO4)	Cyanide (free)	Sulphur (as S)	Total Organic Carbon	Moisture
					%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/kg	uS/cm	mg/kg	mg/kg	mg/kg	mg/kg	%
	EQL				0.1	0.1	0.1	0.1	50	5	5	10	1	50	1	2	2	5	50	5	5	0.1	2	5	5	5	1	1	50	1	50	200	1
	Assessment Criteria - Residential Soil				NA	NA	NA	NA	*77,000*	200	100	*15,000*	60	4500	20	100	100	6000	NA	300	3800	40	400	200	*390*	7400	NA	NA	NA	250	NA	NA	NA
Property ID	**Sample ID**	**Depth**	**Date**	**Within/Outside Costerfield Dome**																													
44	44_BH1/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	343	168	-	-	-	<1	-	-	38	35,800	92	344	1	34	-	-	199	-	-	-	<1	-	-	2.5
44	44_BH10/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	35	9	30	<1	<50	<1	36	10	18	-	15	76	<0.1	30	<5	31	44	-	31	<50	<1	200	8400	9
44	44_BH10/4002_20141006	0.2-0.3	6/10/2014	Within	-	-	-	-	-	7	<5	30	1	<50	<1	40	12	24	-	17	63	<0.1	39	<5	26	54	-	17	<50	<1	200	3600	12.5
44	44_BH2/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	<5	34	-	-	-	<1	-	-	29	5070	58	62	<0.1	4	-	-	74	-	-	-	<1	-	-	12.8
44	44_BH3/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	107	23	-	-	-	<1	-	-	15	29,200	32	136	0.1	18	-	-	58	-	-	-	<1	-	-	6.3
44	44_BH4/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	<5	6	-	-	-	<1	-	-	24	46,300	23	31	0.2	28	-	-	49	-	-	-	<1	-	-	17.7
44	44_BH5/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	199	21	-	-	-	<1	-	-	19	44,500	33	125	0.2	14	-	-	150	-	-	-	<1	-	-	4.6
44	44_BH6/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	276	25	-	-	-	<1	-	-	10	34,600	37	81	<0.1	13	-	-	35	-	-	-	<1	-	-	5.5
44	44_BH7/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	82	8	-	-	-	<1	-	-	13	34,600	16	171	<0.1	25	-	-	43	-	-	-	<1	-	-	5.5
44	44_BH8/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	105	13	-	-	-	<1	-	-	14	44,200	19	82	<0.1	24	-	-	42	-	-	-	<1	-	-	5.1
44	44_BH9/4001_20141006	0-0.05	6/10/2014	Within	-	-	-	-	-	30	9	-	-	-	<1	-	-	28	52,100	21	82	<0.1	39	-	-	63	-	-	-	<1	-	-	4.2
45	45_BH01/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	19	6	-	-	-	<1	-	-	15	20,200	13	170	<0.1	20	-	-	57	-	-	-	<1	-	-	19.2
45	45_BH02/4001_20141008	0-0.05	8/10/2014	Within	-	-	-	-	-	14	10	120	1	<50	<1	29	23	26	-	15	241	<0.1	49	<5	23	638	-	22	<50	<1	200	30,800	7.6
45	45_BH02/4002_20141008	0.2-0.3	8/10/2014	Within	-	-	-	-	-	<5	7	180	2	<50	<1	29	11	16	-	13	22	<0.1	26	<5	24	86	-	51	<50	<1	200	46,100	14.5
47	47_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	70	15	70	1	<50	<1	26	9	15	-	22	202	<0.1	26	<5	27	55	-	66	<50	<1	400	62,500	12.5
47	47_BH01/4002_20141007	0.2-0.3	7/10/2014	Within	-	-	-	-	-	6	11	100	2	<50	<1	25	17	14	-	19	71	<0.1	32	<5	22	41	-	86	<50	<1	200	12,400	9.8
47	47_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	19	9	-	-	-	<1	-	-	11	59,000	21	78	<0.1	28	-	-	39	-	-	-	<1	-	-	5.4
47	47_BH03/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	8	<5	-	-	-	<1	-	-	<5	9900	6	160	<0.1	3	-	-	28	-	-	-	<1	-	-	<1
47	47_BH04/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	148	17	-	-	-	<1	-	-	14	35,500	42	90	<0.1	19	-	-	52	-	-	-	<1	-	-	7.7
47	47_BH05/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	126	14	-	-	-	<1	-	-	13	33,600	29	94	0.1	23	-	-	57	-	-	-	<1	-	-	9
47	47_BH06/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	65	13	-	-	-	<1	-	-	19	39,700	24	101	<0.1	26	-	-	243	-	-	-	<1	-	-	17.5
47	47_BH07/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	81	11	-	-	-	<1	-	-	12	45,100	20	79	<0.1	27	-	-	51	-	-	-	<1	-	-	7.5
47	47_BH08/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	67	12	-	-	-	<1	-	-	13	37,100	29	173	0.1	28	-	-	60	-	-	-	<1	-	-	12.4
47	47_BH09/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	31	<5	-	-	-	<1	-	-	6	7980	12	74	<0.1	7	-	-	362	-	-	-	<1	-	-	14.6
47	47_BH10/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	92	27	-	-	-	<1	-	-	12	58,500	25	91	<0.1	25	-	-	55	-	-	-	<1	-	-	3.5
48	48_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	7	6	-	-	-	<1	-	-	41	22,000	11	344	<0.1	15	-	-	169	-	-	-	2	-	-	26
48	48_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	16	6	50	<1	<50	<1	16	5	17	-	13	180	<0.1	14	<5	14	253	-	286	<50	1	400	63,100	17.8
48	48_BH02/4002_20141007	0.2-0.3	7/10/2014	Within	-	-	-	-	-	16	8	50	1	<50	<1	32	15	20	-	19	135	<0.1	42	<5	23	120	-	74	<50	<1	200	10,500	17.1
50	50_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	<5	12	30	<1	<50	<1	28	3	7	-	15	36	<0.1	10	<5	30	22	-	25	<50	<1	<100	4900	2.7
50	50_BH01/4002_20141007	0.2-0.3	7/10/2014	Within	-	-	-	-	-	<5	8	20	<1	<50	<1	35	5	12	-	16	39	<0.1	17	<5	32	26	-	298	110	<1	200	1500	5.7
50	50_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	52	18	-	-	-	<1	-	-	21	33,200	66	227	<0.1	13	-	-	175	-	-	-	<1	-	-	8.2
51	51_BH01/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	16	10	80	1	<50	<1	28	15	25	-	23	234	0.2	43	<5	17	85	-	98	<50	<1	<100	5000	7.2
51	51_BH01/4002_20141007	0.2-0.3	7/10/2014	Within	-	-	-	-	-	7	9	70	<1	<50	<1	27	13	27	-	21	220	0.1	41	<5	16	78	-	105	<50	<1	<100	3500	6.1
51	51_BH02/4001_20141007	0-0.05	7/10/2014	Within	-	-	-	-	-	151	26	-	-	-	<1	-	-	11	65,500	26	156	<0.1	27	-	-	74	-	-	-	<1	-	-	10.6

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Statistical Summary

	Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Vanadium	Zinc	CEC	Electrical Conductivity @ 25°C	Sulphate (as SO4)	Cyanide (free)	Sulphur (as S)	Total Organic Carbon	Moisture
Number of Results	14	14	14	14	75	269	269	45	45	45	232	45	45	232	187	269	232	157	232	45	45	232	14	120	59	156	45	59	269
Number of Detects	14	14	14	1	75	237	235	44	13	0	14	45	32	206	187	255	231	52	221	0	45	226	14	120	7	22	40	59	267
Minimum Concentration	1.2	0.9	0.1	<0.1	1280	<5	<5	<10	<1	<50	<1	3	<2	<5	2680	<5	<5	<0.1	<2	<5	6	<5	38	4	<50	<1	<100	900	<1
Minimum Detect	1.2	0.9	0.1	0.4	1280	6	5	10	1	ND	1	3	2	5	2680	5	7	0.1	2	ND	6	7	38	4	60	1	200	900	1.5
Maximum Concentration	18.9	5.2	1.3	0.4	22300	8670	417	200	2	<50	24	46	24	1140	330000	3920	1650	6.8	73	<5	68	13200	254	2270	870	2	700	164000	49.9
Maximum Detect	18.9	5.2	1.3	0.4	22300	8670	417	200	2	ND	24	46	24	1140	330000	3920	1650	6.8	73	ND	68	13200	254	2270	870	2	700	164000	49.9
Average Concentration	7.7	2.9	0.5	0.075	6613	413	38	57	0.71	25	0.78	20	6.8	24	28770	147	217	0.21	16	2.5	21	250	112	120	51	0.61	254	30022	15
Median Concentration	6.45	2.8	0.4	0.05	6000	95	15	40	0.5	25	0.5	19	5	14	24200	29	140.5	0.05	13	2.5	19	74	110	37	25	0.5	200	17000	12.3
Standard Deviation	5.5	1.4	0.32	0.094	3251	1013	60	46	0.41	0	2.1	13	6	76	28177	453	239	0.59	11	0	12	958	68	278	116	0.32	136	34733	11
Number of Guideline Exceedances	0	0	0	0	0	85	28	0	0	0	1	0	0	0	0	29	0	0	0	0	0	1	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)	0	0	0	0	0	85	28	0	0	0	1	0	0	0	0	29	0	0	0	0	0	1	0	0	0	0	0	0	0

Notes: Assessment criteria from NEPM (2013) HIL A, with the exception of:
italics - Residential soil US EPA Regions 3, 6, and 9 Regional Screening Levels for Chemical Contaminants at Superfund Sites

Table D1.2: Soil QA/QC results

			SDG	EM1405428	EM1405428		EM1405428	EM1405428		EM1405428	EM1405428		EM1405428	EM1405428		EM1405428	EM1405428		EM1405428	EM1405491	
			Field_ID	14/4001_20140603	14/4801_20140603	**RPD**	14/4002_20140603	14/4802_20140603	**RPD**	3/4001_20140603	3/4801_20140603	**RPD**	13/4001_20140603	13/4801_20140603	**RPD**	4/4001_20140603	4/4801_20140603	**RPD**	14/4001_20140603	14/4801_20140603	**RPD**
			Sampled_Date-Time	3/06/2014 15:00	3/06/2014 15:00		3/06/2014 15:00	3/06/2014 15:00		3/06/2014 15:00	3/06/2014 15:00		3/06/2014 15:00	3/06/2014 15:00		3/06/2014 15:00	3/06/2014 15:00		3/06/2014 15:00	3/06/2014 15:00	
Method_Type	**ChemName**	**Units**	**EQL**																		
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)	141	127	10	50	66	28	36	38	5	36	37	3	1390	1780	25	141		
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1																		
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	44.7	40.5	10	31.4	34.4	9	17.6	18.1	3	37.8	37.9	0	49.4	43.3	13	44.7	44.6	0
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1	7.1	7	1	5.3	5.4	2	4.6	4.7	2	5.5	5.5	0	6.6	6.4	3	7.1		
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)																		
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)																		
Total Mercury by FIMS	Mercury	mg/kg	0.1																		
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)	**13400**	**7420**	**57**	6870	7640	11	9720	9710	0	5060	5170	2	4480	5460	20	13400		
	Antimony	mg/kg	5 : 2 (Interlab)	114	120	5	73	83	13	**97**	**58**	**50**	182	155	16	8	8	0	114		
	Arsenic	mg/kg	5 : 2 (Interlab)	10	10	0	**19**	**44**	**79**	18	16	12	16	20	22	<5	5	0	10		
	Barium	mg/kg	10 : 5 (Interlab)																		
	Beryllium	mg/kg	1 : 2 (Interlab)																		
	Boron	mg/kg	50 : 5 (Interlab)																		
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<1	<1	0	<1	<1	0	<1	<1	0	<1	<1	0	<1	<1	0	<1		
	Chromium	mg/kg	2 : 5 (Interlab)																		
	Cobalt	mg/kg	2 : 5 (Interlab)																		
	Copper	mg/kg	5	37	40	8	12	13	8	10	10	0	21	20	5	114	81	34	37		
	Iron	mg/kg	50 : 5 (Interlab)	21500	20600	4	16100	17000	5	36800	29400	22	**8260**	**15500**	**61**	7980	10700	29	21500		
	Lead	mg/kg	5	128	154	18	58	42	32	26	25	4	45	44	2	5	6	18	128		
	Sodium	mg/kg	50 : 5 (Interlab)																		
	Manganese	mg/kg	5	610	673	10	128	116	10	110	106	4	436	430	1	714	504	34	610		
	Potassium	mg/kg	50 : 5 (Interlab)																		
	Calcium	mg/kg	50 : 5 (Interlab)																		
	Molybdenum	mg/kg	2 : 5 (Interlab)																		
	Nickel	mg/kg	2 : 5 (Interlab)	11	12	9	8	8	0	13	12	8	6	6	0	11	10	10	11		
	Magnesium	mg/kg	50 : 5 (Interlab)																		
	Selenium	mg/kg	5 : 2 (Interlab)																		
	Silver	mg/kg	2 : 1 (Interlab)																		
	Strontium	mg/kg	2																		
	Thallium	mg/kg	5 : 10 (Interlab)																		
	Tin	mg/kg	5																		
	Titanium	mg/kg	10																		
	Vanadium	mg/kg	5 : 10 (Interlab)																		
	Zinc	mg/kg	5	240	263	9	**216**	**126**	**53**	42	43	2	239	231	3	525	349	40	240		
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)																		
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)																		
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)																		

*RPDs have only been considered where a concentration is greater than 0 times the EQL.
**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30 x EQL))
***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the row header relate to those used in the primary laboratory

Table D1.2: Soil QA/QC results

			SDG Field_ID Sampled_Date-Time	EM1405428 14/4002_20140603 3/06/2014 15:00	EM1405491 14/4802_20140603 3/06/2014 15:00	RPD
Method_Type	**ChemName**	**Units**	**EQL**			
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)	50		
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1			
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	31.4	33.6	7
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1	5.3		
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)			
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)			
Total Mercury by FIMS	Mercury	mg/kg	0.1			
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)	6870		
	Antimony	mg/kg	5 : 2 (Interlab)	73		
	Arsenic	mg/kg	5 : 2 (Interlab)	19		
	Barium	mg/kg	10 : 5 (Interlab)			
	Beryllium	mg/kg	1 : 2 (Interlab)			
	Boron	mg/kg	50 : 5 (Interlab)			
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<1		
	Chromium	mg/kg	2 : 5 (Interlab)			
	Cobalt	mg/kg	2 : 5 (Interlab)			
	Copper	mg/kg	5	12		
	Iron	mg/kg	50 : 5 (Interlab)	16100		
	Lead	mg/kg	5	58		
	Sodium	mg/kg	50 : 5 (Interlab)			
	Manganese	mg/kg	5	128		
	Potassium	mg/kg	50 : 5 (Interlab)			
	Calcium	mg/kg	50 : 5 (Interlab)			
	Molybdenum	mg/kg	2 : 5 (Interlab)			
	Nickel	mg/kg	2 : 5 (Interlab)	8		
	Magnesium	mg/kg	50 : 5 (Interlab)			
	Selenium	mg/kg	5 : 2 (Interlab)			
	Silver	mg/kg	2 : 1 (Interlab)			
	Strontium	mg/kg	2			
	Thallium	mg/kg	5 : 10 (Interlab)			
	Tin	mg/kg	5			
	Titanium	mg/kg	10			
	Vanadium	mg/kg	5 : 10 (Interlab)			
	Zinc	mg/kg	5	216		
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)			
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)			
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)			

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

Table D1.2: Soil QA/QC results

			SDG	EM1406868	EM1406868		EM1406868	EM1406868		EM1406868	EM1406868		EM1407187	EM1407187		EM1410438	EM1410438	
			Field_ID	DC002/4008_20140710	DC002/4808_20140710	**RPD**	DC002/4001_20140710	DC002/4801_20140710	**RPD**	DC002/4011_20140710	DC002/4811_20140710	**RPD**	51/4001_20140718	51/4801_20140718	**RPD**	27_BH6/4001_20141006	27_BH6/4801_20141006	**RPD**
			Sampled_Date-Time	10/07/2014 15:00	10/07/2014 15:00		10/07/2014 15:00	10/07/2014 15:00		10/07/2014 15:00	10/07/2014 15:00		18/07/2014 15:00	18/07/2014 15:00		6/10/2014 15:00	6/10/2014 15:00	
Method_Type	**ChemName**	**Units**	**EQL**															
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)	97	95	2	32	37	14	6	6	0						
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1													<1	<1	0
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	33.5	32	5	9.4	10.4	10	13.3	12	10	**48.5**	**6.8**	**151**	3.4	3.4	0
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1	6.9	6.9	0	6.2	6.6	6	4.8	4.7	2	6.3	6.2	2	7.8	7.9	1
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)										60	<50	18			
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)															
Total Mercury by FIMS	Mercury	mg/kg	0.1										0.4	0.5	22	<0.1	<0.1	0
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)	7380	6090	19	4330	3120	32	880	990	12	22200	21600	3			
	Antimony	mg/kg	5 : 2 (Interlab)	<5	<5	0	34	38	11	<5	<5	0	**40**	**16**	**86**	<5	<5	0
	Arsenic	mg/kg	5 : 2 (Interlab)	9	8	12	12	8	40	<5	<5	0	21	32	42	<5	<5	0
	Barium	mg/kg	10 : 5 (Interlab)										380	380	0			
	Beryllium	mg/kg	1 : 2 (Interlab)										<1	<1	0			
	Boron	mg/kg	50 : 5 (Interlab)										<50	<50	0			
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<1	<1	0	<1	<1	0	<1	<1	0	3	3	0	<1	<1	0
	Chromium	mg/kg	2 : 5 (Interlab)										54	56	4			
	Cobalt	mg/kg	2 : 5 (Interlab)										6	7	15			
	Copper	mg/kg	5	74	83	11	6	6	0	<5	<5	0	67	74	10	10	11	10
	Iron	mg/kg	50 : 5 (Interlab)	9770	11500	16	**29500**	**11200**	**90**	8220	5120	46	56900	48600	16	5950	6860	14
	Lead	mg/kg	5	24	25	4	**36**	**20**	**57**	<5	<5	0	505	504	0	<5	<5	0
	Sodium	mg/kg	50 : 5 (Interlab)										140	150	7			
	Manganese	mg/kg	5	238	272	13	172	179	4	65	41	45	209	235	12	91	77	17
	Potassium	mg/kg	50 : 5 (Interlab)										3910	3880	1			
	Calcium	mg/kg	50 : 5 (Interlab)										1350	1390	3			
	Molybdenum	mg/kg	2 : 5 (Interlab)										<2	<2	0			
	Nickel	mg/kg	2 : 5 (Interlab)	10	16	46	10	10	0	<2	2	0	25	26	4	11	9	20
	Magnesium	mg/kg	50 : 5 (Interlab)										4130	4280	4			
	Selenium	mg/kg	5 : 2 (Interlab)										<5	<5	0			
	Silver	mg/kg	2 : 1 (Interlab)										<2	<2	0			
	Strontium	mg/kg	2										17	19	11			
	Thallium	mg/kg	5 : 10 (Interlab)										<5	<5	0			
	Tin	mg/kg	5										7	7	0			
	Titanium	mg/kg	10										210	130	47			
	Vanadium	mg/kg	5 : 10 (Interlab)										37	36	3			
	Zinc	mg/kg	5	229	235	3	23	22	4	6	5	18	27900	28900	4	31	31	0
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)										1310	1350	3			
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)										1670	1680	1			
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)															

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

			SDG	EM1410438	EM1410438	
			Field_ID	27_BH7/4001_20141006	27_BH7/4801_20141006	**RPD**
			Sampled_Date-Time	6/10/2014 15:00	6/10/2014 15:00	
Method_Type	**ChemName**	**Units**	**EQL**			
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)			
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1	<1	1	0
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	36.7	25.9	35
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1	6	5.9	2
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)			
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)			
Total Mercury by FIMS	Mercury	mg/kg	0.1	<0.1	<0.1	0
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)			
	Antimony	mg/kg	5 : 2 (Interlab)	11	11	0
	Arsenic	mg/kg	5 : 2 (Interlab)	6	<5	18
	Barium	mg/kg	10 : 5 (Interlab)			
	Beryllium	mg/kg	1 : 2 (Interlab)			
	Boron	mg/kg	50 : 5 (Interlab)			
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<1	<1	0
	Chromium	mg/kg	2 : 5 (Interlab)			
	Cobalt	mg/kg	2 : 5 (Interlab)			
	Copper	mg/kg	5	6	6	0
	Iron	mg/kg	50 : 5 (Interlab)	7540	7250	4
	Lead	mg/kg	5	9	9	0
	Sodium	mg/kg	50 : 5 (Interlab)			
	Manganese	mg/kg	5	143	129	10
	Potassium	mg/kg	50 : 5 (Interlab)			
	Calcium	mg/kg	50 : 5 (Interlab)			
	Molybdenum	mg/kg	2 : 5 (Interlab)			
	Nickel	mg/kg	2 : 5 (Interlab)	4	4	0
	Magnesium	mg/kg	50 : 5 (Interlab)			
	Selenium	mg/kg	5 : 2 (Interlab)			
	Silver	mg/kg	2 : 1 (Interlab)			
	Strontium	mg/kg	2			
	Thallium	mg/kg	5 : 10 (Interlab)			
	Tin	mg/kg	5			
	Titanium	mg/kg	10			
	Vanadium	mg/kg	5 : 10 (Interlab)			
	Zinc	mg/kg	5	432	390	10
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)			
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)			
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)			

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

Table D1.2: Soil QA/QC results

			SDG	EM1410438	EM1410438		EM1410438	EM1410438		EM1410485	EM1410485		EM1410486	EM1410486		EM1410486
			Field_ID	1_BH04/4001_20141006	1_BH04/4801_20141006	**RPD**	38_BH02/4001_20141006	38_BH02/4801_20141006	**RPD**	30_BH08/4001_20141007	30_BH08/4801_20141007	**RPD**	47_BH10/4001_20141007	47_BH10/4801_20141007	**RPD**	34_BH01/4001_20141007
			Sampled_Date-Time	6/10/2014 15:00	6/10/2014 15:00		6/10/2014 15:00	6/10/2014 15:00		7/10/2014 15:00	7/10/2014 15:00		7/10/2014 15:00	7/10/2014 15:00		7/10/2014 15:00
Method_Type	**ChemName**	**Units**	**EQL**													
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)	**110**	**369**	**108**										10
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1	<1	<1	0	1	<1	0	<1	<1	0	<1	<1	0	<1
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	5	6.1	20	1.5	1.2	22	25.4	19.1	28	3.5	4.2	18	7.8
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1	6.1	6	2	5.4	4.8	12	4.9	5.1	4	4.4	4.4	0	4.8
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)	**<50**	**170**	**109**										<50
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)	300	300	0										200
Total Mercury by FIMS	Mercury	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.1	0	**0.2**	**0.1**	**67**	<0.1	<0.1	0	<0.1
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)													
	Antimony	mg/kg	5 : 2 (Interlab)	92	97	5	9	11	20	100	80	22	40	34	16	201
	Arsenic	mg/kg	5 : 2 (Interlab)	27	23	16	<5	<5	0	18	20	11	16	15	6	8
	Barium	mg/kg	10 : 5 (Interlab)	130	150	14										20
	Beryllium	mg/kg	1 : 2 (Interlab)	1	<1	0										<1
	Boron	mg/kg	50 : 5 (Interlab)	<50	<50	0										<50
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<1	<1	0	<1	<1	0	<1	<1	0	<1	<1	0	<1
	Chromium	mg/kg	2 : 5 (Interlab)	19	14	30										5
	Cobalt	mg/kg	2 : 5 (Interlab)	24	15	46										<2
	Copper	mg/kg	5	25	18	33	<5	<5	0	27	33	20	12	11	9	<5
	Iron	mg/kg	50 : 5 (Interlab)				4050	4820	17	28000	42700	42	58500	60800	4	
	Lead	mg/kg	5	38	29	27	<5	<5	0	103	75	31	25	26	4	10
	Sodium	mg/kg	50 : 5 (Interlab)													
	Manganese	mg/kg	5	**239**	**141**	**52**	62	43	36	535	417	25	91	80	13	121
	Potassium	mg/kg	50 : 5 (Interlab)													
	Calcium	mg/kg	50 : 5 (Interlab)													
	Molybdenum	mg/kg	2 : 5 (Interlab)													
	Nickel	mg/kg	2 : 5 (Interlab)	41	26	45	<2	<2	0	25	30	18	25	27	8	4
	Magnesium	mg/kg	50 : 5 (Interlab)													
	Selenium	mg/kg	5 : 2 (Interlab)	<5	<5	0										<5
	Silver	mg/kg	2 : 1 (Interlab)													
	Strontium	mg/kg	2													
	Thallium	mg/kg	5 : 10 (Interlab)													
	Tin	mg/kg	5													
	Titanium	mg/kg	10													
	Vanadium	mg/kg	5 : 10 (Interlab)	18	14	25										7
	Zinc	mg/kg	5	84	63	29	7	6	15	237	203	15	55	54	2	16
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)													
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)													
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)	4200	7000	50										**4900**

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

			SDG	EM1410486	
			Field_ID	34_BH01/4801_20141007	**RPD**
			Sampled_Date-Time	7/10/2014 15:00	
Method_Type	**ChemName**	**Units**	**EQL**		
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)	9	11
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1	<1	0
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	7.2	8
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1	4.8	0
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)	<50	0
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)	200	0
Total Mercury by FIMS	Mercury	mg/kg	0.1	<0.1	0
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)		
	Antimony	mg/kg	5 : 2 (Interlab)	171	16
	Arsenic	mg/kg	5 : 2 (Interlab)	9	12
	Barium	mg/kg	10 : 5 (Interlab)	20	0
	Beryllium	mg/kg	1 : 2 (Interlab)	<1	0
	Boron	mg/kg	50 : 5 (Interlab)	<50	0
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<1	0
	Chromium	mg/kg	2 : 5 (Interlab)	5	0
	Cobalt	mg/kg	2 : 5 (Interlab)	<2	0
	Copper	mg/kg	5	<5	0
	Iron	mg/kg	50 : 5 (Interlab)		
	Lead	mg/kg	5	8	22
	Sodium	mg/kg	50 : 5 (Interlab)		
	Manganese	mg/kg	5	117	3
	Potassium	mg/kg	50 : 5 (Interlab)		
	Calcium	mg/kg	50 : 5 (Interlab)		
	Molybdenum	mg/kg	2 : 5 (Interlab)		
	Nickel	mg/kg	2 : 5 (Interlab)	4	0
	Magnesium	mg/kg	50 : 5 (Interlab)		
	Selenium	mg/kg	5 : 2 (Interlab)	<5	0
	Silver	mg/kg	2 : 1 (Interlab)		
	Strontium	mg/kg	2		
	Thallium	mg/kg	5 : 10 (Interlab)		
	Tin	mg/kg	5		
	Titanium	mg/kg	10		
	Vanadium	mg/kg	5 : 10 (Interlab)	6	15
	Zinc	mg/kg	5	13	21
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)		
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)		
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)	**33400**	**149**

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

Table D1.2: Soil QA/QC results

			SDG	EM1410486	EM1410486		EM1410486	EM1410486		EM1406868	Interlab_D		EM1406868	Interlab_D		EM1406868
			Field_ID	23_BH01/4001_20141007	23_BH01/4801_20141007	**RPD**	50_BH01/4001_20141007	50_BH01/4801_20141007	**RPD**	DC002/4008_20140710	DC002/4908_20140710	**RPD**	DC002/4001_20140710	DC002/4901_20140710	**RPD**	DC002/4011_20140710
			Sampled_Date-Time	7/10/2014 15:00	7/10/2014 15:00		7/10/2014 15:00	7/10/2014 15:00		10/07/2014 15:00	10/07/2014 15:00		10/07/2014 15:00	10/07/2014 15:00		10/07/2014 15:00
Method_Type	**ChemName**	**Units**	**EQL**													
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)	39	28	33	25	31	21	97	96	1	32	40	22	**6**
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1	<1	<1	0	<1	<1	0							
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	17	17.4	2	2.7	2.8	4	33.5	33	2	9.4	8.6	9	13.3
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1	4	4.1	2	4.5	4.4	2	6.9			6.2			4.8
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)	<50	<50	0	<50	<50	0							
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)	200	300	40	**<100**	**200**	**67**							
Total Mercury by FIMS	Mercury	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.1	0							
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)							7380	5100	37	4330	3700	16	880
	Antimony	mg/kg	5 : 2 (Interlab)	**62**	**28**	**76**	<5	<5	0	<5	<10	0	**34**	**65**	**63**	<5
	Arsenic	mg/kg	5 : 2 (Interlab)	13	10	26	6	6	0	9	11	20	12	10	18	<5
	Barium	mg/kg	10 : 5 (Interlab)	50	40	22	30	40	29							
	Beryllium	mg/kg	1 : 2 (Interlab)	<1	<1	0	<1	<1	0							
	Boron	mg/kg	50 : 5 (Interlab)	<50	<50	0	<50	<50	0							
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<1	<1	0	<1	<1	0	<1			<1			<1
	Chromium	mg/kg	2 : 5 (Interlab)	12	10	18	28	26	7							
	Cobalt	mg/kg	2 : 5 (Interlab)	2	<2	0	3	3	0							
	Copper	mg/kg	5	7	6	15	7	8	13	74			6			<5
	Iron	mg/kg	50 : 5 (Interlab)							9770	9500	3	**29500**	**7700**	**117**	8220
	Lead	mg/kg	5	**75**	**13**	**141**	15	14	7	24			36			<5
	Sodium	mg/kg	50 : 5 (Interlab)													
	Manganese	mg/kg	5	51	36	34	36	42	15	238	240	1	172	170	1	65
	Potassium	mg/kg	50 : 5 (Interlab)													
	Calcium	mg/kg	50 : 5 (Interlab)													
	Molybdenum	mg/kg	2 : 5 (Interlab)													
	Nickel	mg/kg	2 : 5 (Interlab)	6	5	18	10	11	10	10			10			<2
	Magnesium	mg/kg	50 : 5 (Interlab)													
	Selenium	mg/kg	5 : 2 (Interlab)	<5	<5	0	<5	<5	0							
	Silver	mg/kg	2 : 1 (Interlab)													
	Strontium	mg/kg	2													
	Thallium	mg/kg	5 : 10 (Interlab)													
	Tin	mg/kg	5													
	Titanium	mg/kg	10													
	Vanadium	mg/kg	5 : 10 (Interlab)	19	17	11	30	30	0							
	Zinc	mg/kg	5	17	16	6	22	22	0	229			23			6
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)													
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)													
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)	**23100**	**6100**	**116**	4900	6100	22							

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

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Table D1.2: Soil QA/QC results

			SDG	Interlab_D	
			Field_ID	DC002/4911_20140710	**RPD**
			Sampled_Date-Time	10/07/2014 15:00	
Method_Type	**ChemName**	**Units**	**EQL**		
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)	**11**	**59**
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1		
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	14	5
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1		
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)		
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)		
Total Mercury by FIMS	Mercury	mg/kg	0.1		
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)	1400	46
	Antimony	mg/kg	5 : 2 (Interlab)	<10	0
	Arsenic	mg/kg	5 : 2 (Interlab)	3.9	25
	Barium	mg/kg	10 : 5 (Interlab)		
	Beryllium	mg/kg	1 : 2 (Interlab)		
	Boron	mg/kg	50 : 5 (Interlab)		
	Cadmium	mg/kg	1 : 0.4 (Interlab)		
	Chromium	mg/kg	2 : 5 (Interlab)		
	Cobalt	mg/kg	2 : 5 (Interlab)		
	Copper	mg/kg	5		
	Iron	mg/kg	50 : 5 (Interlab)	8000	3
	Lead	mg/kg	5		
	Sodium	mg/kg	50 : 5 (Interlab)		
	Manganese	mg/kg	5	71	9
	Potassium	mg/kg	50 : 5 (Interlab)		
	Calcium	mg/kg	50 : 5 (Interlab)		
	Molybdenum	mg/kg	2 : 5 (Interlab)		
	Nickel	mg/kg	2 : 5 (Interlab)		
	Magnesium	mg/kg	50 : 5 (Interlab)		
	Selenium	mg/kg	5 : 2 (Interlab)		
	Silver	mg/kg	2 : 1 (Interlab)		
	Strontium	mg/kg	2		
	Thallium	mg/kg	5 : 10 (Interlab)		
	Tin	mg/kg	5		
	Titanium	mg/kg	10		
	Vanadium	mg/kg	5 : 10 (Interlab)		
	Zinc	mg/kg	5		
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)		
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)		
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)		

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

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			SDG	EM1407187	Interlab_D		EM1405428	Interlab_D		EM1405428	Interlab_D		EM1405428	Interlab_D		EM1405428	Interlab_D		EM1405428	Interlab_D	
			Field_ID	51/4001_20140718	51/4901_20140718	**RPD**	3/4001_20140603	3/4901_20140603	**RPD**	13/4001_20140603	13/4901_20140603	**RPD**	4/4001_20140603	4/4901_20140603	**RPD**	14/4001_20140603	14/4901_20140603	**RPD**	14/4002_20140603	14/4902_20140603	**RPD**
			Sampled_Date-Time	18/07/2014 15:00	18/07/2014 15:00		3/06/2014 15:00	3/06/2014 15:00		3/06/2014 15:00	3/06/2014 15:00		3/06/2014 15:00	3/06/2014 15:00		3/06/2014 15:00	3/06/2014 15:00		3/06/2014 15:00	3/06/2014 15:00	
Method_Type	**ChemName**	**Units**	**EQL**																		
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)				36	41	13	**36**	**61**	**52**	1390	940	39	141			50	54	8
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1																		
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	48.5	77	45	17.6	17	3	37.8	41	8	49.4	49	1	44.7	41	9	31.4	34	8
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1	6.3			4.6			5.5			6.6			7.1			5.3		
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)	**60**	**<30**	**67**															
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)																		
Total Mercury by FIMS	Mercury	mg/kg	0.1	**0.4**	**0.2**	**67**															
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)	22200	18000	21	9720	11000	12	5060	3900	26	4480	7100	45	13400			6870	9100	28
	Antimony	mg/kg	5 : 2 (Interlab)	40	43	7	97	120	21	182	210	14	8	11	32	114			73	110	40
	Arsenic	mg/kg	5 : 2 (Interlab)	**21**	**<2**	**165**	**18**	**4.7**	**117**	**16**	**8.9**	**57**	<5	4	22	10			19	18	5
	Barium	mg/kg	10 : 5 (Interlab)	**380**	**180**	**71**															
	Beryllium	mg/kg	1 : 2 (Interlab)	<1	<2	0															
	Boron	mg/kg	50 : 5 (Interlab)	**<50**	**7**	**151**															
	Cadmium	mg/kg	1 : 0.4 (Interlab)	3	1.9	45	<1			<1			<1			<1			<1		
	Chromium	mg/kg	2 : 5 (Interlab)	**54**	**26**	**70**															
	Cobalt	mg/kg	2 : 5 (Interlab)	6	<5	18															
	Copper	mg/kg	5	67	41	48	10			21			114			37			12		
	Iron	mg/kg	50 : 5 (Interlab)	**56900**	**27000**	**71**	36800	45000	20	8260	10000	19	7980	11000	32	21500			16100	21000	26
	Lead	mg/kg	5	505	430	16	26			45			5			128			58		
	Sodium	mg/kg	50 : 5 (Interlab)	140	110	24															
	Manganese	mg/kg	5	**209**	**71**	**99**	110	80	32	436	490	12	714	630	13	610			128	110	15
	Potassium	mg/kg	50 : 5 (Interlab)	**3910**	**2200**	**56**															
	Calcium	mg/kg	50 : 5 (Interlab)	**1350**	**740**	**58**															
	Molybdenum	mg/kg	2 : 5 (Interlab)	<2	<5	0															
	Nickel	mg/kg	2 : 5 (Interlab)	**25**	**13**	**63**	13			6			11			11			8		
	Magnesium	mg/kg	50 : 5 (Interlab)	**4130**	**2200**	**61**															
	Selenium	mg/kg	5 : 2 (Interlab)	<5	<5	0															
	Silver	mg/kg	2 : 1 (Interlab)	<2	<1	0															
	Strontium	mg/kg	2	17																	
	Thallium	mg/kg	5 : 10 (Interlab)	<5	<10	0															
	Tin	mg/kg	5	7	<5	33															
	Titanium	mg/kg	10	**210**	**77**	**93**															
	Vanadium	mg/kg	5 : 10 (Interlab)	**37**	**19**	**64**															
	Zinc	mg/kg	5	27900	24000	15	42			239			525			240			216		
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)	**1310**	**760**	**53**															
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)	1670	1700	2															
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)																		

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

			SDG	EM1405428	Interlab_D		EM1410486	Interlab_D		EM1410486	Interlab_D		EM1410438	Interlab_D		EM1410485
			Field_ID	26/4001_20140603	26/4901_20140603	**RPD**	50_BH01/4001_20141007	50_BH01/4901_20141007	**RPD**	47_BH10/4001_20141007	47_BH10/4901_20141007	**RPD**	38_BH02/4001_20141006	38_BH02/4901_20141006	**RPD**	30_BH08/4001_20141007
			Sampled_Date-Time	3/06/2014 15:00	3/06/2014 15:00		7/10/2014 15:00	7/10/2014 15:00		7/10/2014 15:00	7/10/2014 15:00		6/10/2014 15:00	6/10/2014 15:00		7/10/2014 15:00
Method_Type	**ChemName**	**Units**	**EQL**													
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)	10	<10	0	25	20	22							
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1				<1			<1			1			<1
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	12.7	11	14	2.7	3.4	23	3.5	4.1	16	**1.5**	**0.8**	**61**	25.4
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1				4.5			4.4			5.4			4.9
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)				<50									
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)				<100	<100	0							
Total Mercury by FIMS	Mercury	mg/kg	0.1				<0.1	<0.1	0	<0.1	<0.1	0	<0.1	<0.1	0	**0.2**
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)	9970	13000	26										
	Antimony	mg/kg	5 : 2 (Interlab)	**18**	**91**	**134**	<5	<10	0	**40**	**92**	**79**	9	<10	11	100
	Arsenic	mg/kg	5 : 2 (Interlab)	**7**	**<2**	**111**	**6**	**12**	**67**	**16**	**27**	**51**	<5	4.2	17	18
	Barium	mg/kg	10 : 5 (Interlab)				30	46	42							
	Beryllium	mg/kg	1 : 2 (Interlab)				<1	<2	0							
	Boron	mg/kg	50 : 5 (Interlab)				<50	<10	0							
	Cadmium	mg/kg	1 : 0.4 (Interlab)				<1	<0.4	0	<1	<0.4	0	<1	<0.4	0	<1
	Chromium	mg/kg	2 : 5 (Interlab)				28	23	20							
	Cobalt	mg/kg	2 : 5 (Interlab)				3	<5	50							
	Copper	mg/kg	5				7	6.4	9	12	11	9	<5	<5	0	27
	Iron	mg/kg	50 : 5 (Interlab)	31200	33000	6				58500	55000	6	4050	4100	1	**28000**
	Lead	mg/kg	5				15	11	31	25	19	27	<5	<5	0	103
	Sodium	mg/kg	50 : 5 (Interlab)													
	Manganese	mg/kg	5	**304**	**68**	**127**	36	44	20	91	100	9	62	55	12	535
	Potassium	mg/kg	50 : 5 (Interlab)													
	Calcium	mg/kg	50 : 5 (Interlab)													
	Molybdenum	mg/kg	2 : 5 (Interlab)													
	Nickel	mg/kg	2 : 5 (Interlab)				10	9.8	2	25	24	4	<2	<5	0	25
	Magnesium	mg/kg	50 : 5 (Interlab)													
	Selenium	mg/kg	5 : 2 (Interlab)				<5	<2	0							
	Silver	mg/kg	2 : 1 (Interlab)													
	Strontium	mg/kg	2													
	Thallium	mg/kg	5 : 10 (Interlab)													
	Tin	mg/kg	5													
	Titanium	mg/kg	10													
	Vanadium	mg/kg	5 : 10 (Interlab)				30	25	18							
	Zinc	mg/kg	5				22	22	0	55	51	8	7	8.7	22	237
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)													
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)													
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)				4900	6400	27							

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

Table D1.2: Soil QA/QC results

			SDG	Interlab_D	
			Field_ID	30_BH08/4901_20141007	**RPD**
			Sampled_Date-Time	7/10/2014 15:00	
Method_Type	**ChemName**	**Units**	**EQL**		
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)		
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1		
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	21	19
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1		
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)		
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)		
Total Mercury by FIMS	Mercury	mg/kg	0.1	**0.1**	**67**
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)		
	Antimony	mg/kg	5 : 2 (Interlab)	140	33
	Arsenic	mg/kg	5 : 2 (Interlab)	26	36
	Barium	mg/kg	10 : 5 (Interlab)		
	Beryllium	mg/kg	1 : 2 (Interlab)		
	Boron	mg/kg	50 : 5 (Interlab)		
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<0.4	0
	Chromium	mg/kg	2 : 5 (Interlab)		
	Cobalt	mg/kg	2 : 5 (Interlab)		
	Copper	mg/kg	5	23	16
	Iron	mg/kg	50 : 5 (Interlab)	**330000**	**169**
	Lead	mg/kg	5	93	10
	Sodium	mg/kg	50 : 5 (Interlab)		
	Manganese	mg/kg	5	430	22
	Potassium	mg/kg	50 : 5 (Interlab)		
	Calcium	mg/kg	50 : 5 (Interlab)		
	Molybdenum	mg/kg	2 : 5 (Interlab)		
	Nickel	mg/kg	2 : 5 (Interlab)	24	4
	Magnesium	mg/kg	50 : 5 (Interlab)		
	Selenium	mg/kg	5 : 2 (Interlab)		
	Silver	mg/kg	2 : 1 (Interlab)		
	Strontium	mg/kg	2		
	Thallium	mg/kg	5 : 10 (Interlab)		
	Tin	mg/kg	5		
	Titanium	mg/kg	10		
	Vanadium	mg/kg	5 : 10 (Interlab)		
	Zinc	mg/kg	5	190	22
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)		
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)		
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)		

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

Table D1.2: Soil QA/QC results

			SDG	EM1410438	Interlab_D		EM1410438	Interlab_D		EM1410438	Interlab_D		EM1410486	Interlab_D		EM1410486
			Field_ID	27_BH6/4001_20141006	27_BH06/4901_20141006	**RPD**	27_BH9/4001_20141006	27_BH09/4901_20141006	**RPD**	1_BH04/4001_20141006	1_BH04/4901_20141006	**RPD**	23_BH01/4001_20141007	23_BH01/4901_20141007	**RPD**	34_BH01/4001_20141007
			Sampled_Date-Time	6/10/2014 15:00	6/10/2014 15:00		6/10/2014 15:00	6/10/2014 15:00		6/10/2014 15:00	6/10/2014 15:00		7/10/2014 15:00	7/10/2014 15:00		7/10/2014 15:00
Method_Type	**ChemName**	**Units**	**EQL**													
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)							**110**	**460**	**123**	**39**	**19**	**69**	10
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1	<1						<1			<1			<1
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	**3.4**	**6.3**	**60**	**13.2**	**31**	**81**	5	3.4	38	17	19	11	7.8
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1	7.8						6.1			4			4.8
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)							<50			<50			<50
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)							300	310	3	200	180	11	**200**
Total Mercury by FIMS	Mercury	mg/kg	0.1	<0.1	<0.1	0	<0.1	<0.1	0	<0.1	<0.1	0	<0.1	<0.1	0	<0.1
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)													
	Antimony	mg/kg	5 : 2 (Interlab)	<5	<10	0	**9**	**16**	**56**	**92**	**650**	**150**	62	62	0	201
	Arsenic	mg/kg	5 : 2 (Interlab)	<5	5	0	<5	6.3	23	27	43	46	13	14	7	8
	Barium	mg/kg	10 : 5 (Interlab)							130	180	32	50	42	17	20
	Beryllium	mg/kg	1 : 2 (Interlab)							**1**	**<2**	**67**	<1	<2	0	<1
	Boron	mg/kg	50 : 5 (Interlab)							<50	<10	0	<50	<10	0	<50
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<1	<0.4	0	<1	0.8	22	<1	<0.4	0	<1	<0.4	0	<1
	Chromium	mg/kg	2 : 5 (Interlab)							19	18	5	12	9.2	26	5
	Cobalt	mg/kg	2 : 5 (Interlab)							24	16	40	**2**	**<5**	**86**	<2
	Copper	mg/kg	5	10	10	0	<5	6.1	20	25	21	17	7	<5	33	<5
	Iron	mg/kg	50 : 5 (Interlab)	5950	7300	20	**3480**	**9800**	**95**							
	Lead	mg/kg	5	<5	<5	0	9	11	20	38	33	14	**75**	**13**	**141**	10
	Sodium	mg/kg	50 : 5 (Interlab)													
	Manganese	mg/kg	5	91	90	1	**16**	**180**	**167**	239	230	4	51	44	15	121
	Potassium	mg/kg	50 : 5 (Interlab)													
	Calcium	mg/kg	50 : 5 (Interlab)													
	Molybdenum	mg/kg	2 : 5 (Interlab)													
	Nickel	mg/kg	2 : 5 (Interlab)	11	8.9	21	**2**	**<5**	**86**	41	29	34	6	<5	18	4
	Magnesium	mg/kg	50 : 5 (Interlab)													
	Selenium	mg/kg	5 : 2 (Interlab)							<5	<2	0	<5	<2	0	<5
	Silver	mg/kg	2 : 1 (Interlab)													
	Strontium	mg/kg	2													
	Thallium	mg/kg	5 : 10 (Interlab)													
	Tin	mg/kg	5													
	Titanium	mg/kg	10													
	Vanadium	mg/kg	5 : 10 (Interlab)							18	19	5	19	15	24	7
	Zinc	mg/kg	5	31	35	12	**8**	**560**	**194**	84	72	15	17	15	13	16
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)													
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)													
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)							**4200**	**13000**	**102**	23100	34000	38	**4900**

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

			SDG	Interlab_D	
			Field_ID	34_BH01/4901_20141007	**RPD**
			Sampled_Date-Time	7/10/2014 15:00	
Method_Type	**ChemName**	**Units**	**EQL**		
Electrical Conductivity (1:5)	Electrical Conductivity @ 25°C	uS/cm	1 : 10 (Interlab)	<10	0
Free Cyanide by Segmented Flow Analyser	Cyanide (free)	mg/kg	1		
Moisture Content	Moisture	%	1 : 0.1 (Interlab)	8	3
pH in soil using a 0.01M CaCl2 extract	PH_CACL2	pH Unit	0.1		
Sulfate - Calcium Phosphate Soluble	Sulphate (as SO4)	mg/kg	50 : 30 (Interlab)		
Sulfur - Total as S (LECO)	Sulphur (as S)	mg/kg	100 : 5 (Interlab)	**<100**	**67**
Total Mercury by FIMS	Mercury	mg/kg	0.1	<0.1	0
Total Metals by ICP-AES	Aluminium	mg/kg	50 : 10 (Interlab)		
	Antimony	mg/kg	5 : 2 (Interlab)	220	9
	Arsenic	mg/kg	5 : 2 (Interlab)	9.2	14
	Barium	mg/kg	10 : 5 (Interlab)	29	37
	Beryllium	mg/kg	1 : 2 (Interlab)	<2	0
	Boron	mg/kg	50 : 5 (Interlab)	<10	0
	Cadmium	mg/kg	1 : 0.4 (Interlab)	<0.4	0
	Chromium	mg/kg	2 : 5 (Interlab)	<5	0
	Cobalt	mg/kg	2 : 5 (Interlab)	<5	0
	Copper	mg/kg	5	<5	0
	Iron	mg/kg	50 : 5 (Interlab)		
	Lead	mg/kg	5	8.4	17
	Sodium	mg/kg	50 : 5 (Interlab)		
	Manganese	mg/kg	5	130	7
	Potassium	mg/kg	50 : 5 (Interlab)		
	Calcium	mg/kg	50 : 5 (Interlab)		
	Molybdenum	mg/kg	2 : 5 (Interlab)		
	Nickel	mg/kg	2 : 5 (Interlab)	<5	22
	Magnesium	mg/kg	50 : 5 (Interlab)		
	Selenium	mg/kg	5 : 2 (Interlab)	<2	0
	Silver	mg/kg	2 : 1 (Interlab)		
	Strontium	mg/kg	2		
	Thallium	mg/kg	5 : 10 (Interlab)		
	Tin	mg/kg	5		
	Titanium	mg/kg	10		
	Vanadium	mg/kg	5 : 10 (Interlab)	<10	35
	Zinc	mg/kg	5	16	0
	Total Phosphorus (as P)	mg/kg	50 : 5 (Interlab)		
	Sulphur (as S)	mg/kg	50 : 5 (Interlab)		
Total Organic Carbon	Total Organic Carbon	mg/kg	200 : 50 (Interlab)	**11000**	**77**

*RPDs have only been considered where a concentration is greater than 0 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (0-10 x EQL); 50 (10-30 x EQL); 50 (> 30

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the ro

Table D1-3: Field blanks, rinsate and laboratory blank results

			SDG	EM1410438	EM1410438	EM1410485	EM1410485	EM1410580	EM1410580	EM1405428	EM1405428	EM1405497	EM1405497	EM1405497	EM1405497	EM1405497	EM1405497	EM1405497	EM1405497
			Field_ID	13/5602_20141006	53/5602_20141006	35/5602_20141007	52/5601_20141007	18/5601_20141008	19/5602_20141008	40/5501_20140602	40/5502_20140602	12/4502_20140604	1/4501_20140603	1/5501_20140603	1/5502_20140603	1/5503_20140603	12/5501_20140604	12/5502_20140604	12/5503_20140604
			Sampled_Date-Time	6/10/2014 15:00	6/10/2014 15:00	7/10/2014 15:00	7/10/2014 15:00	8/10/2014 15:00	8/10/2014 15:00	2/06/2014 15:00	2/06/2014 15:00	4/06/2014 15:00	3/06/2014 15:00	3/06/2014 15:00	3/06/2014 15:00	3/06/2014 15:00	4/06/2014 15:00	4/06/2014 15:00	4/06/2014 15:00
			Sample_Type	Field_B	Field_B	Field_B	Field_B	Field_B	Field_B	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate
Method_Type	**ChemName**	**Units**	**EQL**																
Conductivity	Electrical Conductivity @ 25°C	uS/cm	1									<1	**1**						
Dissolved Mercury by FIMS	Mercury (Filtered)	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001										
Dissolved Metals by ICP-MS - Suite A	Aluminium (Filtered)	mg/l	0.01									<0.01	<0.01						
	Antimony (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Arsenic (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Barium (Filtered)	mg/l	0.001	<0.001				<0.001											
	Beryllium (Filtered)	mg/l	0.001	<0.001				<0.001											
	Boron (Filtered)	mg/l	0.05	<0.05				<0.05											
	Cadmium (Filtered)	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Chromium (Filtered)	mg/l	0.001	<0.001				<0.001											
	Cobalt (Filtered)	mg/l	0.001	<0.001				<0.001											
	Copper (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Iron (Filtered)	mg/l	0.05		<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Lead (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Manganese (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001						
	Nickel (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Selenium (Filtered)	mg/l	0.01	<0.01				<0.01											
	Vanadium (Filtered)	mg/l	0.01	<0.01				<0.01											
	Zinc (Filtered)	mg/l	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Field	Colour (Field Observation)	Obs																	
	Odour (Field Observation)	Obs																	
	Electrolytic Conductivity (Field)	mS/cm																	
	pH (Field)	pH_Units																	
	Temp (Field)	oC																	
Heavy Metal	Antimony	mg/l	0.005																
	Antimony (Filtered)	mg/l	0.005																
	Arsenic	mg/l	0.001																
	Arsenic (Filtered)	mg/L	0.001																
	Barium	mg/L	0.02																
	Beryllium	mg/l	0.001																
	Beryllium (Filtered)	mg/l	0.001																
	Boron	mg/l	0.05																
	Boron (Filtered)	mg/L	0.05																
	Cadmium	mg/L	0.0002																
	Cadmium (Filtered)	mg/l	0.0002																
	Chromium	mg/L	0.001																
	Chromium (Filtered)	mg/l	0.001																
	Cobalt	mg/L	0.001																
	Cobalt (Filtered)	mg/l	0.001																
	Copper	mg/L	0.001																
	Copper (Filtered)	mg/l	0.001																
	Lead	mg/L	0.001																
	Lead (Filtered)	mg/l	0.001																
	Manganese	mg/L	0.005																
	Manganese (Filtered)	mg/l	0.005																
	Mercury	mg/L	0.0001																
	Mercury (Filtered)	mg/l	0.0001																
	Nickel	mg/L	0.001																
	Nickel (Filtered)	mg/l	0.001																
	Selenium	mg/L	0.001																
	Selenium (Filtered)	mg/l	0.001																
	Vanadium	mg/l	0.005																
	Vanadium (Filtered)	mg/l	0.005																
	Zinc	mg/l	0.001																
	Zinc (Filtered)	mg/L	0.001																
Heavy Metals	Arsenic (Filtered)	mg/l	0.001																
	Cadmium (Filtered)	mg/l	0.0002																
	Chromium (Filtered)	mg/l	0.001																
	Copper (Filtered)	mg/l	0.001																
	Lead (Filtered)	mg/l	0.001																
	Nickel (Filtered)	mg/l	0.001																
	Zinc (Filtered)	mg/l	0.001																
Leachable Metals by ICPAES	Antimony (Filtered)	mg/l	0.1																
pH by PC Titrator	pH (Lab)	pH_Units	0.01									**6.01**	**5.53**						
pH by PC Titrator1	pH (Lab)	pH_Units	0.01																
Sulfate (Turbidimetric) as SO4 2- by Discrete Anal	Sulphate (as SO4) (Filtered)	mg/l	1									**1**	**1**						
Total Dissolved Solids (High Level)	Total Dissolved Solids @180°C	mg/l	10																
Total Dissolved Solids (High Level)1	Total Dissolved Solids @180°C	mg/l	10																
Total Mercury by FIMS	Mercury	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001										
Total Metals by ICP-MS - Suite A	Aluminium	mg/l	0.01									<0.01	<0.01						
	Antimony	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Arsenic	mg/l	0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Barium	mg/l	0.001	<0.001				<0.001											
	Beryllium	mg/l	0.001	<0.001				<0.001											
	Boron	mg/l	0.05	<0.05				<0.05											
	Cadmium	mg/l	0.0001	<0.0001	**0.0005**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Chromium	mg/l	0.001	<0.001				<0.001											
	Cobalt	mg/l	0.001	<0.001				<0.001											
	Copper	mg/l	0.001	<0.001	**0.002**	<0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	**0.001**	**0.207**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Iron	mg/l	0.05		<0.05	<0.05	**0.08**		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Lead	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.007**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Manganese	mg/l	0.001	<0.001	**0.001**	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001						
	Nickel	mg/l	0.001	<0.001	<0.001	<0.001	**0.003**	<0.001	<0.001	<0.001	<0.001	<0.001	**0.007**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Selenium	mg/L	0.01	<0.01				<0.01											
	Vanadium	mg/l	0.01	<0.01				<0.01											
	Zinc	mg/l	0.005	<0.005	**0.016**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	**0.04**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
UNK	Barium (Filtered)	mg/l	0.02																
Water Leachable Metals by ICPAES	Antimony	mg/l	0.01																

Table D1-3: Field blanks, rinsate and laboratory blank results

			SDG	EM1405562	EM1405562	EM1405562	EM1410438	EM1410580	EM1410580	EM1410485	EM1405562	EM1410438	EM1410438	EM1410485	EM1410485	EM1410580	EM1410580	EM1410438	EM1410438
			Field_ID	43/5501_20140605	43/5502_20140605	43/5503_20140605	26/5501_20141006	31/5502_20141008	17/5502_20141008	50/5501_20141007	43/4501_20140605	27/4512_20141006	53/4502_20141006	35/4502_20141007	50/4501_20141007	32/4501_20141008	17/4502_20141008	pH: 4	pH: 7
			Sampled_Date-Time	5/06/2014 15:00	5/06/2014 15:00	5/06/2014 15:00	6/10/2014 15:00	8/10/2014 15:00	8/10/2014 15:00	7/10/2014 15:00	5/06/2014 15:00	6/10/2014 15:00	6/10/2014 15:00	7/10/2014 15:00	7/10/2014 15:00	8/10/2014 15:00	8/10/2014 15:00	8/10/2014 15:00	8/10/2014 15:00
			Sample_Type	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate
Method_Type	**ChemName**	**Units**	**EQL**																
Conductivity	Electrical Conductivity @ 25°C	uS/cm	1								<1								
Dissolved Mercury by FIMS	Mercury (Filtered)	mg/l	0.0001				<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		
Dissolved Metals by ICP-MS - Suite A	Aluminium (Filtered)	mg/l	0.01								<0.01								
	Antimony (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
	Arsenic (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
	Barium (Filtered)	mg/l	0.001				<0.001	<0.001	<0.001			<0.001					<0.001		
	Beryllium (Filtered)	mg/l	0.001				<0.001	<0.001	<0.001			<0.001					<0.001		
	Boron (Filtered)	mg/l	0.05				**0.12**	<0.05	<0.05			<0.05					<0.05		
	Cadmium (Filtered)	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		
	Chromium (Filtered)	mg/l	0.001				<0.001	<0.001	<0.001			<0.001					<0.001		
	Cobalt (Filtered)	mg/l	0.001				<0.001	<0.001	<0.001			<0.001					<0.001		
	Copper (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
	Iron (Filtered)	mg/l	0.05	<0.05	<0.05	<0.05				<0.05	<0.05		<0.05	<0.05	<0.05	<0.05			
	Lead (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
	Manganese (Filtered)	mg/l	0.001				**0.006**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
	Nickel (Filtered)	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
	Selenium (Filtered)	mg/l	0.01				<0.01	<0.01	<0.01			<0.01					<0.01		
	Vanadium (Filtered)	mg/l	0.01				<0.01	<0.01	<0.01			<0.01					<0.01		
	Zinc (Filtered)	mg/l	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	**0.032**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		
Field	Colour (Field Observation)	Obs																	
	Odour (Field Observation)	Obs																	
	Electrolytic Conductivity (Field)	mS/cm																	
	pH (Field)	pH_Units																	
	Temp (Field)	oC																	
Heavy Metal	Antimony	mg/l	0.005																
	Antimony (Filtered)	mg/l	0.005																
	Arsenic	mg/l	0.001																
	Arsenic (Filtered)	mg/L	0.001																
	Barium	mg/L	0.02																
	Beryllium	mg/l	0.001																
	Beryllium (Filtered)	mg/l	0.001																
	Boron	mg/l	0.05																
	Boron (Filtered)	mg/L	0.05																
	Cadmium	mg/L	0.0002																
	Cadmium (Filtered)	mg/l	0.0002																
	Chromium	mg/L	0.001																
	Chromium (Filtered)	mg/l	0.001																
	Cobalt	mg/L	0.001																
	Cobalt (Filtered)	mg/l	0.001																
	Copper	mg/L	0.001																
	Copper (Filtered)	mg/l	0.001																
	Lead	mg/L	0.001																
	Lead (Filtered)	mg/l	0.001																
	Manganese	mg/L	0.005																
	Manganese (Filtered)	mg/l	0.005																
	Mercury	mg/L	0.0001																
	Mercury (Filtered)	mg/l	0.0001																
	Nickel	mg/L	0.001																
	Nickel (Filtered)	mg/l	0.001																
	Selenium	mg/L	0.001																
	Selenium (Filtered)	mg/l	0.001																
	Vanadium	mg/l	0.005																
	Vanadium (Filtered)	mg/l	0.005																
	Zinc	mg/l	0.001																
	Zinc (Filtered)	mg/L	0.001																
Heavy Metals	Arsenic (Filtered)	mg/l	0.001																
	Cadmium (Filtered)	mg/l	0.0002																
	Chromium (Filtered)	mg/l	0.001																
	Copper (Filtered)	mg/l	0.001																
	Lead (Filtered)	mg/l	0.001																
	Nickel (Filtered)	mg/l	0.001																
	Zinc (Filtered)	mg/l	0.001																
Leachable Metals by ICPAES	Antimony (Filtered)	mg/l	0.1																
pH by PC Titrator	pH (Lab)	pH_Units	0.01								**5.97**								
pH by PC Titrator1	pH (Lab)	pH_Units	0.01																
Sulfate (Turbidimetric) as SO4 2- by Discrete Anal	Sulphate (as SO4) (Filtered)	mg/l	1								<1								
Total Dissolved Solids (High Level)	Total Dissolved Solids @180°C	mg/l	10																
Total Dissolved Solids (High Level)1	Total Dissolved Solids @180°C	mg/l	10																
Total Mercury by FIMS	Mercury	mg/l	0.0001				<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Metals by ICP-MS - Suite A	Aluminium	mg/l	0.01								<0.01								
	Antimony	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.007**	<0.001	<0.001	<0.001	**0.001**	<0.001	<0.001
	Arsenic	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Barium	mg/l	0.001				**0.001**	<0.001	<0.001			<0.001					<0.001		
	Beryllium	mg/l	0.001				<0.001	<0.001	<0.001			<0.001					<0.001		
	Boron	mg/l	0.05				<0.05	<0.05	<0.05			<0.05					<0.05		
	Cadmium	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	**0.0006**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Chromium	mg/l	0.001				<0.001	<0.001	<0.001			<0.001					<0.001	<0.001	<0.001
	Cobalt	mg/l	0.001				<0.001	<0.001	<0.001			<0.001					<0.001		
	Copper	mg/l	0.001	<0.001	<0.001	<0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	**0.001**	**0.007**	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**
	Iron	mg/l	0.05	<0.05	<0.05	<0.05				<0.05	<0.05		<0.05	<0.05	<0.05	<0.05			
	Lead	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Manganese	mg/l	0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	<0.001	<0.001	<0.001	<0.001		
	Nickel	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Selenium	mg/L	0.01				<0.01	<0.01	<0.01			<0.01					<0.01		
	Vanadium	mg/l	0.01				<0.01	<0.01	<0.01			<0.01					<0.01		
	Zinc	mg/l	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	**0.022**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
UNK	Barium (Filtered)	mg/l	0.02																
Water Leachable Metals by ICPAES	Antimony	mg/l	0.01																

Table D1-3: Field blanks, rinsate and laboratory blank results

			SDG	EM1410485	EM1410485	EM1409308	EM1409308	EM1410580	EM1410580	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130
			Field_ID	pH: 4	pH: 7	pH 2 Blank	pH 7 Blank	pH: 4	pH: 7	pH 4_1	pH 4_2	pH 4_3	pH 4_4	pH 4_5	pH 4_6	pH 4_7	pH 4_8	pH 4_9	pH 4_10	pH 7_1
			Sampled_Date-Time	8/10/2014 15:00	8/10/2014 15:00	13/08/2014 15:00	13/08/2014 15:00	8/10/2014 15:00	8/10/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00
			Sample_Type	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate
Method_Type	**ChemName**	**Units**	**EQL**																	
Conductivity	Electrical Conductivity @ 25°C	uS/cm	1																	
Dissolved Mercury by FIMS	Mercury (Filtered)	mg/l	0.0001																	
Dissolved Metals by ICP-MS - Suite A	Aluminium (Filtered)	mg/l	0.01																	
	Antimony (Filtered)	mg/l	0.001																	
	Arsenic (Filtered)	mg/l	0.001																	
	Barium (Filtered)	mg/l	0.001																	
	Beryllium (Filtered)	mg/l	0.001																	
	Boron (Filtered)	mg/l	0.05																	
	Cadmium (Filtered)	mg/l	0.0001																	
	Chromium (Filtered)	mg/l	0.001																	
	Cobalt (Filtered)	mg/l	0.001																	
	Copper (Filtered)	mg/l	0.001																	
	Iron (Filtered)	mg/l	0.05																	
	Lead (Filtered)	mg/l	0.001																	
	Manganese (Filtered)	mg/l	0.001																	
	Nickel (Filtered)	mg/l	0.001																	
	Selenium (Filtered)	mg/l	0.01																	
	Vanadium (Filtered)	mg/l	0.01																	
	Zinc (Filtered)	mg/l	0.005																	
Field	Colour (Field Observation)	Obs																		
	Odour (Field Observation)	Obs																		
	Electrolytic Conductivity (Field)	mS/cm																		
	pH (Field)	pH_Units																		
	Temp (Field)	oC																		
Heavy Metal	Antimony	mg/l	0.005																	
	Antimony (Filtered)	mg/l	0.005																	
	Arsenic	mg/l	0.001																	
	Arsenic (Filtered)	mg/L	0.001																	
	Barium	mg/L	0.02																	
	Beryllium	mg/l	0.001																	
	Beryllium (Filtered)	mg/l	0.001																	
	Boron	mg/l	0.05																	
	Boron (Filtered)	mg/L	0.05																	
	Cadmium	mg/L	0.0002																	
	Cadmium (Filtered)	mg/l	0.0002																	
	Chromium	mg/L	0.001																	
	Chromium (Filtered)	mg/l	0.001																	
	Cobalt	mg/L	0.001																	
	Cobalt (Filtered)	mg/l	0.001																	
	Copper	mg/L	0.001																	
	Copper (Filtered)	mg/l	0.001																	
	Lead	mg/L	0.001																	
	Lead (Filtered)	mg/l	0.001																	
	Manganese	mg/L	0.005																	
	Manganese (Filtered)	mg/l	0.005																	
	Mercury	mg/L	0.0001																	
	Mercury (Filtered)	mg/l	0.0001																	
	Nickel	mg/L	0.001																	
	Nickel (Filtered)	mg/l	0.001																	
	Selenium	mg/L	0.001																	
	Selenium (Filtered)	mg/l	0.001																	
	Vanadium	mg/l	0.005																	
	Vanadium (Filtered)	mg/l	0.005																	
	Zinc	mg/l	0.001																	
	Zinc (Filtered)	mg/L	0.001																	
Heavy Metals	Arsenic (Filtered)	mg/l	0.001																	
	Cadmium (Filtered)	mg/l	0.0002																	
	Chromium (Filtered)	mg/l	0.001																	
	Copper (Filtered)	mg/l	0.001																	
	Lead (Filtered)	mg/l	0.001																	
	Nickel (Filtered)	mg/l	0.001																	
	Zinc (Filtered)	mg/l	0.001																	
Leachable Metals by ICPAES	Antimony (Filtered)	mg/l	0.1																	
pH by PC Titrator	pH (Lab)	pH_Units	0.01																	
pH by PC Titrator1	pH (Lab)	pH_Units	0.01																	
Sulfate (Turbidimetric) as SO4 2- by Discrete Anal	Sulphate (as SO4) (Filtered)	mg/l	1																	
Total Dissolved Solids (High Level)	Total Dissolved Solids @180°C	mg/l	10																	
Total Dissolved Solids (High Level)1	Total Dissolved Solids @180°C	mg/l	10																	
Total Mercury by FIMS	Mercury	mg/l	0.0001	<0.0001	<0.0001			<0.0001	<0.0001											
Total Metals by ICP-MS - Suite A	Aluminium	mg/l	0.01																	
	Antimony	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	**0.001**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Arsenic	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Barium	mg/l	0.001																	
	Beryllium	mg/l	0.001																	
	Boron	mg/l	0.05																	
	Cadmium	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	**0.0001**	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Chromium	mg/l	0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Cobalt	mg/l	0.001																	
	Copper	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	**0.005**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Iron	mg/l	0.05			<0.05	<0.05													
	Lead	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Manganese	mg/l	0.001																	
	Nickel	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Selenium	mg/L	0.01																	
	Vanadium	mg/l	0.01																	
	Zinc	mg/l	0.005	<0.005	<0.005	<0.005	<0.005	**0.012**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
UNK	Barium (Filtered)	mg/l	0.02																	
Water Leachable Metals by ICPAES	Antimony	mg/l	0.01																	

Table D1-3: Field blanks, rinsate and laboratory blank results

			SDG	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	EM1412130	438958	438958	438958	438958	438958
			Field_ID	pH 7_2	pH 7_3	pH 7_4	pH 7_5	pH 7_6	pH 7_7	pH 7_8	pH 7_9	pH 7_10	BLANK - 1	BLANK - 2	BLANK - 3	BLANK - 4	BLANK - 5
			Sampled_Date-Time	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	14/11/2014 15:00	17/11/2014	17/11/2014	17/11/2014	17/11/2014	17/11/2014
			Sample_Type	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate
Method_Type	**ChemName**	**Units**	**EQL**														
Conductivity	Electrical Conductivity @ 25°C	uS/cm	1														
Dissolved Mercury by FIMS	Mercury (Filtered)	mg/l	0.0001														
Dissolved Metals by ICP-MS - Suite A	Aluminium (Filtered)	mg/l	0.01														
	Antimony (Filtered)	mg/l	0.001														
	Arsenic (Filtered)	mg/l	0.001														
	Barium (Filtered)	mg/l	0.001														
	Beryllium (Filtered)	mg/l	0.001														
	Boron (Filtered)	mg/l	0.05														
	Cadmium (Filtered)	mg/l	0.0001														
	Chromium (Filtered)	mg/l	0.001														
	Cobalt (Filtered)	mg/l	0.001														
	Copper (Filtered)	mg/l	0.001														
	Iron (Filtered)	mg/l	0.05														
	Lead (Filtered)	mg/l	0.001														
	Manganese (Filtered)	mg/l	0.001														
	Nickel (Filtered)	mg/l	0.001														
	Selenium (Filtered)	mg/l	0.01														
	Vanadium (Filtered)	mg/l	0.01														
	Zinc (Filtered)	mg/l	0.005														
Field	Colour (Field Observation)	Obs															
	Odour (Field Observation)	Obs															
	Electrolytic Conductivity (Field)	mS/cm															
	pH (Field)	pH_Units															
	Temp (Field)	oC															
Heavy Metal	Antimony	mg/l	0.005										<0.005	<0.005	<0.005	<0.005	<0.005
	Antimony (Filtered)	mg/l	0.005										<0.005	<0.005	<0.005	<0.005	<0.005
	Arsenic	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Arsenic (Filtered)	mg/L	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Barium	mg/L	0.02										<0.02	<0.02	<0.02	<0.02	<0.02
	Beryllium	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Beryllium (Filtered)	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Boron	mg/l	0.05										<0.05	<0.05	<0.05	<0.05	<0.05
	Boron (Filtered)	mg/L	0.05										<0.05	<0.05	<0.05	<0.05	<0.05
	Cadmium	mg/L	0.0002										<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	Cadmium (Filtered)	mg/l	0.0002										<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	Chromium	mg/L	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Chromium (Filtered)	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Cobalt	mg/L	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Cobalt (Filtered)	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Copper	mg/L	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (Filtered)	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Lead	mg/L	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Lead (Filtered)	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Manganese	mg/L	0.005										<0.005	<0.005	<0.005	<0.005	<0.005
	Manganese (Filtered)	mg/l	0.005										<0.005	<0.005	<0.005	<0.005	<0.005
	Mercury	mg/L	0.0001										<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Mercury (Filtered)	mg/l	0.0001										<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Nickel	mg/L	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Nickel (Filtered)	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Selenium	mg/L	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Selenium (Filtered)	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Vanadium	mg/l	0.005										<0.005	<0.005	<0.005	<0.005	<0.005
	Vanadium (Filtered)	mg/l	0.005										<0.005	<0.005	<0.005	<0.005	<0.005
	Zinc	mg/l	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
	Zinc (Filtered)	mg/L	0.001										<0.001	<0.001	<0.001	<0.001	<0.001
Heavy Metals	Arsenic (Filtered)	mg/l	0.001														
	Cadmium (Filtered)	mg/l	0.0002														
	Chromium (Filtered)	mg/l	0.001														
	Copper (Filtered)	mg/l	0.001														
	Lead (Filtered)	mg/l	0.001														
	Nickel (Filtered)	mg/l	0.001														
	Zinc (Filtered)	mg/l	0.001														
Leachable Metals by ICPAES	Antimony (Filtered)	mg/l	0.1														
pH by PC Titrator	pH (Lab)	pH_Units	0.01														
pH by PC Titrator1	pH (Lab)	pH_Units	0.01														
Sulfate (Turbidimetric) as SO4 2- by Discrete Anal	Sulphate (as SO4) (Filtered)	mg/l	1														
Total Dissolved Solids (High Level)	Total Dissolved Solids @180°C	mg/l	10														
Total Dissolved Solids (High Level)1	Total Dissolved Solids @180°C	mg/l	10														
Total Mercury by FIMS	Mercury	mg/l	0.0001														
Total Metals by ICP-MS - Suite A	Aluminium	mg/l	0.01														
	Antimony	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001					
	Arsenic	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001					
	Barium	mg/l	0.001														
	Beryllium	mg/l	0.001														
	Boron	mg/l	0.05														
	Cadmium	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001					
	Chromium	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001					
	Cobalt	mg/l	0.001														
	Copper	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001					
	Iron	mg/l	0.05														
	Lead	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001					
	Manganese	mg/l	0.001														
	Nickel	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001					
	Selenium	mg/L	0.01														
	Vanadium	mg/l	0.01														
	Zinc	mg/l	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005					
UNK	Barium (Filtered)	mg/l	0.02										<0.02	<0.02	<0.02	<0.02	<0.02
Water Leachable Metals by ICPAES	Antimony	mg/l	0.01														

APPENDIX D2
Summary of Water Data

1.0 INTRODUCTION

Appendix D2 presents a summary of the tank water assessment program conducted by Golder in the Costerfield region. Data collected for a swimming pool, tank sediment and bottled water is also discussed in this appendix. The data will be used in the HRA exposure assessment (Appendix E), to determine the concentrations used to calculate the estimated daily intakes of selected chemicals due to their presence in tank water or bottled water. This Appendix describes the following:

- summary of the sampling approach and methodology;
- summary of the results and statistical analysis of the data;
- comparison of the data to published assessment criteria to establish the chemicals of potential concern (COPC) which is the list of chemicals to be modelled in the HRA; and
- establishment of the ‘average’ and ‘upper estimate’ water concentrations of COPC for input into the HRA exposure model.

The following tables are referred to throughout and attached to this appendix:

- Table D2.1: Water Analytical Results Pre-Tank Cleaning – Within Costerfield Dome
- Table D2.2: Water Analytical Results Pre-Tank Cleaning – Outside Costerfield Dome
- Table D2.3: Water Analytical Results Post-Tank Cleaning – Within Costerfield Dome
- Table D2.4: Water Analytical Results Post-Tank Cleaning – Outside Costerfield Dome
- Table D2.5: Statistical Summaries
- Table D2.6: Water Analytical Results for the Swimming Pool
- Table D2.7: Tank Sediment Analytical Results
- Table D2.8: QAQC – Analytical Results for Blank Samples collected January – May 2015
- Table D2.9: QAQC – Analytical Results for Duplicate Samples collected January – May 2015.

2.0 SAMPLING AND ASSESSMENT METHODOLOGY

Collection of tank water samples was summarised in *Assessment of Soil and Tank Water, Costerfield, Victoria* (Golder reference: 1413212-003-L-Rev0, dated 12 December 2014). The sampling and assessment methodology is also summarised in Table 1, below.

Table 1: Sampling and Assessment Methodology – Water

Item	Description
Adopted Sampling Guidelines	■ **Australian/New Zealand Standard 5667.1 (1998) Water Quality – Sampling Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.** This Standard provides general principles to be applied in sampling for the physical, chemical, microbiological or radiological analysis of waters and waste waters, including bottom sediment and sludges, for the purposes of process control, quality characterization, identification of sources of pollution and the monitoring of background levels. The guidance on sampling procedures provided in this Standard is generally applicable. Where alternative procedures are used they are to be demonstrated to be at least as reliable as those provided in this Standard or that they will achieve the

Item	Description
	objectives of the sampling and analysis program. ■ **Australian/New Zealand Standard 5667.5 (1998) Water Quality – Sampling Part 5: Guidance on sampling of drinking water and water used for food and beverage processing.** This is Part 5 in a series of Standards on the sampling of waters, waste waters, sediments and sludges. The objective this series of standards is to provide parties interested in monitoring and techniques, preservation, handling and transport of samples for the purposes of process control, quality characterisation, identification of sources of pollution, compliance with water quality guidelines or standards, and other activities. This part of the series provides detailed principles to be applied to the sampling of drinking water and water used for food and beverage processing.
Sample Points	■ **Rainwater tank** (sample collected within the tank). ■ **Kitchen tap** (sample collected when a resident was present to provide access). ■ **Rainwater tank tap** (collected when a tap was present and a sample could not be collected from within the tank due to logistical constraints). ■ **Outdoor tap** (collected when a garden tap was present and a resident was not present to provide access to the kitchen tap). ■ **Other internal tap** (collected when resident was present to provide access, however kitchen tap was not able to be sampled)
Number of Primary Samples Collected Within Costerfield Dome	<u>Sampling Round Prior to Tank Cleaning</u> (June – October 2014, 81 samples) ■ **Rainwater tank** – 28 samples ■ **Kitchen tap** – 34 samples ■ **Rainwater tank tap** - 11 samples ■ **Outdoor tap** – 7 samples ■ **Other internal tap** – 1 sample <u>Sampling Post Tank Cleaning</u> (October 2014 – May 2015, 86 samples) ■ **Rainwater tank** – 36 samples ■ **Kitchen tap** – 16 samples ■ **Rainwater tank tap** – 22 samples ■ **Outdoor tap** – 11 samples ■ **Other internal tap** – 1 sample
Number of Primary Samples Collected Outside of Costerfield Dome	<u>Sampling Round Prior to Tank Cleaning</u> (June – October 2014, 14 samples) ■ **Rainwater tank** – 5 samples ■ **Kitchen tap** – 5 samples ■ **Rainwater tank tap** - 1 samples

Item	Description
	■ **Outdoor tap** – 2 samples ■ **Other internal tap** – 1 sample <u>Sampling Post Tank Cleaning</u> (January 2015 – May 2015, 2 samples) ■ **Other internal tap** – 2 sample
Rainwater tank sample collection methodology	The tank water samples were collected within the tank at approximately 30 cm to 50 cm below the water surface using a high density polyethylene foot valve and tubing. Water was transferred directly into sample bottles from the tubing with no contact between tubing and bottles. All hosing and foot valves were stored in clean packaging prior to use from the supplier and the sampling equipment was replaced between rainwater tanks.
Tap sample collection methodology	■ **Initial draw off (all tap sample points) –** water was collected from the initial draw off water as this was considered to represent the sample with the highest potential sediment load. ■ **Post flush (10 tap sample points) –** samples were collected after 2 to 3 minutes of water flow as per Australian/New Zealand Standard 5667.5 to assess the effect of flush out of stale water. A comparison of results from each sample collection methodology was presented during the rapid health assessment (report reference: 147613051-003-L-Rev0).
Field Data	pH, redox, temperature and conductivity of the tank water was measured in a bucket using a water quality meter for the majority of samples.
Record of Sample Location	The sampling locations were recorded with hand-held GPS with +/- 10 m accuracy.
Sample Storage	The samples were transferred into appropriately preserved bottles supplied by the NATA accredited laboratory.
Sample Delivery	The sample bottles were transferred into chilled, insulated containers and delivered to the laboratory under Chain of Custody (CoC) procedures.
Laboratory for Water Analysis	The laboratory engaged as the primary laboratory for the analysis was ALS Environmental Pty Ltd. The secondary laboratory selected for quality assurance testing was Eurofins MGT. Both laboratories are registered by the National Association of Testing Authority (NATA) for the analyses performed.
Laboratory Analytical Schedule	All samples were analysed for total and dissolved metals (including antimony, arsenic, cadmium, copper, iron, lead, nickel and zinc). Selected samples were also analysed for additional metals (manganese and mercury) as well as pH, total dissolved solids and sulphate.
Adopted Assessment Criteria	■ **World Health Organisation *Guidelines for Drinking Water Quality*, 2011 (WHO Guidelines).** The Guidelines provide the recommendations of the World Health Organisation for managing the risk from hazards that may compromise the safety of drinking-water. The Guidelines describe reasonable minimum requirements of safe practice to protect the health of consumers and derive numerical guideline values for constituents of water

Item	Description
	of indicators of water quality. The Guidelines state that when defining mandatory limits, it is preferable to consider the Guidelines in the context of location or national environmental, social, economic and cultural conditions. ■ **National Water Quality Management Strategy *Australian Drinking Water Guidelines 6 Version 2.0*, 2011 (ADWG).** The ADWG are derived so as to take account of the needs of an individual through a normal lifetime, including changes in sensitivity that may occur between life stages. The ADWG includes both health related guideline values and aesthetic guideline values. ▪ **Health related guideline values:** concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption. ***<u>The adopted antimony value is a health related guideline value.</u>*** ▪ **Aesthetic related guideline values:** concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer; for example, appearance, taste, odour.

Table 2: Sampling and Assessment Methodology – Sediment

Item	Description
Sample Points	■ **Rainwater tanks**: sample collected from within tanks on the base ■ **Samples were primarily collected from rainwater tanks used for drinking water**.
Number of Primary Samples Collected	■ **Base of rainwater tanks**: 17 samples
Rainwater tank sediment sample collection methodology	Water was first drained to expose the sediment on the base of the tank. Samples were then collected using a swing sampler which consisted of an extendable arm with a dedicated sample container. The arm was extended to the base of the tank and used to transfer sediment directly into sample jars provided by the laboratory. After collection the swing sampler was decontaminated in a three stage process using a solution of phosphate free detergent, tap water and de-ionised water. The sample container was replaced between rainwater tanks.
Record of Sample Location	The sampling locations were recorded with hand-held GPS with +/- 10 m accuracy.
Sample Storage	The samples were transferred into unpreserved jars supplied by the NATA accredited laboratory.
Sample Delivery	The sample jars were transferred into chilled, insulated containers and delivered to the laboratory under Chain of Custody (CoC) procedures.
Laboratory for Water Analysis	The laboratory engaged as the primary laboratory for the analysis was ALS Environmental Pty Ltd. The secondary laboratory selected for quality assurance testing was Eurofins MGT. Both laboratories are registered by the National Association of Testing Authority (NATA) for the analyses performed.

Item	Description
Laboratory Analytical Schedule	The samples were designated for analysis of pH, sulphate, total and dissolved metals (including antimony, arsenic, cadmium, copper, iron, nickel, lead and zinc).
Adopted Assessment Criteria	No relevant Australian sediment quality guidelines exist for application in a human health setting.

3.0 DATA

3.1 Considered in HRA

Water data was collected from the following locations:

- 43 properties located within the Costerfield Dome
- 7 properties located outside of the Costerfield Dome.

The samples were collected in two stages as follows:

- Pre-tank cleaning (June 2014 – October 2014)

  Within Costerfield Dome

  - Total of 81 samples
  - 43 properties were sampled, with 1 to 4 samples collected per property.

  Outside Costerfield Dome

  - Total of 14 samples
  - 7 properties were sampled, with 2 samples collected per property.

- Post-tank cleaning (October 2014 – May 2015)

  Within Costerfield Dome

  - Total of 86 samples
  - Select properties included in the tank cleaning assessment program, with samples collected approximately monthly (up to 8 samples per property) or in January and May 2015 (2 samples per property).

  Outside Costerfield Dome

  - Total of 2 samples
  - One property with 2 samples collected.

Sampling results are discussed in Section 4.0 and Section 5.0.

The impact of tank cleaning is discussed in Section 5.1. Prior to the tanks being cleaned, sediment samples were collected from 17 tanks. The results of sediment sampling is discussed in Section 5.5.

Seven samples were also collected from a swimming pool located at Property 9. Results from the swimming pool monitoring are discussed in Section 5.6.

3.2 Data not considered in HRA

Additional data on water was collected by Golder or provided to Golder during the course of the assessment. However, the data has not been considered further in the Costerfield HRA for the following reasons:

- Collection of seven water samples from within rainwater tanks in the Heathcote area was undertaken on 10 July 2014. In summary, antimony levels in tank water were measured to be below the assessment criteria (ADWGs) for the protection of human health. Therefore, the levels of antimony measured for the Heathcote assessment area are considered to present a low risk to human health that do not warrant further monitoring. This data has not been included in the Costerfield HRA as Heathcote is not considered part of the assessment area.
- Golder obtained Coliban Water data which was collected during their routine monitoring at sources of mains water supply within Heathcote, Kyneton and Bendigo (northern). Antimony was reported as 0.0005 mg/L during all monitoring, which is below the assessment criteria (ADWGs) for the protection of human health (although it is noted that the limit of reporting was reported above the reported results). Coliban water was used to re-fill select tanks following tank cleaning. As Golder collected water samples from the tanks following cleaning, the Coliban Water data has not been considered further in the HRA.
- Mandalay provided Golder with water data for rainwater tanks from select properties, post tank cleaning. The samples were collected between July and September 2014. The sampling methodology and tank sample was not confirmed by the data provided. Given the uncertainty relating to the data collection, it has not been considered further.

4.0 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

As part of the Desktop Review (Golder, 2015, included in Appendix A of the HRA report), Golder reviewed related chemicals of interest (COI), in addition to antimony, which may require consideration in a comprehensive human health risk assessment. Based on the potential sources of chemicals in the environment and the reviewed background soil and ore data, the COI for the water analysis included antimony, arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel and zinc.

Following the identification of the COI, water sampling was undertaken by Golder as outlined in Table 1. The water assessment considered the chemicals of interest in water. To select the chemicals of potential concern (COPC) in water that were carried through into the HRA calculations, the water data was first screened against published guidelines (adopted assessment criteria). The assessment criteria have been developed to assess potential exposures of residents (children and adults) to chemicals in drinking water, these are discussed in Table 1. Where a chemical's result is above the relevant assessment criterion, the chemical was retained for further consideration in the HRA. When a chemical concentration is below the assessment criterion, the concentrations were considered to be acceptable in the residential setting and as such they were not considered further in the HRA.

Chemical results above generic assessment criteria are presented in Tables D2.1 to D2.4, with summary statistics on Table D2.5, attached to this appendix. The summary statistics in Table D2.5 are separated by pre and post tank cleaning.

The screening against assessment criteria highlights the following chemicals for properties within the Costerfield Dome:

- antimony
- cadmium
- copper
- iron

- lead
- manganese
- nickel
- zinc.

As discussed in the Desktop Review (Golder, 2015, included in Appendix A of the HRA report), iron is a common earth metal and was included as a COI to potentially assist with the assessment of the spatial distribution of the source of antimony and arsenic in the environment. Iron is an element which is essential to life, as a natural constituent of biofluids. Iron is not commonly considered a COI in human health risk assessments, as humans have homeostatic mechanisms to process iron. Hazard screening processes normally screen out normal constituents of the body. For instance the ADWG provide aesthetic criteria but not health based criteria for a number of chemicals. The Cramer decision tree for toxicants also considered normal constituents of the body as a low priority for investigation (Cramer and Ford 1977; EC 2011; EFSA 2012). Therefore, iron is not considered a COPC for the purpose of the HRA.

Similar to iron, zinc is ubiquitous in the environment and is an essential element for all living things. The ADWG is based on the taste threshold of 3 mg/L (aesthetics-based guideline). The ADWG state that there is insufficient data to set a guidelines value based on health considerations. Therefore, zinc is not considered a COPC for the purpose of the HRA.

For cadmium, copper, manganese and nickel, exceedances of the adopted assessment criteria were reported for less than 5% of the data set (from a total of up to 167 data points). The following is also noted for each of the chemicals for total metal analysis:

- cadmium – the maximum reported concentration is 0.0098 mg/L and the 95% upper confidence limit of the mean (UCL) is 0.0006 mg/L, compared to an ADWG (health-based) of 0.002 mg/L.
- copper – the maximum reported concentration is 2.17 mg/L and the 95% UCL is 0.27 mg/L, compared to an ADWG (aesthetics-based) of 1 mg/L.
- manganese – the maximum reported concentration is 0.203 mg/L and the 95% UCL is 0.031 mg/L, compared to an ADWG (aesthetics-based) of 0.1 mg/L.
- nickel – the maximum reported concentration is 0.065 mg/L and the 95% UCL is 0.0034 mg/L, compared to an ADWG (health-based) of 0.02 mg/L.

The reported maximum concentration were less than 200% of the assessment criteria and the average concentrations were less than the adopted assessment criteria. In addition, cadmium and copper are COI associated with roofs and tanks, as they are metals which may be present in tank water due to roofing, guttering and pipework materials (CSIRO 2008; enHealth 2010; Andra et al. 2014). Manganese is a common earth metal and was included as a COI as it may assist with the assessment of the spatial distribution of the source of antimony and arsenic in the environment. It is noted that nickel was included as a COI because it has the ability to accumulate through the food chain and is considered potentially relevant to human health cumulative risk assessment. However, as low concentrations of nickel reported indicate it is unlikely to be a risk to human health.

Based on this, cadmium, copper, manganese and nickel are not considered COPC for the purpose of the HRA.

The analytical results for arsenic were reported lower than the adopted assessment criteria (0.01 mg/L). The maximum reported concentration of arsenic was 0.009 mg/L (ADWG is 0.01 mg/L). Out of a total of 167 samples collected from properties within the Costerfield Dome, 153 samples were reported as less than the detection limit (0.001 mg/L). However, arsenic was identified as a COPC in the soil assessment and it is therefore considered a COPC for the HRA and has been carried through this assessment.

The COPC identified for properties within the Costerfield Dome are:

- antimony
- lead
- arsenic.

Antimony was not identified as a COPC for properties located outside of the Costerfield Dome.

As discussed in Section 4.0, when a chemical concentration is below the assessment criteria, the concentrations are considered to be acceptable in the residential setting and as such they are not considered further in the HRA.

The screening against the assessment criteria highlights the following chemicals for properties located outside of the Costerfield Dome:

- lead
- zinc.

As discussed above, zinc is not considered a COPC for the purpose of the human health risk assessment.

Lead exceeded adopted assessment criteria at Property 52 in one sample collected from the rainwater tank tap. The total concentration from the tank tap was reported as 0.062 mg/L and the filtered concentration was 0.017 mg/L, compared to an adopted assessment criterion of 0.01 mg/L. For the same property, the sample collected from the kitchen tap reported concentrations less than the assessment criterion, with the total concentration being 0.007 mg/L and the filtered concentration being 0.005 mg/L. Lead is a common metal found in in tank water due to roofing, guttering and pipework materials (CSIRO 2008; enHealth 2010; Andra et al. 2014). The lead at Property 52 does not appear to be linked to antimony impacts.

Antimony was not identified as a COPC for properties located outside of the Costerfield Dome. Therefore, further assessment of the properties outside of the Costerfield Dome has not been undertaken.

5.0 DATA ASSESSMENT

5.1 Within versus outside Costerfield Dome

The number of analytical results reported above the adopted assessment criterion (AWDG is 0.003 mg/L) for properties located within and outside the Costerfield Dome is presented in Table D2.5. For samples collected from properties within the Costerfield Dome, 73 of a total of 81 total antimony results (sampled pre-tank cleaning) were reported as above the adopted assessment criteria. However, for samples collected from properties location outside of the Costerfield Dome, none of the 14 total antimony results (sampled pre-tank cleaning) were reported above the adopted assessment criteria. Therefore, properties located outside of the Costerfield Dome have not been assessed further as a part of this HRA.

The data use to assess the risk to Costerfield residents is that collected from properties located within the footprint of the Costerfield Dome.

5.2 Comparison between data collected pre and post tank cleaning

Tank cleaning at select properties was undertaken from 10 July until 22 August 2014. To assess the success of tank cleaning, post cleaning water monitoring was undertaken from October 2014 until May 2015. At eight properties, approximately monthly water sampling was undertaken during this period.

The total antimony concentrations reported for this monitoring are presented in Graph 1. A decrease in antimony concentrations was observed following tank cleaning. However, in most cases, the reduced concentration of antimony still exceeded the ADWG for antimony. In addition, the antimony concentrations were observed to trend upwards during the monitoring period, following the initial decrease.

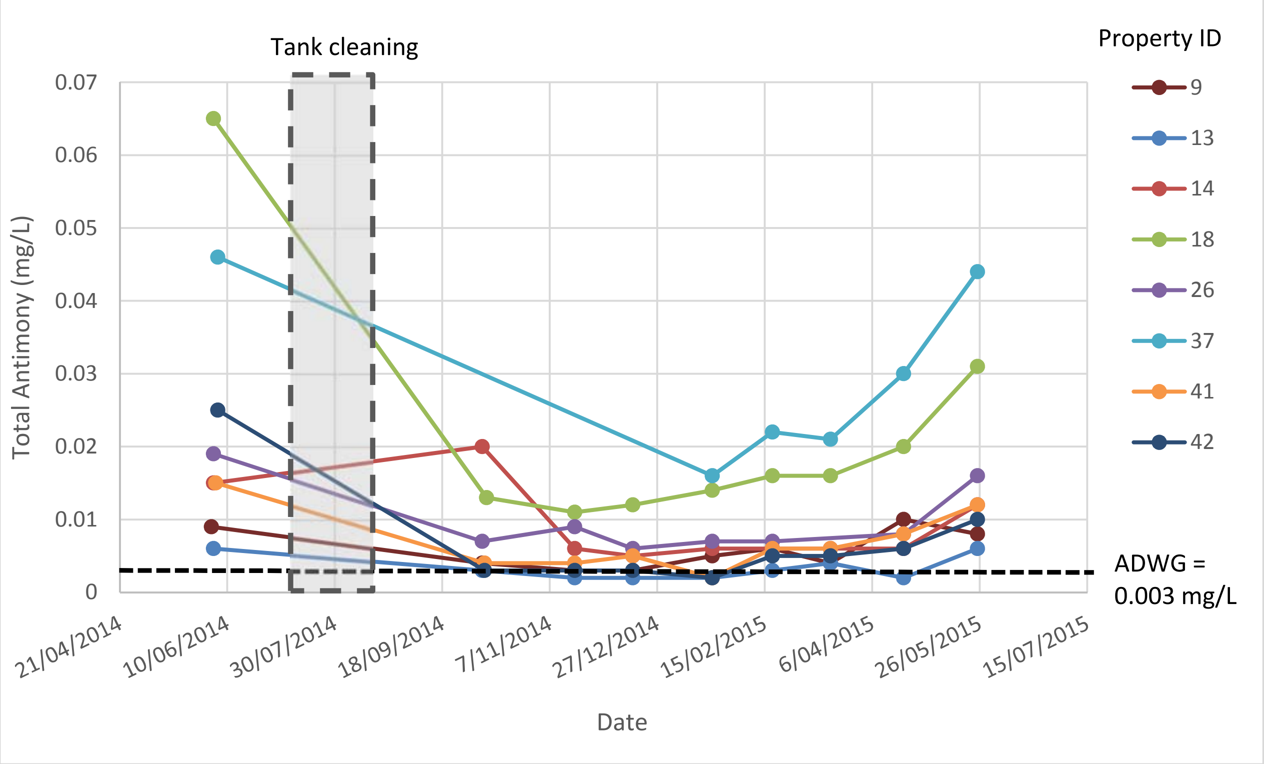
Based on the fact antimony concentration exceeded ADWG following tank cleaning, tank cleaning is not considered a viable mitigation measure.

Based on the fact antimony concentration were higher pre tank cleaning rather than post tank cleaning this dataset was used in the HRA.

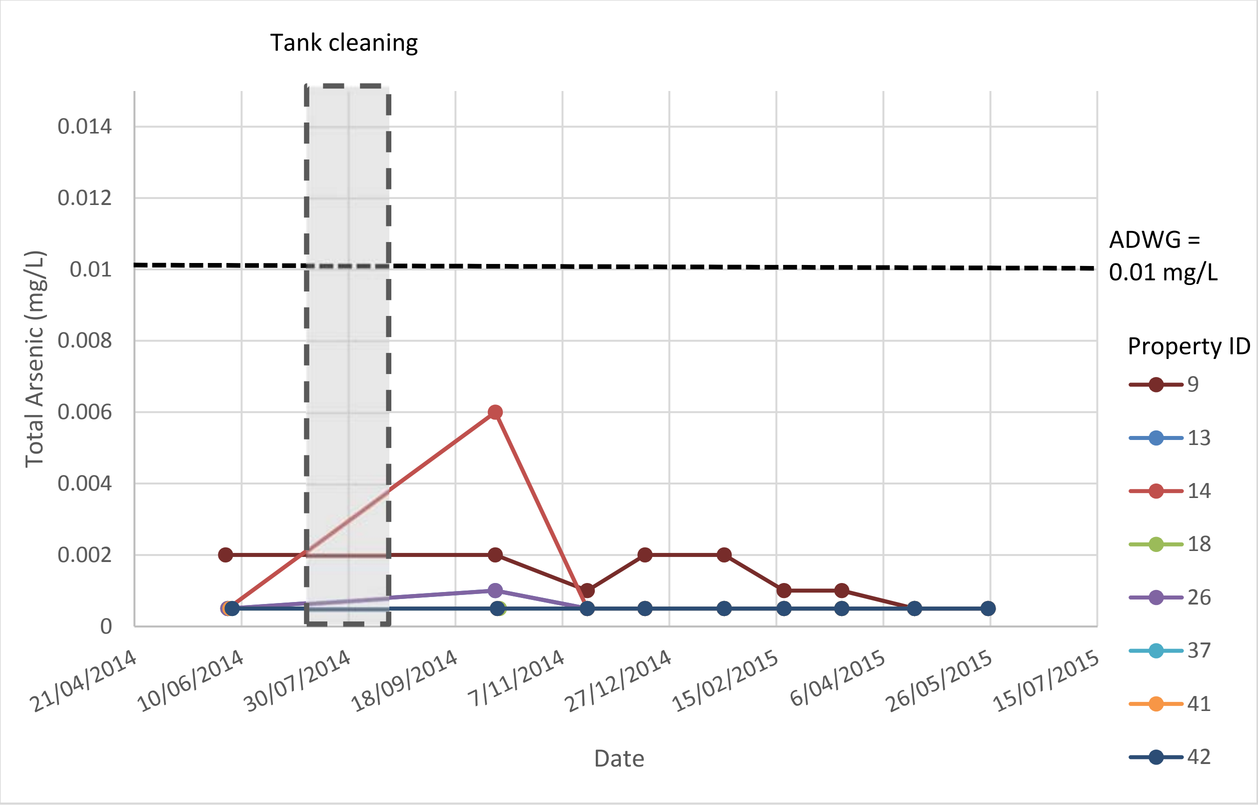
Graph 2 and Graph 3 present the trend in total arsenic and lead concentrations, respectively. Unlike antimony, there was no general observable difference in the concentration pre- and post-tank sampling for these metals.

Arsenic was reported as below the adopted assessment criteria during the monitoring period both pre and post tank cleaning.

Lead was generally reported lower than the limit of reporting, with the exception of Property 14, Property 26 and Property 41. At Property 14 and Property 41, one peak concentration was observed during the monitoring period. The reason for the peaks is unknown but may potentially be due to cross contamination of the samples. Results for the rest of the monitoring period were relatively consistent and considered to be represented of the likely lead concentrations within the tanks located at Properties 14 and Property 41.

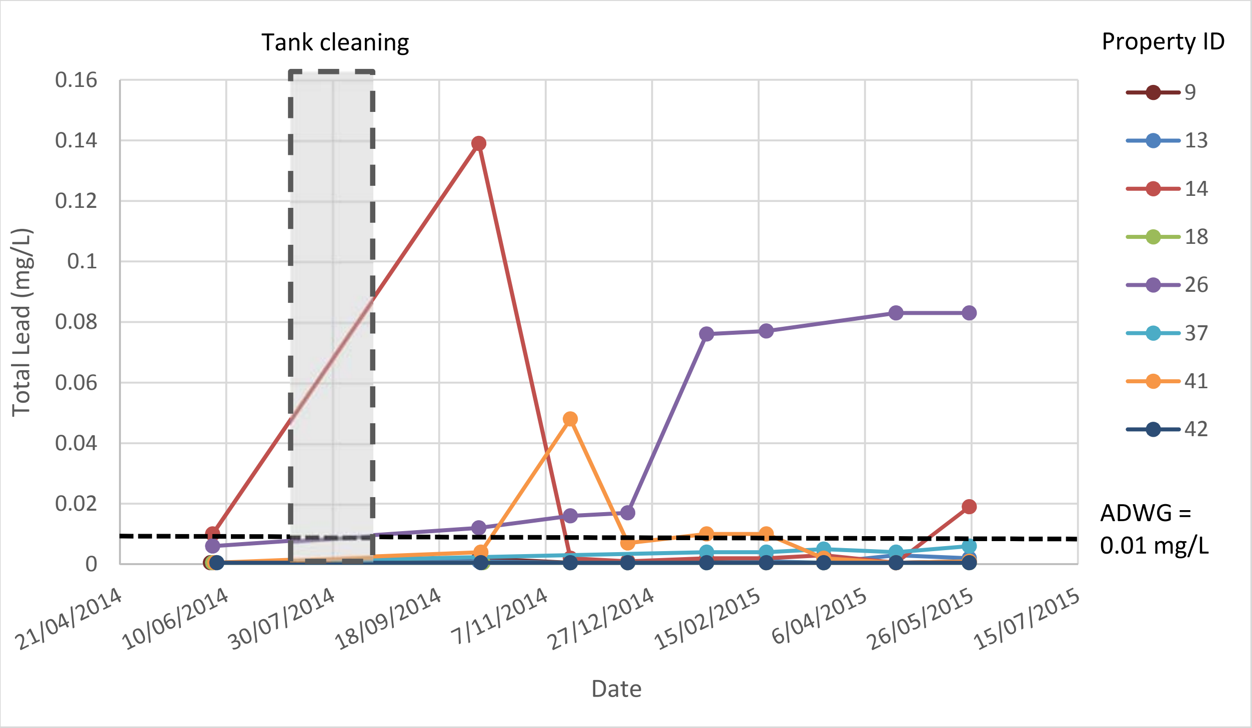


Graph 1: Antimony (total) tank water concentrations over time
ADWG – Australian Drinking Water Guideline



Graph 2: Arsenic (total) tank water concentrations over time

ADWG – Australian Drinking Water Guideline.



Graph 3: Lead (total) tank water concentrations over time

ADWG – Australian Drinking Water Guideline

The antimony concentrations reported prior to tank cleaning have been adopted in the HRA, based on the following factors:

- The pre-tank cleaning data set contains data for all properties and is therefore, more comprehensive than the data set collected post-tank cleaning. The data set collected post-tank cleaning includes only select properties, which could bias the results.
- Antimony concentration at the completion of monitoring (May 2015, approximately 7 months after tank cleaning) were similar to that seen prior to cleaning (June 2014) and therefore, unless bi-annual tank cleaning is implemented, the pre-tank cleaning concentrations are considered most likely to represent the actual tank concentrations.
- Higher antimony results were reported pre-tank cleaning compared to post tank cleaning (refer to the summary statistics presented in Table D2.5. Averaging of all data (June 2014 – May 2015) would likely result in lower values than what was seen in June 2014.

5.3 Total and filtered data

Total and filtered samples were analysed for tank water samples. “Total” refers to where a water sampled was collected directly from the source with no filtering occurring, where as “filtered” refers to where a water sampled was collected following filtration through a 0.45 µm filter. “Filtered” samples are considered to represent the dissolved metal concentration.

In some instance the filtered and total results varied between a pair of samples. However, a consistent trend as to which method resulted in a higher value was not observed. Because of this, both total and filtered samples were considered and the highest results from either was adopted for use in this HRA

5.4 Bottled water

The *Australia New Zealand Food Standards Code - Standard 2.6.2 - Non-Alcoholic Beverages and Brewed Soft Drinks* (the “Standard”) (dated 21 February 2015) sets out certain compositional requirements for packaged water. Clause 2AA of the Standard sets out limits for chemicals in packaged water and states “*Water presented in packaged from must not contain a chemical listed in Table A3.3* Guideline values for chemicals that are of health significance in drinking-water of Annex 3 Chemicals summary tables *in the* Guidelines for drinking-water quality, 4th edition, 2011, Work Health Organization, Geneva*, at a level greater than the guideline value for the chemical specified in that Table*”. The guideline value for antimony provided in Table A3.3 is 0.02 mg/L.

Publically available Australian data on antimony concentrations in bottled water is limited. A study of 132 brands of plastic bottled water, purchased from 28 different countries including Australia, reported a median value of 0.33 µg/L (0.00033 mg/L) antimony, with a minimum value of 0.001 µg/L and maximum value of 2.57 µg/L (Krachler and Shotyk, 2008). The study also suggests that the naturally occurring antimony concentrations in these waters is as little as 1% of the reported values, with the remaining antimony being due to leaching of antimony from poly-ethylene terephthalate (PET) containers (Krachler and Shotyk, 2008).

Mandalay undertook sampling of several bottled non-alcoholic beverages on 12 June 2014. This sampling was undertaken prior to supplying bottled drinking water to residents within Costerfield. The analytical results are presented in Table 3 below. Other bottled drinks, such as Powerade, juice and cola were also analysed for comparison. Antimony was reported at a concentration of 0.001 mg/L in the bottled water (“drinking water”) supplied to the residents. Although there are several limitations with the Mandalay data, such as only one result for each bottle type and no QAQC samples or discussion, based on other data lacking, this data is considered to best represent the potential concentrations in bottled water supplied to Costerfield residents.

Table 3: Antimony Concentrations in Bottled Drinks

Drink Type	Sample ID	Antimony (mg/L)
Drinking water	*DW01*	*0.001*
Powerade	P01	<0.010

Drink Type	Sample ID	Antimony (mg/L)
Juice	J01	<0.010
Black and Gold Cola	BGC01	0.016
Coke Cola	CC01	<0.010

An antimony concentration of 0.001 mg/L has been adopted as the bottled water concentration for use in this HRA. This value appears conservative based on the Krachler and Shotyk, 2008 study.

Mandalay did not analyse the samples for metals other than antimony. The Krachler and Shotyk, 2008 study reported a minimum value of <0.001 µg/L, a median value of 0.009 µg/L, and maximum value of 0.076 µg/L for lead. The median value of 0.000009 mg/L has been adopted for use in this HRA. Golder was unable to find data for the concentration of arsenic in bottled water. Based on this, the LOR of 0.001 mg/L has been adopted as the arsenic concentration in bottled water for use in this HRA.

5.5 Sediment Sampling

Sediment sampling was undertaken during the cleaning of rain water tanks by Mandalay Resources, and comprised the collection of 17 sediment samples from the base of tanks at residential properties in the Costerfield Dome area. The analytical results for chemicals corresponding with water COI are presented in Table D2.7, attached.

Concentrations of antimony reported in sediment samples ranged from 15 to 339 mg/kg.

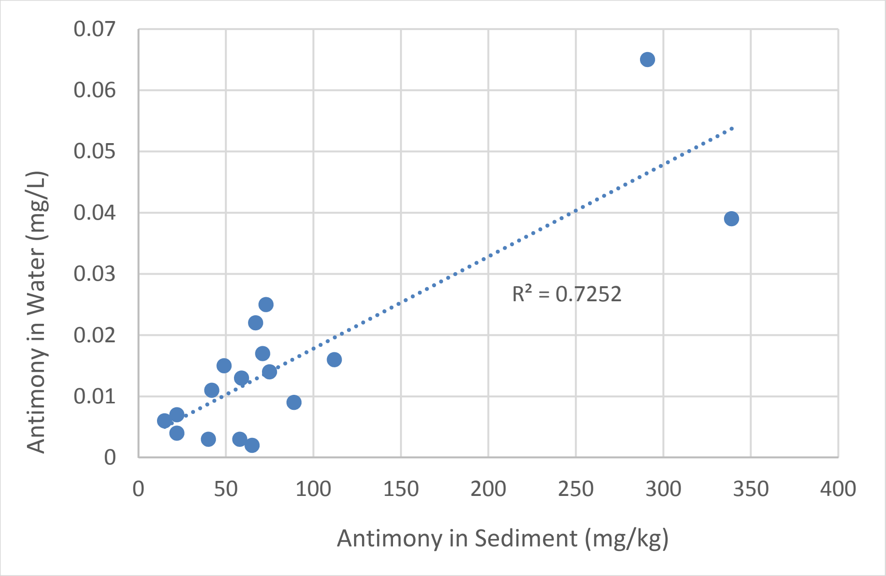
Antimony will tend to bind to fine clays (Wilson et al., 2010) leading to antimony concentrations reported in tank sediment. A comparison of sediment and tank water results, where samples have been collected from the same tank, is presented in Table 4. A scatterplot comparing the concentrations reported for tank sediments and corresponding tank water is presented in Graph 4. A R^2 correlation of 0.73 was observed. Generally, a higher sediment concentrations corresponds with a higher tank water concentration.

Table 4: Comparison of sediment and tank water results

Property ID	Antimony in sediment (mg/kg)	Antimony in tank water* (mg/L)
2	67	0.022^
5	71	0.017
6	58	0.003
7	42	0.011^
8	59	0.013
9	89	0.009
13	15	0.006
14	49	0.015
15	22	0.004
16	75	0.014
18	291	0.065
37	339	0.039
40	22	0.007

Property ID	Antimony in sediment (mg/kg)	Antimony in tank water* (mg/L)
41	112	0.016
42	73	0.025
47	65	0.002
51	40	0.003

Note:* The highest result (total or filtered) collected from a tank or tank tap was adopted for samples collected pre-tank cleaning, with the exception of those marked with "^". Where a tank or tank tap could not be accessed, the sample was collected from a tap not directly attached to the tank, such as the kitchen tap.



Graph 4: Correlation between Antimony in Tank Sediment and Tank Water

There are no Australian sediment quality guidelines that are applicable to assessment of tank water in a human health. Exposure to tank sediment is considered unlikely, with the exception of during tank cleaning activities. Tank cleaning should be undertaken by professionals, under appropriate health and safety management. The tank sediment results have not been considered further in this HRA.

5.6 Swimming pool monitoring

Monitoring of water in a swimming pool located at Property 9 was undertaken approximately monthly from October 2014 until May 2015 (excluding November). Table D2.6 presents analytical results for the swimming pool. The total antimony concentrations ranged from 0.005 mg/L to 0.022 mg/L. These concentrations exceed the ADWG for antimony. However, applying drinking water guidelines for primary contact recreation (PCR) use is conservative as the drinking water guidelines are based on a person consuming 2L of the water per day. In a PCR setting, intake is assumed to be only 0.1 L per swimming event (NHMRC, 2008). Based on this ratio of water ingestion, the drinking water guideline was multiplied by a factor of 10[1] to obtain an adopted PCR guideline of 0.03 mg/L antimony. The pool results were reported as less than the adopted PCR guideline, with the exception of the initial round of sampling undertaken in October 2014. The pool was emptied, cleaned and refilled with potable water following the first round of sampling, resulting in the

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[1] Noting that the ratio is 20-fold, rather than 10-fold. A factor of 10 was used for conservatism.

decreased antimony concentration in subsequent sampling. However, it is noted that the reported antimony concentrations appear to be increasing each month from December to May.

Lead was reported as less than the LOR for swimming pool samples.

Results from the swimming pool have not been included in the data set for assessment of drinking water within the Costerfield area.

Based on these results, the risks associated with swimming in the pool are considered acceptable, provided the pool is cleaned regularly (at least every 6 months).

6.0 DATA ADOPTED FOR USE IN HEALTH RISK ASSESSMENT

Based on the water data assessment, rainwater data collected prior to tank cleaning and from properties located within the Costerfield Dome, was used in the HRA. Table 6 presents the summary statistics for rainwater data collected prior to tank cleaning. The statistics have been calculated for both total and filtered results and to remain conservative the highest value (most conservative) was adopted for use in the HRA (as discussed in Section 5.3. The data was collected from 43 properties, however the number of samples collected varied at each property (between 1 and 4 samples). In order to remove the potential bias in the average concentration due to properties with higher or lower concentrations having a greater number of samples collected, the data was assessed on a per property basis first. The calculation of a minimum, average and maximum concentration from the statistics per property reduces the influence of the number of samples collected. These statistics are presented in Table 6 under “Based per property values”. The distribution of the average concentrations per property for antimony, arsenic and lead are shown in Graph 5, Graph 6 and Graph 7, respectively.

For comparison the average, geometric mean, 95% Upper Confidence Limit of the arithmetic mean and 95th percentile concentration for the complete data set are also presented in Table 6, under “Based on complete data set”.

The HRA requires two concentration inputs: an average exposure concentration and an upper estimate.

To represent the average concentration we have considered the following:

- Arithmetic mean (average) of the full data set for properties within the Costerfield Dome
- Geometric mean of the full data set for properties within the Costerfield Dome
- Median Concentration of the full data set for properties within the Costerfield Dome
- Arithmetic mean (average) of the average concentrations at each property

The input selected for the HRA is the average of the average concentration at each property, as discussed above this approach reduces the influence of the number of samples collected from individual properties, and provides an indication of the average rainwater tank concentrations across the Costerfield Dome. This approach is consistent with that adopted for the soil assessment. It is noted that for antimony, the average of property averages is the same as the average of the entire data set, but it is higher that the geometric mean or the median. The same trend was observed for lead. For arsenic, there was no difference observed between the different average concentrations, which is due to the fact the majority of arsenic results were reported as less than the laboratory limit of reporting (LOR) (<0.001). The LOR has been adopted as the arsenic concentration for the HRA.

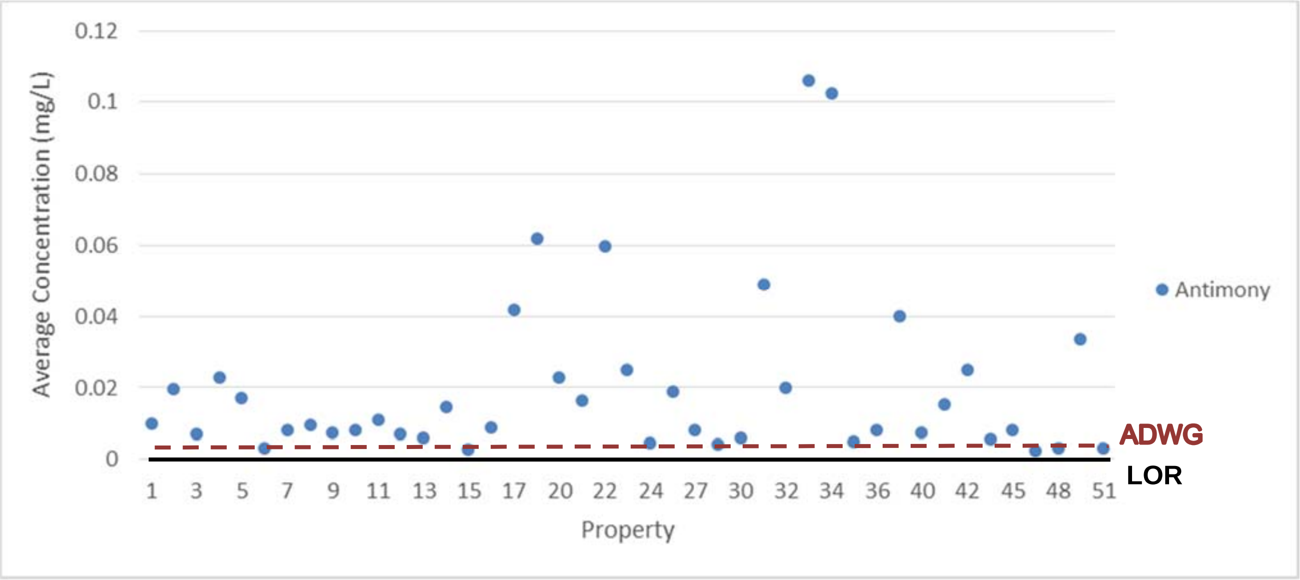
For the upper estimate, the input selected was the 95th UCL concentration for full data set. This approach provides a 95% confidence level that the true population mean will be less than, or equal to this value, and therefore is considered to represent a reasonable upper concentration to which average Costerfield residents may be exposed. The 95th UCL has been calculated using the US EPA software ProUCL 5.0, this is consistent with guidance provided in NEPM (2013).

The data that has been adopted in the HRA is highlighted in bold in Table 6.

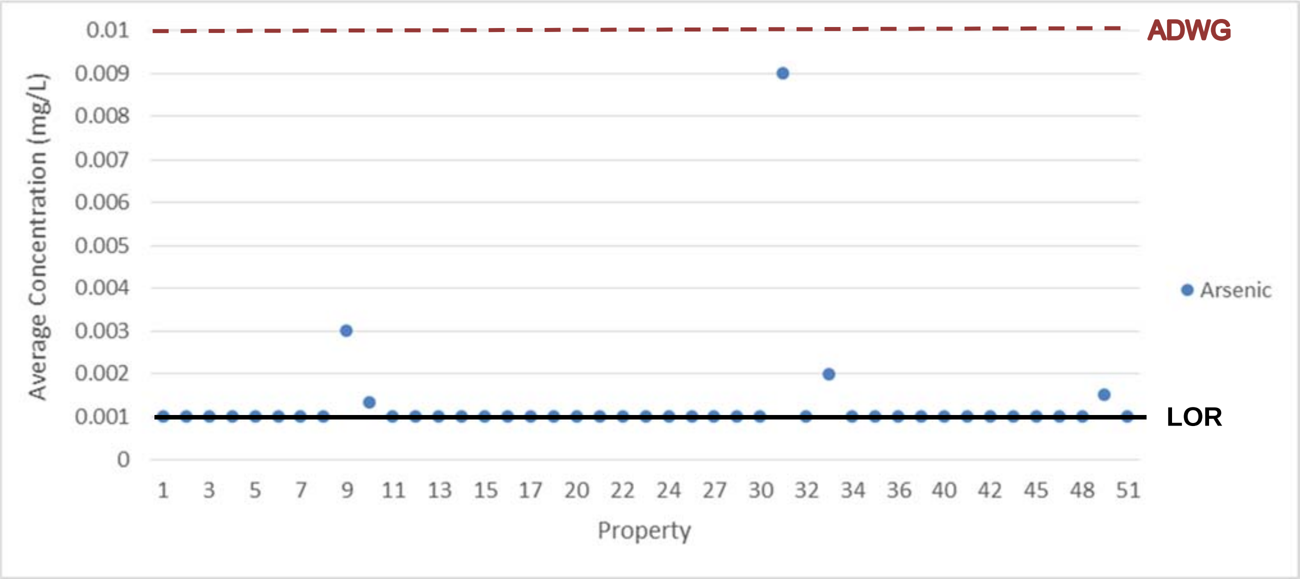
Table 5: Summary Statistics for Rainwater Data Collected from within the Costerfield Dome and prior to Tank Cleaning

Summary Statistic	**Filtered Concentration (mg/L)**			**Total Concentration (mg/L)**		
	Antimony	Arsenic	Lead	Antimony	Arsenic	Lead
Based on per property values						
Average of Minimums per Property	0.016	0.001	0.001	0.019	0.001	0.002
Average of Averages per Property	0.018	0.001	0.002	**0.020**	**0.001**	**0.003**
Average of Maximum per Property	0.019	0.001	0.002	0.022	0.001	0.004
Based on complete data set						
Average Concentration	0.019	0.001	0.002	0.020	0.001	0.003
Geometric Mean	0.011	0.001	0.001	0.012	0.001	0.001
Median Concentration	0.011	0.001	0.001	0.011	0.001	0.001
95% Upper Confidence Limit	0.029	0.001	0.002	**0.032**	**0.001**	**0.004**
95th Percentile	0.053	0.001	0.005	0.065	0.002	0.010

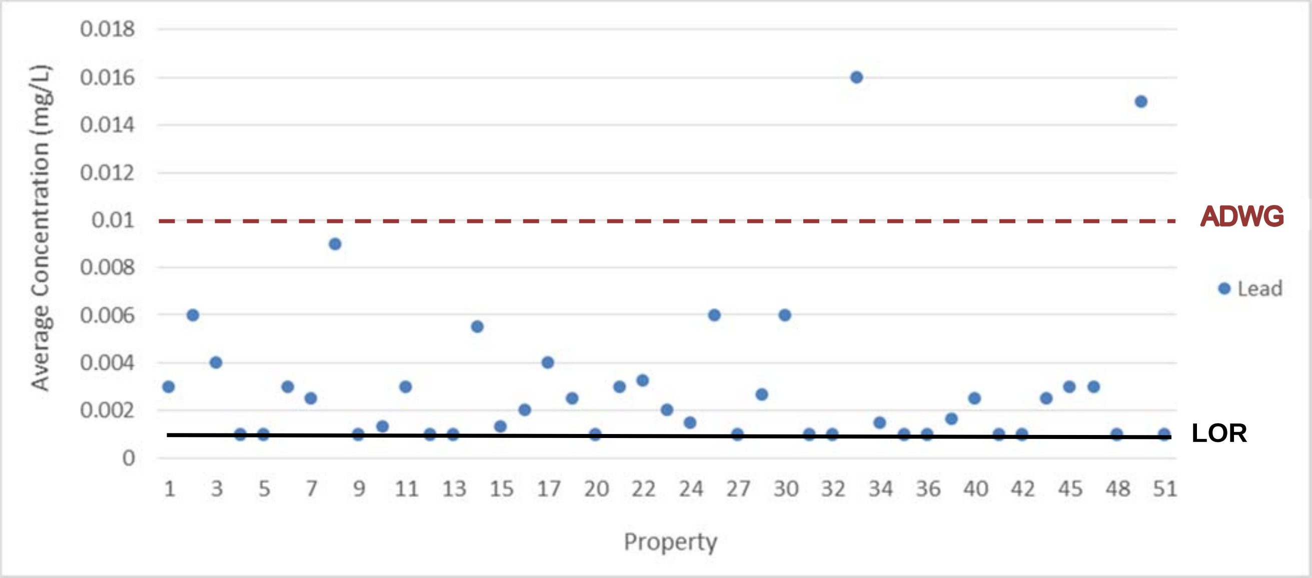
Notes: **Bold** indicates values adopted for use in the HRA



Graph 5: Average Total Antimony Concentration per Property
ADWG – Australian Drinking Water Guideline
LOR – Limit of Reporting



Graph 6: Average Total Arsenic Concentration per Property
ADWG – Australian Drinking Water Guideline
LOR – Limit of Reporting



Graph 7: Average Total Lead Concentration per Property
ADWG – Australian Drinking Water Guideline
LOR – Limit of Reporting

7.0 QUALITY ASSURANCE AND QUALITY CONTROL

The field and laboratory procedures implemented for quality assurance/quality control (QA/QC) along with a discussion of the QA/QC results are presented in Attachment B of *Assessment of Soil and Tank Water, Costerfield, Victoria* (Golder, 2014).

The review assessed data collected prior to December 2014 and concluded that the overall data quality generated during the assessment is of sufficient quality upon which to base decisions for this assessment.

Monthly tank sampling occurred from December 2014 until May 2015). As a part of this sampling addition QAQC samples were collected, which included 3 primary duplicate, 3 secondary duplicate, 2 field blank, 5 rinsates and 3 trip blank samples were collected. The QAQC procedures and samples were assessed in line with Attachment B of *Assessment of Soil and Tank Water, Costerfield, Victoria* (Golder, 2014). The analytical results for the blank and duplicate samples are included in attached tables Table D2.8 and Table D2.9. Section 0 summarises the QAQC assessment of samples collected between January and May 2015.

Table 6: Summary of Water QA/QC Completeness – January to May 2015 Results

QC Sample Type	No. Results (individual analytes) NOT Meeting DQI	Total No. Results (individual analytes)	Percentage Results Meeting DQI
Holding Time Exceedances-Primary Lab	0	1,656	100%
Field Primary Duplicates-Primary Lab	0	60	100%
Field Secondary Duplicates-Secondary Lab	0	60	100%
Field Rinsates-Primary Lab	0	80	100%
Field Blanks-Primary Lab	0	80	100%
Internal Primary Lab Duplicates	2	429	99.9%
Internal Primary Lab Method Blanks	0	248	100%
Internal Primary Lab Control Spikes	0	252	100%
Internal Primary Lab Matrix Spikes	0	142	100%
Internal Primary Lab Surrogate Spikes	0	59	100%
Overall Water Completeness	**2**	**3,066**	**100%**

The achieved QA/QC completeness of 100% is above the overall completeness objective of 95 %. Based on this, it is considered that the overall data quality generated during the assessment of water during January to May 2015 by Golder is of sufficient quality upon which to base decisions for this assessment.

8.0 REFERENCES

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APPENDIX D2

Summary of Water Data

Attachments

1. Table D2.1: Water Analytical Results Pre-Tank Cleaning – Within Costerfield Dome
2. Table D2.2: Water Analytical Results Pre-Tank Cleaning – Outside Costerfield Dome
3. Table D2.3: Water Analytical Results Post-Tank Cleaning – Within Costerfield Dome
4. Table D2.4: Water Analytical Results Post-Tank Cleaning – Outside Costerfield Dome
5. Table D2.5: Statistical Summaries
6. Table D2.6: Water Analytical Results for the Swimming Pool
7. Table D2.7: Tank Sediment Analytical Results
8. Table D2.8: QAQC – Analytical Results for Blank Samples collected January – May 2015
9. Table D2.9: QAQC – Analytical Results for Duplicate Samples collected January – May 2015

Table D2.1 - Water Analytical Results Pre-Tank Cleaning - Within Costerfield Dome

								Metals																				Sample Quality Parameters		
								Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)
								mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH Units	mg/L	mg/L
LOR								0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.005	0.005	0.01	10	1
ADWG 2011 Aesthetic														1	1	0.3	0.3			0.1	0.1					3	3	6.5-8.5	600	250
ADWG 2011 Health								0.003	0.003	0.01	0.01	0.002	0.002	2	2			0.01	0.01	0.5	0.5	0.001	0.001	0.02	0.02					500
WHO Guidelines for Drinking Water Quality (2006)								0.02	0.02	0.01	0.01	0.003	0.003	2	2			0.01	0.01	0.4	0.4	0.006	0.006	0.07	0.07	3	3			
Property ID	**Sample ID**	**Date**	**Within / Outside Costerfield Dome**	**SDG**	**Sample Point**	**Colour**	**Odour**																							
1	1/5001_20140603	03/06/14	Within	EM1405428	tank tap	clear	none	0.01	0.008	<0.001	<0.001	0.0073	0.0042	0.006	0.004	<0.05	<0.05	0.003	0.002	-	-	-	-	0.001	0.001	4.71	3.54	6.96	30	<1
2	2/5001_20140604	04/06/14	Within	EM1405497	kitchen tap	clear	none	0.02	0.021	<0.001	<0.001	0.0005	0.0004	0.022	0.016	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	0.002	2.31	1.94	7	28	1
2	2/5002_20140604	04/06/14	Within	EM1405497	kitchen tap (flushed)	clear	none	0.02	0.021	<0.001	<0.001	0.0005	0.0005	0.026	0.021	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	2.3	2.62	6.94	28	2
2	2/5003_20140604	04/06/14	Within	EM1405497	outside tap	red brown particulates	none	0.019	0.022	<0.001	<0.001	0.0005	0.0004	0.21	0.052	<0.05	<0.05	0.016	0.001	-	-	-	-	0.001	<0.001	2.54	2.23	7.14	28	2
3	3/5001_20140603	03/06/14	Within	EM1405428	within tank	red brown particulates	none	0.007	0.004	<0.001	<0.001	0.0008	0.0006	<0.001	<0.001	<0.05	<0.05	0.004	<0.001	-	-	-	-	<0.001	<0.001	5.73	5.8	6.88	28	<1
4	4/5001_20140603	03/06/14	Within	EM1405428	tank tap	clear	none	0.023	0.021	<0.001	<0.001	0.0001	<0.0001	0.005	0.005	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	1.92	1.76	6.7	27	<1
5	5/5001_20140603	03/06/14	Within	EM1405428	within tank	clear	none	0.017	0.015	<0.001	<0.001	<0.0001	<0.0001	<0.001	0.002	<0.05	0.08	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.417	0.391	7.62	63	<1
5	5/5002_20140603	03/06/14	Within	EM1405428	kitchen tap	clear	none	0.017	0.016	<0.001	<0.001	<0.0001	<0.0001	0.007	0.01	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.392	0.371	7.72	65	<1
6	6/5001_20140604	04/06/14	Within	EM1405497	within tank	clear	none	0.003	0.003	<0.001	<0.001	<0.0001	<0.0001	0.002	0.006	<0.05	<0.05	0.003	0.002	-	-	-	-	<0.001	<0.001	2.11	1.12	6.63	23	<1
6	6/5002_20140604	04/06/14	Within	EM1405497	kitchen tap	clear	none	0.002	0.001	<0.001	<0.001	<0.0001	0.0001	0.128	0.235	0.43	0.1	0.004	0.008	-	-	-	-	0.006	0.004	1.76	1.57	6.71	20	<1
6	6/5003_20140604	04/06/14	Within	EM1405497	kitchen tap (flushed)	clear	none	0.004	0.002	<0.001	<0.001	<0.0001	0.0001	0.017	0.273	0.57	0.08	0.002	0.007	-	-	-	-	0.001	0.005	1.18	2.23	6.59	22	1
7	7/5001_20140603	03/06/14	Within	EM1405428	kitchen tap	clear	none	0.005	0.003	<0.001	<0.001	0.0007	<0.0001	0.292	0.048	0.17	<0.05	0.004	<0.001	-	-	-	-	<0.001	<0.001	3.89	1.11	6.9	36	<1
7	7/5002_20140603	03/06/14	Within	EM1405428	outside tap	clear	none	0.011	0.011	<0.001	<0.001	0.0004	0.0002	0.071	0.034	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	2.36	1.88	7	33	<1
8	8/5001_20140603	03/06/14	Within	EM1405428	kitchen tap	clear	none	0.006	0.005	<0.001	<0.001	<0.0001	<0.0001	0.044	0.071	<0.05	<0.05	0.001	<0.001	-	-	-	-	<0.001	0.001	1.36	1.37	7.48	208	26
8	8/5002_20140603	03/06/14	Within	EM1405428	within tank	particulate matter in base of bailer	none	0.013	0.006	<0.001	<0.001	<0.0001	<0.0001	0.016	0.005	0.66	<0.05	0.017	<0.001	-	-	-	-	<0.001	<0.001	0.298	0.389	7.19	303	24
9	9/5001_20140602	02/06/14	Within	EM1405374	within tank	some black particulates	none	0.006	0.009	0.004	0.004	0.0002	0.0002	0.003	0.004	<0.05	<0.05	0.001	<0.001	-	-	-	-	<0.001	<0.001	0.797	0.615	6.87	12	<1
9	9/5002_20140602	02/06/14	Within	EM1405374	kitchen tap	clear	none	0.009	0.008	0.002	0.002	0.0001	0.0001	0.095	0.174	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.673	0.629	6.78	<10	<1
10	10/5001_20140604	04/06/14	Within	EM1405497	within tank	clear	none	0.013	0.013	0.002	0.002	<0.0001	<0.0001	0.007	0.004	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.511	0.138	5.8	<10	<1
10	10/5002_20140604	04/06/14	Within	EM1405497	kitchen tap	clear	none	0.007	0.006	<0.001	<0.001	0.0002	<0.0001	0.684	0.14	<0.05	<0.05	0.001	0.002	-	-	-	-	<0.001	0.002	2.02	1.29	6.69	14	<1
10	10/5003_20140604	04/06/14	Within	EM1405497	kitchen tap (flushed)	clear	none	0.004	0.006	<0.001	<0.001	0.0001	0.0002	0.066	0.201	<0.05	<0.05	0.002	0.001	-	-	-	-	<0.001	0.001	2.25	2.34	6.66	14	<1
11	11/5001_20140605	05/06/14	Within	EM1405562	outside tap	clear	none	0.011	0.012	<0.001	<0.001	0.0002	0.0002	0.313	0.24	<0.05	<0.05	0.003	0.002	-	-	-	-	<0.001	<0.001	1.13	1.21	7.47	110	2
12	12/5001_20140604	04/06/14	Within	EM1405497	kitchen tap	clear	none	0.007	0.007	<0.001	<0.001	<0.0001	<0.0001	0.051	0.047	<0.05	<0.05	0.001	0.002	-	-	-	-	<0.001	<0.001	0.53	0.612	7.38	195	22
13	13/5001_20140603	03/06/14	Within	EM1405428	kitchen tap	clear	none	0.006	0.005	<0.001	<0.001	0.0004	0.0003	0.019	0.022	<0.05	0.08	0.001	<0.001	-	-	-	-	<0.001	<0.001	1.2	1.3	7.26	58	<1
13	13/5002_20140603	03/06/14	Within	EM1405428	within tank	clear	none	0.006	0.005	<0.001	<0.001	0.0001	<0.0001	<0.001	<0.001	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.605	0.608	7.28	48	<1
14	14/5001_20140603	03/06/14	Within	EM1405428	kitchen tap	clear	none	0.014	0.014	<0.001	<0.001	<0.0001	<0.0001	0.052	0.026	<0.05	<0.05	0.001	<0.001	-	-	-	-	0.001	0.001	1.98	1.62	7.19	56	1
14	14/5002_20140603	03/06/14	Within	EM1405428	tank tap	black particulate matter observed	none	0.015	0.014	<0.001	<0.001	0.0002	<0.0001	0.122	0.004	0.13	<0.05	0.01	<0.001	-	-	-	-	0.001	0.001	2.28	1.74	7.17	55	<1
15	15/5001_20140604	04/06/14	Within	EM1405497	kitchen tap	clear	none	0.002	0.002	<0.001	<0.001	<0.0001	<0.0001	0.004	0.008	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.414	0.337	7.08	21	2
15	15/5002_20140604	04/06/14	Within	EM1405497	kitchen tap (flushed)	clear	none	0.002	0.002	<0.001	<0.001	<0.0001	<0.0001	0.004	0.006	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.433	0.483	7.08	23	1
15	15/5003_20140604	04/06/14	Within	EM1405497	within tank	clear	none	0.004	0.004	<0.001	<0.001	0.0002	0.0001	<0.001	0.002	<0.05	<0.05	0.002	0.002	-	-	-	-	<0.001	0.001	5.68	4.44	6.86	26	1
16	16/5001_20140602	02/06/14	Within	EM1405374	kitchen tap	clear	none	0.004	0.006	<0.001	<0.001	0.0008	0.0004	0.084	0.045	<0.05	<0.05	0.001	<0.001	-	-	-	-	0.002	0.001	0.811	0.805	6.94	12	<1
16	16/5002_20140602	02/06/14	Within	EM1405374	tank tap	clear	none	0.014	0.013	<0.001	<0.001	0.0003	0.0002	0.063	0.017	<0.05	<0.05	0.003	0.001	-	-	-	-	<0.001	0.001	0.336	0.31	3.79	20	<1
17	17/5001_20141008	08/10/14	Within	EM1410580	within tank	clear	none	0.042	0.039	<0.001	<0.001	0.0003	0.0001	0.014	0.012	-	-	0.004	0.002	0.011	0.006	<0.0001	<0.0001	<0.001	<0.001	1.52	1.71	5.7	<10	4
18	18/5001_20140603	03/06/14	Within	EM1405428	within tank	clear, trace black particulate matter	none	0.065	0.046	<0.001	<0.001	<0.0001	<0.0001	0.018	0.01	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	1.78	1.3	7.31	71	<1
18	18/5002_20140603	03/06/14	Within	EM1405428	kitchen tap	clear	none	0.059	0.053	<0.001	<0.001	<0.0001	<0.0001	0.34	0.216	<0.05	<0.05	0.004	0.004	-	-	-	-	<0.001	<0.001	1.86	1.61	7.28	55	<1
20	20/5001_20140604	04/06/14	Within	EM1405497	within tank	clear	none	0.021	0.024	<0.001	<0.001	<0.0001	<0.0001	<0.001	0.004	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.143	0.178	7.77	34	1
20	20/5002_20140604	04/06/14	Within	EM1405497	kitchen tap	clear	none	0.024	0.027	<0.001	<0.001	<0.0001	0.0001	0.019	0.027	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.352	0.441	7.08	21	1
20	20/5003_20140604	04/06/14	Within	EM1405497	kitchen tap (flushed)	clear	none	0.024	0.027	<0.001	<0.001	0.0001	<0.0001	0.074	0.023	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.435	0.276	6.65	19	<1
21	21/5001_20140603	03/06/14	Within	EM1405428	tank tap	clear	none	0.015	0.011	<0.001	<0.001	<0.0001	<0.0001	0.24	0.325	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	2.81	4.85	6.91	40	<1
21	21/5002_20140603	03/06/14	Within	EM1405428	kitchen tap	clear	none	0.018	0.014	<0.001	<0.001	0.0001	<0.0001	2.17	1.02	<0.05	<0.05	0.005	0.002	-	-	-	-	<0.001	<0.001	0.413	0.22	6.71	29	<1
22	22/5001_20140603	03/06/14	Within	EM1405428	tank tap	clear	none	0.047	0.043	<0.001	<0.001	0.0002	<0.0001	0.008	0.006	<0.05	<0.05	0.006	0.004	-	-	-	-	<0.001	<0.001	0.385	0.32	7.57	69	<1
22	22/5002_20140603	03/06/14	Within	EM1405428	within tank	clear	none	0.045	0.02	<0.001	<0.001	0.0001	0.0002	0.002	0.034	<0.05	<0.05	0.005	0.002	-	-	-	-	<0.001	<0.001	0.269	0.862	7.63	76	<1
22	22/5003_20140605	05/06/14	Within	EM1405562	within tank	pale yellow	none	0.061	0.065	<0.001	<0.001	<0.0001	<0.0001	0.055	0.028	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.342	0.253	4.62	26	1
22	22/5004_20140605	05/06/14	Within	EM1405562	within tank	clear	none	0.086	0.087	<0.001	<0.001	<0.0001	<0.0001	0.001	0.002	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	1.23	1.44	7.38	90	1
23	23/5001_20140605	05/06/14	Within	EM1405562	within tank	clear	none	0.022	0.022	<0.001	<0.001	<0.0001	<0.0001	0.011	0.008	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.284	0.27	6.92	67	4
23	23/5002_20140605	05/06/14	Within	EM1405562	outside tap	pale yellow	none	0.028	0.012	<0.001	<0.001	<0.0001	<0.0001	0.086	0.078	0.35	0.22	0.003	0.001	-	-	-	-	0.001	0.003	0.088	0.257	6.86	201	6
24	24/5001_20140605	05/06/14	Within	EM1405562	tank tap	clear	none	0.005	0.005	<0.001	<0.001	0.0095	0.0068	0.008	0.007	<0.05	<0.05	0.002	0.001	-	-	-	-	<0.001	0.001	3.29	2.85	6.8	59	2
24	24/5002_20140605	05/06/14	Within	EM1405562	tank tap (flushed)	clear	none	0.004	0.005	<0.001	<0.001	0.0098	0.0097	0.003	0.003	<0.05	<0.05	<0.001	0.001	-	-	-	-	<0.001	<0.001	3.31	3.86	6.8	54	2
26	26/5001_20140603	03/06/14	Within	EM1405428	outside tap	clear	none	0.019	0.022	<0.001	<0.001	<0.0001	<0.0001	0.03	0.114	<0.05	<0.05	0.006	0.009	-	-	-	-	<0.001	0.002	0.865	0.983	6.54	29	<1
27	27/5001_20140604	04/06/14	Within	EM1405497	within tank	clear	none	0.009	0.009	<0.001	<0.001	0.0008	0.0005	0.004	0.005	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	0.001	0.635	0.463	6.83	18	<1
27	27/5002_20140604	04/06/14	Within	EM1405497	kitchen tap	clear	none	0.008	0.009	<0.001	0.001	0.0003	<0.0001	0.056	0.017	<0.05	<0.05	0.001	<0.001	-	-	-	-	0.001	0.001	0.287	0.084	5.71	<10	<1
27	27/5003_20140604	04/06/14	Within	EM1405497	kitchen tap (flushed)	clear	none	0.008	0.009	<0.001	<0.001	0.0003	0.0004	0.017	0.072	<0.05	<0.05	<0.001	0.001	-	-	-	-	<0.001	0.001	0.207	0.33	5.81	<10	<1
28	28/5001_20140604	04/06/14	Within	EM1405497	within tank	clear	none	0.004	0.005	<0.001	<0.001	0.0001	0.0001	<0.001	0.004	<0.05	<0.05	0.002	0.001	-	-	-	-	<0.001	<0.001	2.6	2.88	7.14	56	<1
28	28/5002_20140604	04/06/14	Within	EM1405497	kitchen tap (flushed)	clear	none	0.004	0.005	<0.001	<0.001	0.0002	0.0002	0.432	0.138	<0.05	<0.05	0.003	0.002	-	-	-	-	<0.001	<0.001	3.74	5.62	7.23	66	1
28	28/5003_20140604	04/06/14	Within	EM1405497	kitchen tap (flushed)	clear	none	0.005	0.005	<0.001	<0.001	0.0002	0.0002	0.015	0.102	<0.05	<0.05	0.003	0.002	-	-	-	-	<0.001	<0.001	3.69	4.26	7.48	63	<1
30	30/5001_20140605	05/06/14	Within	EM1405562	within tank	clear	none	0.006	0.004	<0.001	0.001	<0.0001	<0.0001	0.007	0.01	0.14	0.08	0.006	0.005	-	-	-	-	0.002	0.002	1.98	2.12	6.38	96	<1
31	31/5001_20141008	08/10/14	Within	EM1410580	Tank tap	clear	none	0.049	0.049	0.009	0.008	<0.0001	<0.0001	0.009	0.005	-	-	0.001	<0.001	0.004	0.003	<0.0001	<0.0001	<0.001	<0.001	3.02	3.36	5.99	<10	4
32	32/5001_20140605	05/06/14	Within	EM1405562	outside tap	clear	none	0.02	0.021	<0.001	<0.001	<0.0001	<0.0001	0.021	0.011	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.058	0.109	7.53	204	<1
33	33/5001_20141007	07/10/14	Within	EM1410485	within tank	clear	none	0.106	0.041	0.002	<0.001	0.0003	<0.0001	0.015	0.001	-	-	0.016	<0.001	0.203	0.006	<0.0001	<0.0001	0.005	<0.001	4.06	1.33	6.93	35	<1

Table D2.1 - Water Analytical Results Pre-Tank Cleaning - Within Costerfield Dome

								Metals																				Sample Quality Parameters		
								Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)
								mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH Units	mg/L	mg/L
LOR								0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.005	0.005	0.01	10	1
ADWG 2011 Aesthetic														1	1	0.3	0.3			0.1	0.1					3	3	6.5-8.5	600	250
ADWG 2011 Health								0.003	0.003	0.01	0.01	0.002	0.002	2	2			0.01	0.01	0.5	0.5	0.001	0.001	0.02	0.02					500
WHO Guidelines for Drinking Water Quality (2006)								0.02	0.02	0.01	0.01	0.003	0.003	2	2			0.01	0.01	0.4	0.4	0.006	0.006	0.07	0.07	3	3			
Property ID	**Sample ID**	**Date**	**Within / Outside Costerfield Dome**	**SDG**	**Sample Point**	**Colour**	**Odour**																							
34	34/5001_20140605	05/06/14	Within	EM1405562	within tank	clear	none	0.106	0.11	<0.001	<0.001	0.0001	<0.0001	<0.001	0.002	<0.05	<0.05	0.001	<0.001	-	-	-	-	<0.001	<0.001	0.926	0.654	4.52	72	2
34	34/5002_20140605	05/06/14	Within	EM1405562	outside tap	clear	none	0.099	0.107	<0.001	<0.001	<0.0001	<0.0001	0.64	0.092	<0.05	<0.05	0.002	<0.001	-	-	-	-	<0.001	<0.001	0.966	0.941	6.95	70	5
35	35/5001_20141007	07/10/14	Within	EM1410485	Kitchen tap	clear	none	0.006	0.005	<0.001	<0.001	0.0011	0.0011	0.019	0.012	<0.05	<0.05	0.001	<0.001	0.004	0.004	<0.0001	<0.0001	<0.001	<0.001	4.84	4.96	6.88	32	<1
35	35/5002_20141007	07/10/14	Within	EM1410485	within tank	clear	none	0.004	0.004	<0.001	<0.001	0.0011	0.001	<0.001	<0.001	-	-	<0.001	<0.001	0.004	0.003	<0.0001	<0.0001	<0.001	<0.001	4.59	5.08	6.79	27	<1
36	36/5001_20140602	02/06/14	Within	EM1405374	kitchen tap	clear	none	0.008	0.004	<0.001	<0.001	0.0001	<0.0001	0.074	0.071	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	6.68	6.37	6.94	18	<1
37	37/5001_20140605	05/06/14	Within	EM1405562	kitchen tap	clear	none	0.036	0.038	<0.001	<0.001	<0.0001	0.0001	1.42	0.647	0.09	<0.05	0.003	0.006	-	-	-	-	0.001	0.003	5.77	4.21	6.94	58	<1
37	37/5002_20140605	05/06/14	Within	EM1405562	kitchen tap (flushed)	clear	none	0.046	0.048	<0.001	<0.001	<0.0001	<0.0001	0.111	0.199	0.11	<0.05	<0.001	0.001	-	-	-	-	<0.001	<0.001	4.86	6.31	6.87	41	<1
37	37/5003_20140605	05/06/14	Within	EM1405562	within tank	clear	none	0.038	0.039	<0.001	<0.001	<0.0001	<0.0001	0.001	0.006	0.1	0.06	<0.001	<0.001	-	-	-	-	<0.001	<0.001	3.57	2.79	6.84	48	<1
40	40/5001_20140602	02/06/14	Within	EM1405374	kitchen tap	clear	none	0.008	0.008	<0.001	<0.001	<0.0001	<0.0001	0.006	0.008	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	0.001	0.069	0.046	6.08	<10	<1
40	40/5002_20140602	02/06/14	Within	EM1405374	within tank	slight yellow containing fibrous material	none	0.007	0.007	<0.001	<0.001	<0.0001	<0.0001	0.518	0.203	<0.05	<0.05	0.004	0.004	-	-	-	-	0.001	0.001	0.135	0.082	6.64	15	<1
41	41/5001_20140604	04/06/14	Within	EM1405497	tank tap	clear	none	0.015	0.015	<0.001	<0.001	0.0004	0.0004	0.008	0.014	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.42	0.529	7.25	70	2
41	41/5002_20140604	04/06/14	Within	EM1405497	tank tap (flushed)	clear	none	0.016	0.016	<0.001	<0.001	0.0004	0.0004	0.007	0.01	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	0.405	0.455	7.32	66	2
42	42/5001_20140605	05/06/14	Within	EM1405562	within tank	clear	none	0.025	0.026	<0.001	<0.001	<0.0001	<0.0001	0.002	0.003	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	<0.005	0.006	7.2	51	<1
42	42/5002_20140605	05/06/14	Within	EM1405562	kitchen tap	clear	none	0.025	0.027	<0.001	<0.001	<0.0001	<0.0001	0.022	0.021	<0.05	<0.05	<0.001	<0.001	-	-	-	-	<0.001	<0.001	<0.005	<0.005	7.18	50	1
44	44/60180714	18/07/14	Within	EM1407188	Kitchen tap		none	0.005	0.005	<0.001	<0.001	<0.0001	<0.0001	0.128	0.041	<0.05	<0.05	0.003	<0.001	-	-	-	-	<0.001	<0.001	0.107	0.041	5.95	99	<1
44	44-1/60180714	18/07/14	Within	EM1407188	Within tank		none	0.006	0.004	<0.001	<0.001	<0.0001	<0.0001	0.01	0.003	<0.05	<0.05	0.002	<0.001	-	-	-	-	<0.001	<0.001	0.089	0.021	5.44	84	<1
45	45/5001_20141008	08/10/14	Within	EM1410580	Kitchen tap	clear	none	0.008	0.007	<0.001	<0.001	<0.0001	<0.0001	0.111	0.075	-	-	0.003	0.002	0.005	0.004	<0.0001	<0.0001	<0.001	<0.001	0.402	0.429	6.8	46	<1
47	47/60250714	25/07/14	Within	EM1407483	Kitchen tap		none	0.003	0.002	<0.001	<0.001	0.0002	0.0001	0.026	0.009	0.17	<0.05	0.001	<0.001	-	-	-	-	<0.001	<0.001	1.81	1.19	6.75	16	2
47	47-1/60250714	25/07/14	Within	EM1407483	Within tank		none	0.002	<0.001	<0.001	<0.001	0.0003	<0.0001	0.002	0.002	8.89	<0.05	0.005	<0.001	-	-	-	-	0.001	<0.001	2.21	0.948	6.62	18	<1
48	48/5001_20141007	07/10/14	Within	EM1410485	Kitchen tap	Clear	none	0.003	0.003	<0.001	<0.001	<0.0001	<0.0001	0.358	0.415	-	-	0.001	<0.001	0.004	0.004	<0.0001	<0.0001	<0.001	<0.001	0.425	0.484	6.17	<10	1
50	50/5001_20141007	07/10/14	Within	EM1410485	within tank	slightly brown	none	0.039	0.029	0.002	0.001	0.0013	0.0006	0.006	0.003	-	-	0.024	0.001	0.055	0.003	<0.0001	<0.0001	0.002	<0.001	2.36	0.794	7.17	59	1
50	50/5002_20141007	07/10/14	Within	EM1410485	Internal tap - other	clear	none	0.028	0.025	<0.001	<0.001	0.0005	0.0005	1.16	0.705	0.42	0.13	0.006	0.002	0.002	0.004	<0.0001	<0.0001	0.002	0.003	0.697	0.807	7.28	50	2
51	51/60180714	18/07/14	Within	EM1407188	within tank	Clear	none	0.003	0.002	<0.001	<0.001	<0.0001	<0.0001	0.001	0.002	0.08	<0.05	0.001	<0.001	-	-	-	-	<0.001	<0.001	3.3	2.43	7	69	<1

Table D2.2 - Water Analytical Results Pre-Tank Cleaning - Outside Costerfield Dome

								Metals																				Sample Quality Parameters		
								Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)
								mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH_Units	mg/L	mg/L
LOR								0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.005	0.005	0.01	10	1
ADWG 2011 Aesthetic														1	1	0.3	0.3			0.1	0.1					3	3	6.5-8.5	600	250
ADWG 2011 Health								0.003	0.003	0.01	0.01	0.002	0.002	2	2			0.01	0.01	0.5	0.5	0.001	0.001	0.02	0.02					500
WHO Guidelines for Drinking Water Quality (2006)								0.02	0.02	0.01	0.01	0.003	0.003	2	2			0.01	0.01	0.4	0.4	0.006	0.006	0.07	0.07	3	3			
Property ID	**Sample ID**	**Date**	**Within / Outside Costerfield Dome**	**SDG**	**Sample Point**	**Colour**	**Odour**																							
19	19/5001_20141008	08/10/14	Outside	EM1410580	Kitchen tap	clear	none	0.003	0.002	<0.001	<0.001	<0.0001	<0.0001	0.239	0.243	0.23	<0.05	0.006	0.003	0.008	0.008	<0.0001	<0.0001	0.003	0.002	0.37	0.418	5.83	<10	<1
19	19/5002_20141008	08/10/14	Outside	EM1410580	outside tap	cleat	none	0.003	0.002	<0.001	<0.001	<0.0001	<0.0001	0.024	0.011	-	-	0.002	<0.001	0.005	0.002	<0.0001	<0.0001	<0.001	<0.001	0.065	0.053	5.28	<10	<1
29	29/5001_20141007	07/10/14	Outside	EM1410485	Kitchen tap	clear	none	0.001	0.001	0.002	0.001	<0.0001	<0.0001	0.04	0.032	<0.05	<0.05	0.001	<0.001	0.006	0.006	<0.0001	<0.0001	0.003	0.002	0.639	0.67	6.72	141	18
29	29/5002_20141007	07/10/14	Outside	EM1410485	within tank	clear	none	0.002	0.001	0.001	0.001	<0.0001	<0.0001	0.004	0.003	-	-	<0.001	<0.001	0.008	0.008	<0.0001	<0.0001	<0.001	<0.001	0.773	0.781	7.14	121	16
38	38/5001_20141006	06/10/14	Outside	EM1410438	within tank	clear	none	0.002	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.002	0.005	-	-	<0.001	<0.001	0.003	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.048	0.032	7.37	10	<1
38	38/5002_20141006	06/10/14	Outside	EM1410438	within tank	clear	none	0.002	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.002	<0.001	-	-	0.001	<0.001	0.004	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.035	0.022	6.2	<10	<1
39	39/5001_20141007	07/10/14	Outside	EM1410485	within tank	clear	none	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.004	0.004	-	-	<0.001	<0.001	0.006	0.006	<0.0001	<0.0001	<0.001	<0.001	0.056	0.064	4.99	<10	<1
39	39/5002_20141007	07/10/14	Outside	EM1410485	Kitchen tap	Clear	none	0.003	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.412	0.307	<0.05	<0.05	0.003	0.002	0.006	0.006	<0.0001	<0.0001	<0.001	<0.001	0.11	0.136	5.69	10	<1
46	46/5001_20140710	10/07/14	Outside	EM1406868	Internal tap - other	clear	none	0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.049	0.003	<0.05	<0.05	0.005	<0.001	-	-	-	-	<0.001	<0.001	3.73	3.15	6.75	14	<1
46	46/5002_20140710	10/07/14	Outside	EM1406868	outside tap	clear	none	0.001	0.002	<0.001	<0.001	0.0001	<0.0001	0.021	0.003	<0.05	<0.05	0.001	<0.001	-	-	-	-	0.001	0.001	1.4	1.22	6.96	68	9
52	52/5001_20141007	07/10/14	Outside	EM1410485	Tank tap	pale brown to clear with some black particulate	none	0.002	<0.001	<0.001	<0.001	0.0004	0.0002	0.096	0.045	-	-	0.062	0.017	0.013	0.01	<0.0001	<0.0001	0.008	0.005	0.529	0.522	5.36	11	<1
52	52/5002_20141007	07/10/14	Outside	EM1410485	Kitchen tap	clear	none	<0.001	<0.001	<0.001	<0.001	0.0001	<0.0001	0.122	0.107	<0.05	<0.05	0.007	0.005	0.01	0.009	<0.0001	<0.0001	0.002	0.001	0.495	0.3	5.61	<10	<1
53	53/5001_20141006	06/10/14	Outside	EM1410438	kitchen tap	clear	none	0.002	0.001	0.001	<0.001	<0.0001	<0.0001	0.74	0.809	<0.05	<0.05	0.003	0.002	0.012	0.01	<0.0001	<0.0001	0.001	<0.001	0.198	0.188	6.52	<10	<1
53	53/5002_20141006	06/10/14	Outside	EM1410438	within tank	clear	none	0.002	<0.001	0.001	<0.001	<0.0001	<0.0001	0.046	0.04	-	-	0.002	<0.001	0.011	0.01	<0.0001	<0.0001	0.001	<0.001	0.113	0.109	5.49	<10	<1

Table D2.3 - Water Analytical Results Post-Tank Cleaning - Within Costerfield Dome

					Sample Quality Parameters			Metals																			
					Total Dissolved Solids @180°C	pH (Lab)	Sulphate (as SO4) (Filtered)	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)
					mg/L	pH_Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOR					10	0.01	1	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.005	0.005
ADWG 2011 Aesthetic					600	6.5-8.5	250							1	1	0.3	0.3			0.1	0.1					3	3
ADWG 2011 Health							500	0.003	0.003	0.01	0.01	0.002	0.002	2	2			0.01	0.01	0.5	0.5	0.001	0.001	0.02	0.02		
WHO Guidelines for Drinking Water Quality (2006)								0.02	0.02	0.01	0.01	0.003	0.003	2	2			0.01	0.01	0.4	0.4	0.006	0.006	0.07	0.07	3	3
Field_ID	**Property ID**	**Sample Comment**	**Within / Outside**	**Sampled Date**																							
9/5002_20141006	9	Kitchen tap	Within	6/10/2014	133	7.99	16	0.004	0.003	0.002	0.001	0.0006	<0.0001	0.128	0.111	0.06	<0.05	0.002	<0.001	0.005	0.004	<0.0001	<0.0001	0.001	<0.001	0.467	0.457
13/5002_20141006	13	Within tank	Within	6/10/2014	212	7.98	31	0.003	0.002	0.001	<0.001	0.0006	<0.0001	0.003	<0.001	-	-	0.001	<0.001	0.006	0.007	<0.0001	<0.0001	0.001	<0.001	0.163	0.15
14/5002_20141006	14	Tank tap	Within	6/10/2014	227	7.02	34	0.02	0.005	0.006	<0.001	0.0014	<0.0001	0.113	0.007	-	-	0.139	<0.001	0.137	0.004	<0.0001	<0.0001	0.005	<0.001	14.3	0.743
26/5001_20141006	26	Outside tap	Within	6/10/2014	137	7.94	17	0.007	0.006	0.001	<0.001	0.0006	<0.0001	0.104	0.094	-	-	0.012	0.01	0.008	0.01	<0.0001	<0.0001	0.003	0.002	0.594	0.617
41/5001_20141007	41	Tank tap	Within	7/10/2014	176	7.45	31	0.004	0.004	<0.001	<0.001	0.0005	0.0003	0.027	0.011	-	-	0.004	<0.001	0.004	0.003	<0.0001	<0.0001	0.003	<0.001	0.444	0.287
42/5001_20141007	42	Within tank 1	Within	7/10/2014	227	7.36	34	0.003	0.003	<0.001	<0.001	<0.0001	<0.0001	0.002	0.001	-	-	<0.001	<0.001	0.005	0.001	<0.0001	<0.0001	<0.001	<0.001	0.009	0.01
18/5001_20141008	18	Within tank	Within	8/10/2014	202	7	33	0.013	0.012	<0.001	<0.001	<0.0001	<0.0001	0.003	0.002	-	-	<0.001	<0.001	0.002	0.001	<0.0001	<0.0001	<0.001	<0.001	0.75	0.804
9/5002_20141118	9	Kitchen tap	Within	18/11/2014	185	7.23	15	0.003	0.002	0.001	<0.001	0.0002	<0.0001	0.161	0.145	-	-	<0.001	<0.001	0.007	0.009	<0.0001	<0.0001	<0.001	0.001	0.634	0.668
13/5002_20141118	13	Within tank	Within	18/11/2014	199	7.73	26	0.002	0.002	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	-	-	<0.001	<0.001	0.007	0.004	<0.0001	<0.0001	<0.001	<0.001	0.193	0.194
14/5002_20141118	14	Tank tap	Within	18/11/2014	242	7.6	33	0.006	0.006	<0.001	<0.001	<0.0001	<0.0001	0.004	0.002	-	-	0.002	<0.001	0.005	0.004	<0.0001	<0.0001	<0.001	<0.001	0.484	0.507
18/5001_20141118	18	Within tank	Within	18/11/2014	210	7.56	28	0.011	0.01	<0.001	<0.001	<0.0001	<0.0001	0.004	0.004	-	-	<0.001	<0.001	0.005	0.002	<0.0001	<0.0001	<0.001	<0.001	0.801	0.84
22/5001_20141118	22	Tank tap	Within	18/11/2014	330	8.01	35	0.002	0.002	<0.001	<0.001	<0.0001	<0.0001	0.002	0.001	-	-	0.006	0.004	0.005	0.003	<0.0001	<0.0001	<0.001	<0.001	0.16	0.155
26/5001_20141118	26	Outside tap	Within	18/11/2014	131	6.99	15	0.009	0.007	<0.001	<0.001	0.0001	<0.0001	0.155	0.053	-	-	0.016	0.008	0.01	0.008	<0.0001	<0.0001	0.003	0.001	1.21	1.06
41/5001_20141118	41	Tank tap	Within	18/11/2014	279	7.21	28	0.004	0.002	<0.001	<0.001	0.0011	0.002	0.219	0.036	-	-	0.048	0.002	0.072	0.096	<0.0001	<0.0001	0.025	0.227	1.92	5.83
42/5001_20141118	42	Within tank 1	Within	18/11/2014	245	7.61	31	0.003	0.003	<0.001	<0.001	<0.0001	<0.0001	0.002	0.002	-	-	<0.001	<0.001	0.002	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.013	0.019
9/5002_20141215	9	Kitchen tap	Within	15/12/2014	245	7.43	11	0.003	0.003	0.002	0.001	0.0001	<0.0001	0.071	0.069	0.24	0.2	<0.001	<0.001	0.005	0.008	<0.0001	<0.0001	<0.001	<0.001	0.369	0.437
13/5002_20141215	13	Within tank	Within	15/12/2014	194	7.87	24	0.002	0.002	<0.001	<0.001	<0.0001	<0.0001	0.002	<0.001	<0.05	<0.05	<0.001	<0.001	0.007	0.006	<0.0001	<0.0001	<0.001	<0.001	0.183	0.196
14/5002_20141215	14	Tank tap	Within	15/12/2014	194	7.7	31	0.005	0.005	<0.001	<0.001	0.0001	<0.0001	0.003	0.004	0.05	<0.05	0.001	<0.001	0.003	0.004	<0.0001	<0.0001	<0.001	<0.001	0.444	0.499
18/5001_20141215	18	Within tank	Within	15/12/2014	221	7.7	28	0.012	0.012	<0.001	<0.001	<0.0001	<0.0001	0.003	0.002	<0.05	<0.05	<0.001	<0.001	0.002	0.003	<0.0001	<0.0001	<0.001	<0.001	0.716	0.808
22/5001_20141215	22	Tank tap	Within	15/12/2014	328	9.01	35	0.002	0.002	<0.001	<0.001	<0.0001	<0.0001	0.001	0.001	<0.05	<0.05	0.007	0.005	0.004	0.003	<0.0001	<0.0001	<0.001	<0.001	0.141	0.146
26/5001_20141215	26	Outside tap	Within	15/12/2014	120	7.03	11	0.006	0.006	<0.001	<0.001	0.0001	<0.0001	0.147	0.193	<0.05	<0.05	0.017	0.022	0.008	0.009	<0.0001	<0.0001	0.002	0.002	0.977	1.12
41/2001_20141215	41	Tank tap	Within	15/12/2014	244	7.36	22	0.005	0.005	<0.001	<0.001	0.0014	0.0015	0.14	0.077	0.11	<0.05	0.007	0.004	0.009	0.008	<0.0001	<0.0001	0.059	0.067	1.7	2.03
42/5001_20141215	42	Within tank 1	Within	15/12/2014	297	7.74	34	0.003	0.003	<0.001	<0.001	<0.0001	<0.0001	0.002	0.001	<0.05	<0.05	<0.001	<0.001	0.002	0.001	<0.0001	<0.0001	<0.001	<0.001	0.011	0.012
2/5003_20150121	2	Outside tap	Within	21/01/2015	76	7.18	6	0.006	0.004	<0.001	<0.001	0.0007	0.0007	0.446	0.368	<0.05	<0.05	0.002	0.001	0.008	0.007	<0.0001	<0.0001	0.001	<0.001	2.18	1.95
5/5001_20150121	5	Within tank	Within	21/01/2015	179	8.09	25	0.004	0.003	<0.001	<0.001	<0.0001	<0.0001	0.002	0.001	<0.05	<0.05	<0.001	<0.001	0.003	0.002	<0.0001	<0.0001	<0.001	<0.001	0.141	0.142
6/5001_20150121	6	Within tank	Within	21/01/2015	41	6.66	<1	0.008	0.006	<0.001	<0.001	<0.0001	<0.0001	0.024	0.017	0.57	0.24	0.014	0.009	0.058	0.054	<0.0001	<0.0001	0.002	0.001	4.04	3.96
7/5001_20150121	7	Kitchen tap	Within	21/01/2015	<10	6.97	<1	0.001	0.001	<0.001	<0.001	0.0003	0.0003	0.066	0.037	0.14	<0.05	0.006	0.002	0.015	0.013	<0.0001	<0.0001	<0.001	<0.001	3.15	3.16
8/5002_20150121	8	Within tank	Within	21/01/2015	91	7.04	5	0.003	0.002	<0.001	<0.001	<0.0001	<0.0001	0.003	0.002	0.13	0.1	0.002	0.002	0.023	0.022	<0.0001	<0.0001	<0.001	<0.001	3.9	3.87
9/5002_20150121	9	Kitchen tap	Within	21/01/2015	74	7.26	4	0.005	0.003	0.002	0.001	0.0001	0.0001	0.141	0.107	0.22	0.12	0.001	<0.001	0.007	0.006	<0.0001	<0.0001	<0.001	<0.001	0.586	0.552
13/5002_20150121	13	Within tank	Within	21/01/2015	151	8	15	0.002	0.002	<0.001	<0.001	<0.0001	<0.0001	0.002	0.001	<0.05	<0.05	<0.001	<0.001	0.01	0.006	<0.0001	<0.0001	<0.001	<0.001	0.21	0.184
14/5002_20150121	14	Tank tap	Within	21/01/2015	222	7.97	25	0.006	0.005	<0.001	<0.001	<0.0001	<0.0001	0.005	0.004	0.25	<0.05	0.002	<0.001	0.007	0.006	<0.0001	<0.0001	<0.001	<0.001	0.793	0.614
15/5003_20150121	15	Within tank	Within	21/01/2015	229	7.61	26	<0.001	<0.001	<0.001	<0.001	<0.0001	0.0001	0.003	0.004	0.07	<0.05	0.001	0.001	0.013	0.012	<0.0001	<0.0001	<0.001	<0.001	4.73	4.42
16/5002_20150121	16	Tank tap	Within	21/01/2015	165	7.44	18	0.013	0.012	<0.001	<0.001	<0.0001	<0.0001	0.006	0.004	0.11	<0.05	<0.001	<0.001	0.003	0.002	<0.0001	<0.0001	<0.001	<0.001	0.256	0.246
18/5001_20150121	18	Within tank	Within	21/01/2015	224	7.72	28	0.014	0.013	<0.001	<0.001	<0.0001	<0.0001	0.005	0.003	0.05	<0.05	<0.001	<0.001	0.007	0.004	<0.0001	<0.0001	<0.001	<0.001	1.13	0.79
26/5001_20150121	26	Outside tap	Within	21/01/2015	41	6.55	4	0.007	0.005	<0.001	<0.001	<0.0001	<0.0001	0.463	0.483	0.13	0.12	0.076	0.08	0.022	0.022	<0.0001	<0.0001	0.003	0.003	1.1	1.12
27/5001_20150121	27	Within tank	Within	21/01/2015	117	7.28	15	0.003	0.003	<0.001	<0.001	0.001	0.001	0.003	0.002	<0.05	<0.05	<0.001	<0.001	0.006	0.006	<0.0001	<0.0001	<0.001	<0.001	0.61	0.609
28/5001_20150121	28	Within tank	Within	21/01/2015	93	7.4	8	0.003	0.003	<0.001	<0.001	0.0002	0.0001	0.003	0.002	<0.05	<0.05	0.002	0.002	0.009	0.009	<0.0001	<0.0001	<0.001	<0.001	1.93	1.98
37/5001_20150121	37	Kitchen tap	Within	21/01/2015	134	7.18	10	0.016	0.013	<0.001	<0.001	<0.0001	<0.0001	0.267	0.212	0.09	<0.05	0.004	0.003	0.038	0.033	<0.0001	<0.0001	0.002	0.001	8.32	8.13
41/5001_20150121	41	Tank tap	Within	21/01/2015	199	7.29	19	0.002	0.003	<0.001	<0.001	0.0009	0.0009	0.098	0.08	2.51	0.05	0.01	0.001	0.053	0.034	<0.0001	<0.0001	0.008	0.019	1.12	1.25
42/5001_20150121	42	Within tank 1	Within	21/01/2015	251	7.87	38	0.002	0.002	<0.001	<0.001	<0.0001	<0.0001	0.004	0.004	<0.05	<0.05	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.005	0.022
47/5001_20150121	47	Old tank tap	Within	21/01/2015	226	7.39	35	0.002	0.001	<0.001	<0.001	0.0021	0.0021	0.194	0.09	1.56	<0.05	0.034	0.006	0.048	0.046	<0.0001	<0.0001	0.065	0.06	4.47	4.46
51/5001_20150121	51	Inside tank	Within	21/01/2015	120	7.11	13	0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.002	<0.001	0.14	0.1	0.001	0.001	0.028	0.026	<0.0001	<0.0001	<0.001	<0.001	3.7	3.94
9/5002_20150218	9	Kitchen tap	Within	18/02/2015	84	7.64	4	0.006	0.009	0.001	0.001	<0.0001	<0.0001	0.128	0.141	0.27	0.21	<0.001	0.001	0.006	0.009	<0.0001	<0.0001	<0.001	<0.001	0.612	0.58
13/5002_20150218	13	Within tank	Within	18/02/2015	183	7.68	13	0.003	0.003	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.05	<0.05	0.001	<0.001	0.015	0.011	<0.0001	<0.0001	0.001	<0.001	0.341	0.306
14/5002_20150218	14	Tank tap	Within	18/02/2015	204	7.8	23	0.006	0.007	<0.001	<0.001	0.0001	<0.0001	0.01	0.002	0.11	<0.05	0.002	<0.001	0.004	0.005	<0.0001	<0.0001	0.001	<0.001	0.62	0.529
18/5001_20150218	18	Within tank	Within	18/02/2015	239	7.84	27	0.016	0.019	<0.001	<0.001	<0.0001	<0.0001	0.005	0.004	<0.05	<0.05	<0.001	<0.001	0.006	0.009	<0.0001	<0.0001	<0.001	<0.001	0.927	0.896
26/5001_20150218	26	Outside tap	Within	18/02/2015	118	6.98	7	0.007	0.007	<0.001	<0.001	0.0003	0.0002	0.439	0.313	0.13	0.12	0.077	0.057	0.025	0.026	<0.0001	<0.0001	0.007	0.005	1.98	1.71
37/5001_20150218	37	Kitchen tap	Within	18/02/2015	185	7.42	17	0.022	0.024	<0.001	<0.001	<0.0001	<0.0001	0.854	0.212	<0.05	0.12	0.004	0.003	0.038	0.037	<0.0001	<0.0001	0.005	0.003	6.8	5.94
41/2001_20150218	41	Tank tap	Within	18/02/2015	228	7.46	17	0.006	0.008	<0.001	<0.001	0.0007	0.0006	0.02	0.015	0.79	0.39	0.01	0.005	0.022	0.024	<0.0001	<0.0001	0.002	0.002	0.712	0.73
42/5001_20150218	42	Within tank 1	Within	18/02/2015	203	7.6	23	0.005	0.005	<0.001	<0.001	<0.0001	<0.0001	0.003	0.003	<0.05	<0.05	<0.001	0.003	0.002	<0.001	<0.0001	<0.0001	0.001	<0.001	0.009	0.017
13/5002_20150317	13	Within tank	Within	17/03/2015	162	7.87	12	0.004	0.004	<0.001	<0.001	<0.0001	<0.0001	0.002	0.002	0.1	<0.05	<0.001	<0.001	0.007	0.002	<0.0001	<0.0001	<0.001	<0.001	0.153	0.127
14/5002_20150317	14	Tank tap	Within	17/03/2015	215	7.4	24	0.006	0.006	<0.001	<0.001	0.0001	<0.0001	0.012	0.007	0.7	<0.05	0.003	<0.001	0.006	0.003	<0.0001	<0.0001	<0.001	<0.001	0.637	0.433
18/5001_20150317	18	Within tank	Within	17/03/2015	223	7.76	27	0.016	0.016	<0.001	<0.001	<0.0001	<0.0001	0.004	0.003	<0.05	<0.05	<0.001	<0.001	0.006	0.006	<0.0001	<0.0001	<0.001	<0.001	0.679	0.668
26/5001_20150317	26	Outside tap	Within	17/03/2015	119	6.87	6	0.007	0.006	<0.001	<0.001	<0.0001	<0.0001	0.097	0.036	0.26	0.21	0.024	0.013	0.036	0.031	<0.0001	<0.0001	0.002	0.001	1.23	0.99
37/5001_20150317	37	Kitchen tap	Within	17/03/2015	163	7.27	18	0.021	0.02	<0.001	<0.001	<0.0001	<0.0001	1.43	1.11	0.05	<0.05	0.005	0.002	0.042	0.038	<0.0001	<0.0001	0.004	0.002	7.22	7.02
40/5002_20150317	40	Within tank	Within	17/03/2015	272	7.4	40	0.004	0.003	<0.001	<0.001	<0.0001	<0.0001	0.008	0.007	0.11	0.09	0.002	0.002	0.068	0.062	<0.0001	<0.0001	0.002	0.001	0.114	0.11
41/5001_20150317	41	Tank tap	Within	17/03/2015	186	7.68	17	0.006	0.006	<0.001	<0.001	0.001	0.0007	0.01	0.014	<0.05	<0.05	0.002	0.001	0.004	0.005	<0.0001	<0.0001	0.003	0.001	0.774	0.539
42/5001_20150317	42	Within tank 1	Within	17/03/2015	164	7.6	23	0.005	0.005	<0.001	<0.001	<0.0001	<0.0001	0.002	0.002	<0.05	<0.05	<0.001	<0.001	<0.001	0.001	<0.0001	<0.0001	<0.001	<0.001	0.015	0.015
9/5002_200415	9	Kitchen tap	Within	20/04/2015	256	7.09	23	0.01	0.01	<0.001	<0.001	<0.0001	<0.0001	0.126	0.134	0.12	<0.05	<0.001	<0.001	0.008	0.007	<0.0001	<0.0001	<0.001	<0.001	0.748	0.763
13/5001_200415	13	Kitchen tap	Within	20/04/2015	80	7.19	2	0.002	0.002	<0.001	<0.001	0.0006	0.0005	0.063	0.032	0.07	<0.05	0.003	0.002	0.024	0.023	<0.0001	<0.0001	<0.001	<0.001	3.15	3.41
14/5002_200415	14	Tank tap	Within	20/04/2015	314	7.68	23	0.006	0.006	<0.001	<0.001	<0.0001	<0.0001	0.004	0.001	0.12	<0.05	<0.001	<0.001	0.01	0.003	<0.0001	<0.0001	<0.001	<0.001	0.56	0.561
18/5001_200415	18	Within tank	Within	20/04/2015	270	7.8	27	0.02	0.02	<0.001	<0.001	<0.0001	<0.0001	0.004	0.003	<0.05	<0.05	<0.001	<0.001	0.005	0.004	<0.0001	<0.0001	<0.001	<0.001	0.624	0.681
26/5001_200415	26	Outside tap	Within	20/04/2015	99	6.6	5	0.008	0.007	<0.001	<0.001	0.0003	0.0002	0.541	0.428	0.2	0.15	0.083	0.067	0.036	0.033	<0.0001	<0.0001	0.01	0.008	2.43	2.31
37/5004_200415	37	Outdoor tap	Within	20/04/2015	201	6.93	13	0.03	0.023	<0.001	<0.001	<0.0001	<0.0001	0.131	0.123	0.1	0.07	0.004	0.003	0.053	0.054	<0.0001	<0.0001	0.001	0.001	6.49	7.67
41/5001_200415	41	Tank tap	Within	20/04/2015	218	7.61	16	0.008	0.008	<0.001	<0.001	0.0005	0.0005	0.008	0.006	0.08	<0.05	<0.001	<0.001	0.003	0.001	<0.0001	<0.0001	0.001	<0.001	0.396	0.435
42/5001_200415	42	Within tank 1	Within	20/04/2015	210	7.4	21	0.006	0.006	<0.001	<0.001	<0.0001	<0.0001	0.002	0.001	0.06	<0.05	<0.001	<0.001	0.002	0.002	<0.0001	<0.0001	<0.001	<0.001	0.013	0.014
2/5003_20150525	2	Outside tap	Within	25/05/2015	43	6.69	2	0.011	0.015	<0.001	<0.001	0.0008	0.0007	0.418	0.208	<0.05	<0.05	0.004	0.001	0.003	0.003	<0.0001	<0.0001	<0.001	<0.001	2.48	2.52
5/5001_20150525	5	Within tank	Within	25/05/2015	160	7.11	20	0.014	0.013	<0.001	<0.001	<0.0001	<0.0001	0.001	<0.001	0.08	<0.05	<0.001	<0.001	0.003	0.002	<0.0001	<0.0001	<0.001	<0.001	0.184	0.145
6/5001_20150525	6	Within tank	Within	25/05/2015	17	6.27	<1	0.012	0.011	<0.001	<0.001	0.0001	<0.0001	0.009	0.004	0.18	0.13	0.013	0.009	0.029	0.029	<0.0001	<0.0001	<0.001	<0.001	3.03	3.02
7/5001_20150525	7	Kitchen tap	Within	25/05/2015	20	6.06	1	0.007	0.008	<0.001	<0.001	0.0009	0.0004	0.012	0.008	<0.05	<0.05	0.003	0.001	0.018	0.017	<0.0001	<0.0001	<0.001	<0.001	4.97	5.02
8/5002_20150525	8	Within tank	Within	25/05/2015	82	6.59	9	0.006	0.006	<0.001	<0.001	<0.0001	<0.0001	0.001	<0.001	0.09	<0.05	0.003	0.002	0.021	0.02	<0.0001	<0.0001	<0.001	<0.001	2.44	2.39
9/5002_20150525	9	Kitchen tap	Within	25/05/2015	59	6.85	1	0.008	0.01	<0.001	<0.001	<0.0001	<0.0001	0.078	0.04	0.48	<0.05	0.001	<0.001	0.008	0.001	<0.0001	<0.0001	<0.001	<0.001	0.447	0.332
13/5001_20150525	13	Kitchen tap	Within	25/05/2015	78	6.98	3	0.006	0.006	<0.001	<0.001	0.0002	0.0002	0.215	0.139	0.06	<0.05	0.002	0.001	0.014	0.01	<0.0001	<0.0001	0.001	<0.001	1.37	1.39
14/5002_20150525	14	Tank tap	Within	25/05/2015	148	7.22	21	0.012	0.009	<0.001	<0.001	0.0002	<0.0001	0.289	0.007	0.67	<0.05	0.019	<0.001	0.008	0.002	<0.0001	<0.0001	0.001	<0.001	1.18	0.574
15/5003_20150525	15	Within tank	Within	25/05/2015	145	7.41	19	0.002	0.002	<0.001	<0.001	0.0002	0.0002	0.046	0.001	0.3	0.53	0.007	0.001	0.029	0.029	<0.0001	<0.0001	0.002	<0.001	7.85	4.85

Table D2.3 - Water Analytical Results Post-Tank Cleaning - Within Costerfield Dome

					Sample Quality Parameters			Metals																			
					Total Dissolved Solids @180°C	pH (Lab)	Sulphate (as SO4) (Filtered)	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)
					mg/L	pH_Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOR					10	0.01	1	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.005	0.005
ADWG 2011 Aesthetic					600	6.5-8.5	250							1	1	0.3	0.3			0.1	0.1					3	3
ADWG 2011 Health							500	0.003	0.003	0.01	0.01	0.002	0.002	2	2			0.01	0.01	0.5	0.5	0.001	0.001	0.02	0.02		
WHO Guidelines for Drinking Water Quality (2006)								0.02	0.02	0.01	0.01	0.003	0.003	2	2			0.01	0.01	0.4	0.4	0.006	0.006	0.07	0.07	3	3
Field_ID	**Property ID**	**Sample Comment**	**Within / Outside**	**Sampled Date**																							
16/5002_20150525	16	Tank tap	Within	25/05/2015	252	7.34	32	0.007	0.008	<0.001	<0.001	<0.0001	<0.0001	0.111	0.019	0.18	0.09	0.004	0.003	0.006	0.004	<0.0001	<0.0001	0.001	<0.001	0.207	0.206
18/5001_20150525	18	Within tank	Within	25/05/2015	198	7.56	26	0.031	0.031	<0.001	<0.001	<0.0001	<0.0001	0.004	0.002	0.09	<0.05	<0.001	<0.001	0.012	0.004	<0.0001	<0.0001	<0.001	<0.001	1.01	0.669
26/5001_20150525	26	Outside tap	Within	25/05/2015	75	6.43	6	0.016	0.013	<0.001	<0.001	0.0002	0.0002	0.65	0.503	0.16	0.11	0.083	0.067	0.029	0.028	<0.0001	<0.0001	0.01	0.008	2.2	2.09
27/5001_20150525	27	Within tank	Within	25/05/2015	75	6.91	7	0.011	0.013	<0.001	<0.001	0.0016	0.0016	0.021	0.002	<0.05	0.15	<0.001	<0.001	0.007	0.005	<0.0001	<0.0001	0.001	0.001	1.19	1.36
28/5001_20150525	28	Within tank	Within	25/05/2015	96	6.95	5	0.005	0.005	<0.001	<0.001	<0.0001	0.0002	0.002	0.002	0.09	<0.05	0.002	0.002	0.014	0.012	<0.0001	<0.0001	<0.001	<0.001	3.5	3.46
37/5001_20150525	37	Kitchen tap	Within	25/05/2015	116	6.82	5	0.044	0.03	<0.001	<0.001	<0.0001	0.0001	1.74	0.711	0.08	0.06	0.006	0.003	0.06	0.058	<0.0001	<0.0001	0.006	0.01	7.45	7.17
40/5002_20150525	40	Within tank	Within	25/05/2015	165	6.86	23	0.01	0.008	<0.001	<0.001	<0.0001	<0.0001	0.016	0.013	0.09	0.07	0.002	0.002	0.023	0.021	<0.0001	<0.0001	0.001	0.001	0.276	0.274
41/5001_20150525	41	Tank tap	Within	25/05/2015	158	7.27	12	0.012	0.015	<0.001	<0.001	0.0008	0.0012	0.041	0.059	0.16	0.06	0.001	0.003	0.003	0.004	<0.0001	<0.0001	0.004	0.002	0.821	1.02
42/5001_20150525	42	Within tank 1	Within	25/05/2015	147	7.25	18	0.01	0.009	<0.001	<0.001	<0.0001	<0.0001	0.001	<0.001	<0.05	<0.05	<0.001	<0.001	0.002	0.001	<0.0001	<0.0001	<0.001	<0.001	0.021	0.014
47/5001_20150525	47	Old tank tap	Within	25/05/2015	68	6.42	7	0.007	0.005	<0.001	<0.001	0.0007	0.0008	0.055	0.039	0.4	0.09	0.013	0.007	0.036	0.033	<0.0001	<0.0001	0.021	0.02	3.43	3.6
47/5002_20150525	47	Kitchen tap	Within	25/05/2015	46	6.26	4	0.008	0.007	<0.001	<0.001	0.0008	0.0004	0.027	0.03	0.17	0.1	0.003	0.002	0.021	0.02	<0.0001	<0.0001	<0.001	<0.001	2.47	2.52

Table D2.4 - Water Analytical Results Post-Tank Cleaning - Outside of Costerfield Dome

	Sample Quality Parameters			Metals																			
	Total Dissolved Solids @180°C	pH (Lab)	Sulphate (as SO4) (Filtered)	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)
	mg/L	pH_Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOR	10	0.01	1	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.005	0.005
ADWG 2011 Aesthetic	600	6.5-8.5	250							1	1	0.3	0.3			0.1	0.1					3	3
ADWG 2011 Health			500	0.003	0.003	0.01	0.01	0.002	0.002	2	2			0.01	0.01	0.5	0.5	0.001	0.001	0.02	0.02		
WHO Guidelines for Drinking Water Quality (2006)				0.02	0.02	0.01	0.01	0.003	0.003	2	2			0.01	0.01	0.4	0.4	0.006	0.006	0.07	0.07	3	3

Field_ID	Property ID	Sample Comment	Within / Outside	Sampled Date	Total Dissolved Solids @180°C	pH (Lab)	Sulphate (as SO4) (Filtered)	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)
46/5001_20150121	46	Laundry tap	Outside	21/01/2015	22	7.05	2	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.006	0.004	<0.05	<0.05	0.005	0.004	0.004	0.004	<0.0001	<0.0001	<0.001	<0.001	3	2.9
46/5001_20150525	46	Laundry tap	Outside	25/05/2015	160	7.01	24	0.001	0.001	<0.001	<0.001	<0.0001	<0.0001	0.004	0.003	<0.05	<0.05	0.003	0.002	0.002	0.002	<0.0001	<0.0001	0.001	<0.001	2.97	2.92

Statistical Summary

Statistical Summary	Total Dissolved Solids @180°C	pH (Lab)	Sulphate (as SO4) (Filtered)	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)
Number of Results	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of Detects	2	2	2	1	1	0	0	0	0	2	2	0	0	2	2	2	2	0	0	1	0	2	2
Minimum Concentration	22	7.01	2	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.004	0.003	<0.05	<0.05	0.003	0.002	0.002	0.002	<0.0001	<0.0001	<0.001	<0.001	2.97	2.9
Minimum Detect	22	7.01	2	0.001	0.001	ND	ND	ND	ND	0.004	0.003	ND	ND	0.003	0.002	0.002	0.002	ND	ND	0.001	ND	2.97	2.9
Maximum Concentration	160	7.05	24	0.001	0.001	<0.001	<0.001	<0.0001	<0.0001	0.006	0.004	<0.05	<0.05	0.005	0.004	0.004	0.004	<0.0001	<0.0001	0.001	<0.001	3	2.92
Maximum Detect	160	7.05	24	0.001	0.001	ND	ND	ND	ND	0.006	0.004	ND	ND	0.005	0.004	0.004	0.004	ND	ND	0.001	ND	3	2.92
Average Concentration																							
Median Concentration	91	7.03	13	0.00075	0.00075	0.0005	0.0005	0.00005	0.00005	0.005	0.0035	0.025	0.025	0.004	0.003	0.003	0.003	0.00005	0.00005	0.00075	0.0005	2.985	2.91
Standard Deviation																							
Number of Guideline Exceedances	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table D2.5 - Statistical Summary of Rainwater Data Available for Pre- and Post-tank Cleaning

	Metals																				Sample Quality Parameters		
	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH_Units	mg/L	mg/L
LOR	*0.001*	*0.001*	*0.001*	*0.001*	*0.0001*	*0.0001*	*0.001*	*0.001*	*0.05*	*0.05*	*0.001*	*0.001*	*0.001*	*0.001*	*0.0001*	*0.0001*	*0.001*	*0.001*	*0.005*	*0.005*	*0.01*	*10*	*1*
ADWG 2011 Aesthetic							*1*	*1*	*0.3*	*0.3*			*0.1*	*0.1*					*3*	*3*	*6.5-8.5*	*600*	*250*
ADWG 2011 Health	*0.003*	*0.003*	*0.01*	*0.01*	*0.002*	*0.002*	*2*	*2*			*0.01*	*0.01*	*0.5*	*0.5*	*0.001*	*0.001*	*0.02*	*0.02*					*500*
WHO Guidelines for Drinking Water Quality (2006)	*0.02*	*0.02*	*0.01*	*0.01*	*0.003*	*0.003*	*2*	*2*			*0.01*	*0.01*	*0.4*	*0.4*	*0.006*	*0.006*	*0.07*	*0.07*	*3*	*3*			

Statistical Summary: Pre-Tank Cleaning

Within Costerfield Dome

	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)
Number of Results	**81**	**81**	**81**	**81**	**81**	**81**	**81**	**81**	**74**	**74**	**81**	**81**	**9**	**9**	**9**	**9**	**81**	**81**	**81**	**81**	**81**	**81**	**81**
Number of Detects	81	80	6	7	43	34	73	78	14	8	49	31	9	9	0	0	16	23	79	80	81	73	32
Minimum Concentration	0.002	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.05	<0.05	<0.001	<0.001	0.002	0.003	<0.0001	<0.0001	<0.001	<0.001	<0.005	<0.005	3.79	<10	<1
Minimum Detect	0.002	0.001	0.002	0.001	0.0001	0.0001	0.001	0.001	0.08	0.06	0.001	0.001	0.002	0.003	ND	ND	0.001	0.001	0.058	0.006	3.79	12	1
Maximum Concentration	0.106	0.11	0.009	0.008	0.0098	0.0097	2.17	1.02	8.89	0.22	0.024	0.009	0.203	0.006	<0.0001	<0.0001	0.006	0.005	6.68	6.37	7.77	303	26
Maximum Detect	0.106	0.11	0.009	0.008	0.0098	0.0097	2.17	1.02	8.89	0.22	0.024	0.009	0.203	0.006	ND	ND	0.006	0.005	6.68	6.37	7.77	303	26
Average Concentration	0.02	0.018	0.00072	0.00069	0.00053	0.00041	0.13	0.081	0.19	0.034	0.0027	0.0013	0.032	0.0041	0.00005	0.00005	0.00076	0.00085	1.7	1.6	6.8	52	1.9
Median Concentration	0.011	0.011	0.0005	0.0005	0.0001	0.00005	0.018	0.014	0.025	0.025	0.001	0.0005	0.004	0.004	0.00005	0.00005	0.0005	0.0005	1.18	0.983	6.92	36	0.5
Standard Deviation	0.023	0.022	0.0011	0.00094	0.0017	0.0014	0.33	0.17	1	0.029	0.0041	0.0017	0.066	0.0012	0	0	0.00084	0.00082	1.6	1.6	0.69	52	4.5
Number of Guideline Exceedances	**73**	**71**	**0**	**0**	**3**	**3**	**3**	**1**	**6**	**0**	**4**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**17**	**13**	**13**	**0**	**0**

Outside Costerfield Dome

	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)
Number of Results	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**7**	**7**	**14**	**14**	**12**	**12**	**12**	**12**	**14**	**14**	**14**	**14**	**14**	**14**	**14**
Number of Detects	12	6	4	2	3	1	14	13	1	0	11	5	12	10	0	0	7	5	14	14	14	7	3
Minimum Concentration	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.002	<0.001	<0.05	<0.05	<0.001	<0.001	0.003	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.035	0.022	4.99	<10	<1
Minimum Detect	0.001	0.001	0.001	0.001	0.0001	0.0002	0.002	0.003	0.23	ND	0.001	0.002	0.003	0.002	ND	ND	0.001	0.001	0.035	0.022	4.99	10	9
Maximum Concentration	0.003	0.002	0.002	0.001	0.0004	0.0002	0.74	0.809	0.23	<0.05	0.062	0.017	0.013	0.01	<0.0001	<0.0001	0.008	0.005	3.73	3.15	7.37	141	18
Maximum Detect	0.003	0.002	0.002	0.001	0.0004	0.0002	0.74	0.809	0.23	ND	0.062	0.017	0.013	0.01	ND	ND	0.008	0.005	3.73	3.15	7.37	141	18
Average Concentration	0.0018	0.00093	0.00071	0.00057	0.000082	0.000061	0.13	0.12	0.054	0.025	0.0068	0.0024	0.0077	0.0063	0.00005	0.00005	0.0016	0.0011	0.61	0.55	6.1	29	3.5
Median Concentration	0.002	0.0005	0.0005	0.0005	0.00005	0.00005	0.043	0.0215	0.025	0.025	0.002	0.0005	0.007	0.007	0.00005	0.00005	0.00075	0.0005	0.284	0.244	6.015	7.5	0.5
Standard Deviation	0.00087	0.00062	0.00043	0.00018	0.000093	0.00004	0.21	0.22	0.077	0	0.016	0.0044	0.0032	0.0036	0	0	0.002	0.0012	0.98	0.83	0.77	46	6.2
Number of Guideline Exceedances	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**8**	**0**	**0**

Statistical Summary: Post-Tank Cleaning

Within Costerfield Dome

	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)
Number of Results	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**72**	**72**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**	**86**
Number of Detects	85	84	8	4	38	28	84	78	49	25	55	44	84	83	0	0	38	26	85	86	85	86	83
Minimum Concentration	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.05	<0.05	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.005	0.01	<10	6.06	<1
Minimum Detect	0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.05	0.05	0.001	0.001	0.002	0.001	ND	ND	0.001	0.001	0.009	0.01	17	6.06	1
Maximum Concentration	0.044	0.031	0.006	0.001	0.0021	0.0021	1.74	1.11	2.51	0.53	0.139	0.08	0.137	0.096	<0.0001	<0.0001	0.065	0.227	14.3	8.13	330	9.01	40
Maximum Detect	0.044	0.031	0.006	0.001	0.0021	0.0021	1.74	1.11	2.51	0.53	0.139	0.08	0.137	0.096	ND	ND	0.065	0.227	14.3	8.13	330	9.01	40
Average Concentration	0.0081	0.0075	0.00064	0.00052	0.00029	0.00024	0.12	0.077	0.19	0.067	0.0095	0.0052	0.017	0.014	0.00005	0.00005	0.0034	0.0056	1.8	1.6	167	7.3	18
Median Concentration	0.006	0.006	0.0005	0.0005	0.00005	0.00005	0.011	0.0065	0.09	0.025	0.002	0.001	0.008	0.0065	0.00005	0.00005	0.0005	0.0005	0.762	0.7055	177.5	7.375	18
Standard Deviation	0.0072	0.0063	0.00065	0.00011	0.00042	0.00043	0.28	0.17	0.36	0.086	0.023	0.014	0.021	0.017	0	0	0.0099	0.026	2.4	2	76	0.49	11
Number of Guideline Exceedances	**73**	**70**	**0**	**0**	**1**	**2**	**2**	**1**	**9**	**2**	**17**	**7**	**1**	**0**	**0**	**0**	**4**	**4**	**18**	**18**	**0**	**6**	**0**

Outside Costerfield Dome

	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)
Number of Results	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Number of Detects	1	1	0	0	0	0	2	2	0	0	2	2	2	2	0	0	1	0	2	2	2	2	2
Minimum Concentration	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.004	0.003	<0.05	<0.05	0.003	0.002	0.002	0.002	<0.0001	<0.0001	<0.001	<0.001	2.97	2.9	22	7.01	2
Minimum Detect	0.001	0.001	ND	ND	ND	ND	0.004	0.003	ND	ND	0.003	0.002	0.002	0.002	ND	ND	0.001	ND	2.97	2.9	22	7.01	2
Maximum Concentration	0.001	0.001	<0.001	<0.001	<0.0001	<0.0001	0.006	0.004	<0.05	<0.05	0.005	0.004	0.004	0.004	<0.0001	<0.0001	0.001	<0.001	3	2.92	160	7.05	24
Maximum Detect	0.001	0.001	ND	ND	ND	ND	0.006	0.004	ND	ND	0.005	0.004	0.004	0.004	ND	ND	0.001	ND	3	2.92	160	7.05	24
Average Concentration	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Median Concentration	0.00075	0.00075	0.0005	0.0005	0.00005	0.00005	0.005	0.0035	0.025	0.025	0.004	0.003	0.003	0.003	0.00005	0.00005	0.00075	0.0005	2.985	2.91	91	7.03	13
Standard Deviation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Number of Guideline Exceedances	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**

Table D2.6 - Water Analytical Results - Swimming Pool

	Heavy Metals																									
	Antimony	**Antimony (Filtered)**	**Arsenic**	**Arsenic (Filtered)**	**Barium**	**Barium (Filtered)**	**Beryllium**	**Beryllium (Filtered)**	**Boron**	**Boron (Filtered)**	**Cadmium**	**Cadmium (Filtered)**	**Chromium**	**Chromium (Filtered)**	**Cobalt**	**Cobalt (Filtered)**	**Copper**	**Copper (Filtered)**	**Iron**	**Iron (Filtered)**	**Lead**	**Lead (Filtered)**	**Manganese**	**Manganese (Filtered)**	**Mercury**	**Mercury (Filtered)**
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.05	0.05	0.0001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.001	0.0001	0.0001
ADWG 2011 Aesthetic																	1	1	0.3	0.3			0.1	0.1		
ADWG 2011 Health	0.003	0.003	0.01	0.01	2	2	0.06	0.06	4	4	0.002	0.002					2	2			0.01	0.01	0.5	0.5	0.001	0.001
WHO Guidelines for Drinking Water Quality (2006)	0.02	0.02	0.01	0.01	0.7	0.7					0.003	0.003	0.05	0.05			2	2			0.01	0.01	0.4	0.4	0.006	0.006

Site_ID	Monitoring_Zone	SampleCode	Field_ID	Location_Code	Sampled_Date_Time	Lab_Report_Number	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Barium	Barium (Filtered)	Beryllium	Beryllium (Filtered)	Boron	Boron (Filtered)	Cadmium	Cadmium (Filtered)	Chromium	Chromium (Filtered)	Cobalt	Cobalt (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)
147613051	9	EM1410438042	9/5003_20141006	9/5003	6/10/2014	EM1410438	0.058	0.059	0.002	<0.001	0.03	0.03	<0.001	<0.001	<0.05	0.06	0.0006	<0.0001	0.002	<0.001	0.001	<0.001	0.006	0.004	-	-	<0.001	<0.001	0.008	0.002	<0.0001	<0.0001
147613051	9	EM1413447002	9/5003_20141215	9/5003	15/12/2014	EM1413447	0.005	0.005	<0.001	<0.001	-	-	-	-	-	-	<0.0001	<0.0001	-	-	-	-	0.002	0.001	<0.05	<0.05	<0.001	<0.001	0.002	0.003	<0.0001	<0.0001
147613051	9	EM1500689002	9/5003_20150121	9/5003	21/01/2015	EM1500689	0.008	0.006	<0.001	<0.001	-	-	-	-	-	-	<0.0001	<0.0001	-	-	-	-	0.003	0.001	<0.05	<0.05	<0.001	<0.001	0.002	<0.001	<0.0001	<0.0001
147613051	9	EM1501799002	9/5003_20150218	9/5003	18/02/2015	EM1501799	0.01	0.014	<0.001	<0.001	-	-	-	-	-	-	<0.0001	<0.0001	-	-	-	-	0.005	0.003	<0.05	<0.05	<0.001	<0.001	0.004	0.003	<0.0001	<0.0001
147613051	9	EM1502843002	9/5003_20150317	9/5003	17/03/2015	EM1502843	0.011	0.012	<0.001	<0.001	-	-	-	-	-	-	<0.0001	<0.0001	-	-	-	-	0.003	0.015	<0.05	<0.05	<0.001	<0.001	0.002	0.002	<0.0001	<0.0001
147613051	9	EM1504064002	9/5003_200415	9/5003	20/04/2015	EM1504064	0.014	0.013	<0.001	<0.001	-	-	-	-	-	-	<0.0001	<0.0001	-	-	-	-	0.003	0.001	0.1	<0.05	<0.001	<0.001	0.003	0.002	<0.0001	<0.0001
147613051	9	EM1510199002	9/5003_20150525	9/5003	25/05/2015	EM1510199	0.022	0.022	0.001	<0.001	-	-	-	-	-	-	0.0001	<0.0001	-	-	-	-	0.002	0.002	<0.05	<0.05	<0.001	<0.001	0.002	<0.001	<0.0001	<0.0001

Statistical Summary

	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Barium	Barium (Filtered)	Beryllium	Beryllium (Filtered)	Boron	Boron (Filtered)	Cadmium	Cadmium (Filtered)	Chromium	Chromium (Filtered)	Cobalt	Cobalt (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)	Mercury	Mercury (Filtered)
Number of Results	7	7	7	7	1	1	1	1	1	1	7	7	1	1	1	1	7	7	6	6	7	7	7	7	7	7
Number of Detects	7	7	2	0	1	1	0	0	0	1	2	0	1	0	1	0	7	7	1	0	0	0	7	5	0	0
Minimum Concentration	0.005	0.005	<0.001	<0.001	0.03	0.03	<0.001	<0.001	<0.05	0.06	<0.0001	<0.0001	0.002	<0.001	0.001	<0.001	0.002	0.001	<0.05	<0.05	<0.001	<0.001	0.002	<0.001	<0.0001	<0.0001
Minimum Detect	0.005	0.005	0.001	ND	0.03	0.03	ND	ND	ND	0.06	0.0001	ND	0.002	ND	0.001	ND	0.002	0.001	0.1	ND	ND	ND	0.002	0.002	ND	ND
Maximum Concentration	0.058	0.059	0.002	<0.001	0.03	0.03	<0.001	<0.001	<0.05	0.06	0.0006	<0.0001	0.002	<0.001	0.001	<0.001	0.006	0.015	0.1	<0.05	<0.001	<0.001	0.008	0.003	<0.0001	<0.0001
Maximum Detect	0.058	0.059	0.002	ND	0.03	0.03	ND	ND	ND	0.06	0.0006	ND	0.002	ND	0.001	ND	0.006	0.015	0.1	ND	ND	ND	0.008	0.003	ND	ND
Average Concentration	0.018	0.019	0.00079	0.0005							0.00014	0.00005					0.0034	0.0039	0.038	0.025	0.0005	0.0005	0.0033	0.0019	0.00005	0.00005
Median Concentration	0.011	0.013	0.0005	0.0005	0.03	0.03	0.0005	0.0005	0.025	0.06	0.00005	0.00005	0.002	0.0005	0.001	0.0005	0.003	0.002	0.025	0.025	0.0005	0.0005	0.002	0.002	0.00005	0.00005
Standard Deviation	0.018	0.019	0.00057	0							0.00021	0					0.0015	0.005	0.031	0	0	0	0.0022	0.001	0	0
Number of Guideline Exceedances	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table D2.6 - Water Analytical Results - Swimming Pool

															ample Quality Parameter		
							Nickel	**Nickel (Filtered)**	**Selenium**	**Selenium (Filtered)**	**Vanadium**	**Vanadium (Filtered)**	**Zinc**	**Zinc (Filtered)**	**pH (Lab)**	**Total Dissolved Solids @180°C**	**Sulphate (as SO4) (Filtered)**
							mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH_Units	mg/L	mg/L
EQL							0.001	0.001	0.01	0.01	0.01	0.01	0.005	0.005	0.01	10	1
ADWG 2011 Aesthetic													3	3	6.5-8.5	600	250
ADWG 2011 Health							0.02	0.02	0.01	0.01							500
WHO Guidelines for Drinking Water Quality (2006)							0.07	0.07	0.01	0.01			3	3			
Site_ID	**Monitoring_Zone**	**SampleCode**	**Field_ID**	**Location_Code**	**Sampled_Date_Time**	**Lab_Report_Number**											
147613051	9	EM1410438042	9/5003_20141006	9/5003	6/10/2014	EM1410438	<0.001	<0.001	<0.01	<0.01	<0.01	<0.01	0.035	0.005	8.76	1360	47
147613051	9	EM1413447002	9/5003_20141215	9/5003	15/12/2014	EM1413447	<0.001	<0.001	-	-	-	-	0.014	0.014	7.95	959	132
147613051	9	EM1500689002	9/5003_20150121	9/5003	21/01/2015	EM1500689	<0.001	<0.001	-	-	-	-	0.012	0.009	8.05	1150	184
147613051	9	EM1501799002	9/5003_20150218	9/5003	18/02/2015	EM1501799	<0.001	<0.001	-	-	-	-	0.011	0.01	8.08	1990	211
147613051	9	EM1502843002	9/5003_20150317	9/5003	17/03/2015	EM1502843	<0.001	<0.001	-	-	-	-	0.007	0.006	7.75	2420	222
147613051	9	EM1504064002	9/5003_200415	9/5003	20/04/2015	EM1504064	<0.001	<0.001	-	-	-	-	0.008	<0.005	8.71	2540	244
147613051	9	EM1510199002	9/5003_20150525	9/5003	25/05/2015	EM1510199	<0.001	<0.001	-	-	-	-	0.011	0.007	7.85	2190	243

Statistical Summary

	Nickel	Nickel (Filtered)	Selenium	Selenium (Filtered)	Vanadium	Vanadium (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)
Number of Results	7	7	1	1	1	1	7	7	7	7	7
Number of Detects	0	0	0	0	0	0	7	6	7	7	7
Minimum Concentration	<0.001	<0.001	<0.01	<0.01	<0.01	<0.01	0.007	<0.005	7.75	959	47
Minimum Detect	ND	ND	ND	ND	ND	ND	0.007	0.005	7.75	959	47
Maximum Concentration	<0.001	<0.001	<0.01	<0.01	<0.01	<0.01	0.035	0.014	8.76	2540	244
Maximum Detect	ND	ND	ND	ND	ND	ND	0.035	0.014	8.76	2540	244
Average Concentration	0.0005	0.0005					0.014	0.0076	8.2	1801	183
Median Concentration	0.0005	0.0005	0.005	0.005	0.005	0.005	0.011	0.007	8.05	1990	211
Standard Deviation	0	0					0.0096	0.0037	0.41	638	72
Number of Guideline Exceedances	0	0	0	0	0	0	0	0	2	7	0
Number of Guideline Exceedances(Detects Only)	0	0	0	0	0	0	0	0	2	7	0

Table D2.7: Sediment Analytical Results

					Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
					mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
LOR					5	5	1	5	50	5	5	0.1	2	5
Sample ID	**Property ID**	**Date**	**Matrix**	**SDG**										
2/4001_20140724	2	24/07/2014	Sediment	EM1407482	67	14	10	38	31,300	420	348	0.2	22	60,800
5/8001_20140814	5	14/08/2014	Sediment	EM1408258	71	21	1	117	41,600	68	-	-	73	48,100
6/4001_20140724	6	24/07/2014	Sediment	EM1407482	58	16	<1	58,900	42,000	1890	230	0.2	17	7080
7/4001_20140717	7	17/07/2014	Sediment	EM1407187	42	16	2	53	37,500	274	414	0.2	42	17,900
8/8001_20140822	8	22/08/2014	Sediment	EM1408598	59	29	<1	304	38,800	520	-	-	23	2480
9/8001_20140806	9	6/08/2014	Sediment	EM1407890	89	46	7	73	44,600	577	-	-	25	32,000
13/8001_20140814	13	14/08/2014	Sediment	EM1408258	15	22	12	93	39,900	467	-	-	29	70,200
14/8001_20140822	14	22/08/2014	Sediment	EM1408598	49	53	8	120	39,200	1030	-	-	26	87,400
15/8001_20140814	15	14/08/2014	Sediment	EM1408258	22	18	2	60	107,000	341	-	-	38	34,100
16/4001_20140718	16	18/07/2014	Sediment	EM1407187	75	34	8	317	23,000	334	584	0.3	22	52,100
18/8001_20140806	18	6/08/2014	Sediment	EM1407890	291	13	1	102	22,900	121	-	-	23	15,500
37/8001_20140801	37	1/08/2014	Sediment	EM1407675	339	<5	1	29	16,400	21	100	0.2	53	30,000
40/8001_20140801	40	1/08/2014	Sediment	EM1407675	22	9	<1	585	23,000	140	708	0.4	21	696
41/4002_20140725	41	25/07/2014	Sediment	EM1407482	112	14	15	107	49,800	645	196	0.2	24	16,200
42/4001_20140717	42	17/07/2014	Sediment	EM1407187	73	38	6	756	36,100	682	1100	0.4	42	2280
47/4001_20140725	47	25/07/2014	Sediment	EM1407482	65	6	<1	256	30,400	75	132	0.3	27	3100
51/4001_20140718	51	18/07/2014	Sediment	EM1407187	40	21	3	67	56,900	505	209	0.4	25	27,900

Statistical Summary

	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
Number of Results	17	17	17	17	17	17	10	10	17	17
Number of Detects	17	16	13	17	17	17	10	10	17	17
Minimum Concentration	15	<5	<1	29	16400	21	100	0.2	17	696
Minimum Detect	15	6	1	29	16400	21	100	0.2	17	696
Maximum Concentration	339	53	15	58900	107000	1890	1100	0.4	73	87400
Maximum Detect	339	53	15	58900	107000	1890	1100	0.4	73	87400
Average Concentration	88	22	4.6	3646	40024	477	402	0.28	31	29873
Median Concentration	65	18	2	107	38800	420	289	0.25	25	27900
Standard Deviation	89	14	4.6	14240	20182	450	315	0.092	14	26078
Number of Guideline Exceedances	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)	0	0	0	0	0	0	0	0	0	0

Table D2.8 - Water Analytical Results

			Lab Report Number	EM1500689	EM1501799	EM1502843	EM1504064	EM1510199	EM1510199	EM1500689	EM1501799	EM1502843	EM1502843	EM1504064	EM1501799	EM1502843
			Field ID	13/5602_20150121	9/5602_20150218	41/5602_20150317	41/5601_200415	26/5601_20150525	46/5501_20150525	26/5501_20150121	13/5502_20150218	13/5502_20150317	13/5501_20150317	13/5501_200415	37/5701_20150218	41/5701_20150317
			Sampled Date	21/01/2015 15:00	18/02/2015 15:00	17/03/2015 15:00	20/04/2015 15:00	25/05/2015 15:00	25/05/2015 15:00	21/01/2015 15:00	18/02/2015 15:00	17/03/2015 15:00	17/03/2015 15:00	20/04/2015 15:00	18/02/2015 15:00	17/03/2015 15:00
			Sample Type	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank	Rinsate	Rinsate	Rinsate	Rinsate	Rinsate	Trip Blank	Trip Blank
Chemical Group	**Chemical Name**	**Units**	**EQL**													
Heavy Metals	Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Antimony (Filtered)	mg/L	0.001	<0.001					<0.001		<0.001	<0.001	<0.001			
	Arsenic	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Arsenic (Filtered)	mg/L	0.001	<0.001					<0.001		<0.001	<0.001	<0.001			
	Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Cadmium (Filtered)	mg/L	0.0001	<0.0001					<0.0001		<0.0001	<0.0001	<0.0001			
	Copper	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Copper (Filtered)	mg/l	0.001	<0.001					<0.001		<0.001	<0.001	<0.001			
	Iron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Iron (Filtered)	mg/L	0.05	<0.05					<0.05		<0.05	<0.05	<0.05			
	Lead	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Lead (Filtered)	mg/l	0.001	<0.001					<0.001		<0.001	<0.001	<0.001			
	Manganese	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Manganese (Filtered)	mg/l	0.001	<0.001					<0.001		<0.001	<0.001	<0.001			
	Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Mercury (Filtered)	mg/l	0.0001	<0.0001					<0.0001		<0.0001	<0.0001	<0.0001			
	Nickel	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Nickel (Filtered)	mg/l	0.001	<0.001					<0.001		<0.001	<0.001	<0.001			
	Zinc	mg/L	0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Zinc (Filtered)	mg/L	0.001	<0.005					<0.005		<0.005	<0.005	<0.005			

Table D2.8 - Water Analytical Results

EM1504064 41/5701_200415 20/04/2015 15:00 Trip Blank
<0.001
<0.001
<0.0001
<0.001
<0.05
<0.001
<0.001
<0.0001
<0.001
<0.005

Table D2.9: QAQC – Analytical Results for Duplicate Samples collected January – May 2015

			Lab Report Number	EM1500689	EM1500689		EM1502843	EM1502843		EM1510199	EM1510199		EM1500689	Interlab_D		EM1502843	Interlab_D	
			Field ID	15/5003_20150121	15/5803_20150121	**RPD**	41/5001_20150317	41/5801_20150317	**RPD**	6/5001_20150525	6/5801_20150525	**RPD**	15/5003_20150121	15/5903_20150121	**RPD**	41/5001_20150317	41/5901_20150317	**RPD**
			Sampled Date	21/01/2015	21/01/2015		17/03/2015	17/03/2015		25/05/2015	25/05/2015		21/01/2015	21/01/2015		17/03/2015	17/03/2015	
Chemical Group	**Chemical Name**	**Units**	**EQL**															
Heavy Metals	Antimony	mg/l	0.001 : 0.005 (Interlab)	<0.001	<0.001	0	0.006	0.006	0	0.012	0.012	0	<0.001	<0.005	0	0.006	0.008	29
	Antimony (Filtered)	mg/l	0.001 : 0.005 (Interlab)	<0.001	<0.001	0	0.006	0.006	0	0.011	0.012	9	<0.001	<0.005	0	0.006	0.007	15
	Arsenic	mg/l	0.001	<0.001	<0.001	0	<0.001	<0.001	0	<0.001	<0.001	0	<0.001	<0.001	0	<0.001	0.001	0
	Arsenic (Filtered)	mg/l	0.001	<0.001	<0.001	0	<0.001	<0.001	0	<0.001	<0.001	0	<0.001	<0.001	0	<0.001	<0.001	0
	Cadmium	mg/l	0.0001 : 0.0002 (Interlab)	<0.0001	<0.0001	0	0.001	0.001	0	0.0001	<0.0001	0	<0.0001	<0.0002	0	0.001	0.0009	11
	Cadmium (Filtered)	mg/l	0.0001 : 0.0002 (Interlab)	0.0001	<0.0001	0	0.0007	0.0006	15	<0.0001	0.0001	0	0.0001	<0.0002	0	0.0007	0.0007	0
	Copper	mg/l	0.001	0.003	0.003	0	0.01	0.01	0	0.009	0.007	25	0.003	0.005	50	0.01	0.014	33
	Copper (Filtered)	mg/l	0.001	0.004	0.002	67	0.014	0.022	44	0.004	0.005	22	0.004	0.005	22	0.014	0.014	0
	Iron	mg/l	0.05	0.07	0.06	15	<0.05	<0.05	0	0.18	0.18	0	0.07	<0.05	33	<0.05	<0.05	0
	Iron (Filtered)	mg/l	0.05	<0.05	<0.05	0	<0.05	<0.05	0	0.13	0.12	8	<0.05	<0.05	0	<0.05	<0.05	0
	Lead	mg/l	0.001	0.001	0.001	0	0.002	0.002	0	0.013	0.012	8	0.001	0.002	67	0.002	0.002	0
	Lead (Filtered)	mg/l	0.001	0.001	<0.001	0	0.001	0.001	0	0.009	0.009	0	0.001	0.002	67	0.001	0.001	0
	Manganese	mg/l	0.001 : 0.005 (Interlab)	0.013	0.014	7	0.004	0.004	0	0.029	0.031	7	0.013	0.015	14	0.004	<0.005	0
	Manganese (Filtered)	mg/l	0.001 : 0.005 (Interlab)	0.012	0.013	8	0.005	0.003	50	0.029	0.029	0	0.012	0.015	22	0.005	<0.005	0
	Mercury	mg/l	0.0001	<0.0001	<0.0001	0	<0.0001	<0.0001	0	<0.0001	<0.0001	0	<0.0001	<0.0001	0	<0.0001	<0.0001	0
	Mercury (Filtered)	mg/l	0.0001	<0.0001	<0.0001	0	<0.0001	<0.0001	0	<0.0001	<0.0001	0	<0.0001	<0.0001	0	<0.0001	<0.0001	0
	Nickel	mg/l	0.001	<0.001	<0.001	0	0.003	0.003	0	<0.001	<0.001	0	<0.001	<0.001	0	0.003	0.005	50
	Nickel (Filtered)	mg/l	0.001	<0.001	<0.001	0	0.001	0.002	67	<0.001	<0.001	0	<0.001	<0.001	0	0.001	0.003	100
	Zinc	mg/l	0.005 : 0.001 (Interlab)	4.73	4.7	1	0.774	0.728	6	3.03	3.15	4	4.73	5	6	0.774	0.88	13
	Zinc (Filtered)	mg/l	0.005 : 0.001 (Interlab)	4.42	4.77	8	0.539	0.512	5	3.02	3.05	1	4.42	5	12	0.539	0.6	11

*RPDs have only been considered where a concentration is greater than 5 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (5-10 x EQL); 50 (10-30 x EQL); 50 (> 30 x EQL))

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the row header relate to those used in the primary laboratory

Table D2.9: QAQC – Analytical Results for Duplicate Samples collected January – May 2015

			Lab Report Number	EM1510199	Interlab_D	
			Field ID	6/5001_20150525	6/5901_20150525	**RPD**
			Sampled Date	25/05/2015	25/05/2015	
Chemical Group	**Chemical Name**	**Units**	**EQL**			
Heavy Metals	Antimony	mg/l	0.001 : 0.005 (Interlab)	0.012	0.012	0
	Antimony (Filtered)	mg/l	0.001 : 0.005 (Interlab)	0.011	0.01	10
	Arsenic	mg/l	0.001	<0.001	<0.001	0
	Arsenic (Filtered)	mg/l	0.001	<0.001	<0.001	0
	Cadmium	mg/l	0.0001 : 0.0002 (Interlab)	0.0001	<0.0002	0
	Cadmium (Filtered)	mg/l	0.0001 : 0.0002 (Interlab)	<0.0001	<0.0002	0
	Copper	mg/l	0.001	0.009	0.006	40
	Copper (Filtered)	mg/l	0.001	0.004	0.006	40
	Iron	mg/l	0.05	0.18	0.18	0
	Iron (Filtered)	mg/l	0.05	0.13	0.18	32
	Lead	mg/l	0.001	0.013	0.011	17
	Lead (Filtered)	mg/l	0.001	0.009	0.011	20
	Manganese	mg/l	0.001 : 0.005 (Interlab)	0.029	0.035	19
	Manganese (Filtered)	mg/l	0.001 : 0.005 (Interlab)	0.029	0.035	19
	Mercury	mg/l	0.0001	<0.0001	<0.0001	0
	Mercury (Filtered)	mg/l	0.0001	<0.0001	<0.0001	0
	Nickel	mg/l	0.001	<0.001	<0.001	0
	Nickel (Filtered)	mg/l	0.001	<0.001	<0.001	0
	Zinc	mg/l	0.005 : 0.001 (Interlab)	3.03	3.4	12
	Zinc (Filtered)	mg/l	0.005 : 0.001 (Interlab)	3.02	3.2	6

*RPDs have only been considered where a concentration is greater than 5 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (5-10 x EQ

***Interlab Duplicates are matched on a per compound basis as methods vary between labo

1.0 INTRODUCTION

This Appendix D3 presents a summary of the air quality monitoring program conducted by Golder Associates (Golder) in the vicinity of Mandalay Resources gold-antimony operation at Costerfield.

The air quality data will be used in the health risk assessment (HRA) exposure assessment (Appendix E), to calculate the estimated daily intakes of selected chemicals from ambient air. This Appendix describes the following:

- summary of the sampling approach and methodology
- summary of the results and statistical analysis of the data, including consideration of metrological parameters and the location of the monitoring station with respect to the mining operations
- establishment of the ‘average’ and ‘upper estimate’ ambient air concentrations of COPC for input into the HRA exposure model.

2.0 AIR MONITORING PROGRAM

Golder undertook air quality monitoring at two locations in the vicinity of Mandalay Resources gold-antimony operation at Costerfield, Victoria.

The scheduled monitoring programme was conducted for the period October 2014 to September 2015. The scope is summarised in Table 1.

Table 1: Monitoring Programme Scope

Atmospheric Contaminant	Sample Duration	Sample Frequency Details	
		Oct 2014, Jul 2015 – Aug 2015	Nov 2014 – Jun 2015
PM_{10} [A]	24 hours	One every six days	One every three days
Particulate metal, measured in the PM_{10} fraction [B]	24 hours	One every six days	One every three days
$PM_{2.5}$ [C]	24 hours	One every six days	One every three days
$PM_{2.5}$ (Respirable) Crystalline Silica (RCS)	24 hours	One every month	One every month
Indicative PM_{10} [D]	Continuous	Continuous	Continuous

Notes

A Particulate matter with an equivalent aerodynamic diameter (EAD) less than 10 microns (PM_{10}).
B Mercury, arsenic, cadmium, copper, manganese, nickel, lead, antimony, zinc, iron.
C Particulate matter with an EAD less than 2.5 microns ($PM_{2.5}$).
D Instrument operated and data reported by Mandalay Resources.

The laboratory reports have issued in accordance with Golder’s National Association of Testing Authorities (NATA) laboratory accreditation, 1910. The results of the tests included in this document are traceable to Australian/national standards. Golder is accredited for compliance with ISO/IEC 17025.

3.0 METHODOLOGY

3.1 Test Methods

3.1.1 PM_{10}

Ambient air was drawn at a constant flowrate through a size selective inlet and pre-weighed quartz filter using a High Volume Sampler (HVS). PM_{10} is separated from suspended matter by the size selective inlet and collected on the filter media.

Filter samples were allowed to equilibrate in a temperature and humidity controlled environment before gravimetric analysis.

The weight change of the quartz filter was determined using a Mettler Toledo four figure balance. Control filters were used to check for changes in environmental conditions between weight determinations.

The Mettler Toledo balance was calibrated to comply with NATA specifications (NATA Calibration Report Nos. BE158143, 26 May 2014 and 42143AL3, 19 May 2015).

The method used was in accordance with Golder Test Method *H3: High Volume Sampler (HVS) Operation TSP, PM_{10} and $PM_{2.5}$ Determination – In Ambient Air,* based on Australian Standard AS/NZS 3580.9.6 *Methods for Sampling and Analysis of Ambient Air. Method 9.6: Determination of Suspended Particulate Matter – PM_{10} High Volume Sampler with Size Selective Inlet – Gravimetric Method.*

3.1.2 Particulate Metals (PM_{10} Fraction)

Following gravimetric analysis filter samples were analysed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) to determine the metals content. Sample analysis was conducted by ALS Sydney, NATA Accreditation No. 825.

3.1.3 $PM_{2.5}$

Ambient air was drawn at a constant flowrate through a size selective inlet and pre-weighed filter using a Partisol low volume sampler (LVS). $PM_{2.5}$ is separated from suspended matter by the size selective inlet and collected on the filter media.

Filter samples were allowed to equilibrate in a temperature and humidity controlled environment before gravimetric analysis.

The weight change of the filter was determined using a Mettler Toledo six figure balance. Control filters were used to check for changes in environmental conditions between weight determinations.

The Mettler Toledo balance was calibrated to comply with NATA specifications (NATA Calibration Report Nos. BE158143, 26 May 2014 and 42143AL3, 19 May 2015.

The method used was in accordance with Golder Test Method *L2: Low Volume Sampler (LVS) Operation TSP, PM_{10} and PM_1 Determination – In Ambient Air*, based on Australian Standard AS/NZS 3580.9.7 *Methods for Sampling and Analysis of Ambient Air - Dichotomous sampler (PM_{10}, coarse PM and $PM_{2.5}$) - Gravimetric method.*

3.1.4 RCS (as $PM_{2.5}$)

$PM_{2.5}$ samples were selected for crystalline silica analysis by x-ray diffraction on a monthly basis giving preference to those which were collected under predominantly south to south-easterly wind conditions and report highest mass concentrations. Crystalline silica sample analysis was conducted by AEC Environmental, NATA Accreditation No. 17053.

3.1.5 Indicative PM_{10}

Indicative PM_{10} monitoring was conducted using a continuous laser light scattering instrument co-located with the HVSs. The measurement technique is not an Australian Standard method, however the indicative results provide a measure of PM_{10} trends and variation during collection of the discrete HVS filter samples.

NATA accreditation does not cover indicative instruments.

The instruments were operated by Mandalay Resources who were also responsible for calibration and maintenance.

3.2 Measurement Uncertainty

A comment regarding the uncertainty of each of the test is present in Table 2.

Table 2: Summary of Measurement Uncertainty

Test	Uncertainty Comment
PM_{10}	AS3580.9.6 estimates the method precision as typically 5 µg/m^3 over the measurement range.
Particulate Metals (PM_{10} Fraction)	The analytical laboratory has not reported a measurement uncertainty for metals determination from HVS filters.
$PM_{2.5}$	The estimated measurement uncertainty for $PM_{2.5}$ by LVS is ± 5 µg/m^3 over the measurement range.
Deposited Dust (Insoluble Solids)	The estimated measurement uncertainty for deposited dust (insoluble solids) is ± 0.3 g/m^2/month, at a 95% confidence interval, calculated using a coverage factor of 1.96.
Deposited Dust (Particulate Metals)	The analytical laboratory has not reported a measurement uncertainty for metals determination from dust deposit gauge samples.

3.3 Monitoring Locations

Two monitoring locations were established in paddocks in the vicinity of the Mandalay Resources' Brunswick Processing Plant, one at *Residence 1* adjacent to Heathcote-North Costerfield Road and one at the *Residence 2* adjacent to Philips Lane. Monitoring location details are presented in Table 3. Location Residence 1 was considered representative of the Costerfield township while location Residence 2 is located within Mandalay Resources's mining lease and might be expected to be impacted to some degree by current mining activities (mining, trucking, processing). Monitoring locations are illustrated in Table 3.

Table 3: Monitoring Location Details

Element	Residence 1	Residence 2
Monitoring	■ PM_{10} ■ PM_{10} metals ■ $PM_{2.5}$ ■ $PM_{2.5}$ (Respirable) Crystalline Silica ■ Indicative PM_{10}	■ PM_{10} ■ PM_{10} metals ■ Indicative PM_{10}
Classification of Air Monitoring Site	Neighbourhood	Neighbourhood
UTM Co-ordinates (m) (Zone 55)	302940 E, 5916 610 S	303870 E, 5914500 S
Approx. Elevation (m)	200	180
Description	The monitoring location is located in a grassed paddock, approximately 20 m from the nearest building.	The monitoring location is located in a grassed paddock, approximately 20 m from the nearest building.
Distance and direction from Mandalay Resources (Brunswick Plant)	Approximately 1.3 km north	Approximately 1 km southeast
Extraneous sources	Approximately 110 m from an unsealed road	Approximately 90 m from an unsealed road

The monitoring location was selected with consideration of the requirements of Australian Standard AS/NZS 3580.1.1 Methods for Sampling and Analysis of Ambient Air. Part 1.1: Guide to Siting Air Monitoring Equipment. An assessment of the Residence 1 residence and Residence 2 residence monitoring location compliance with the Standard requirements is presented in Table 4.

Table 4: Monitoring Location Compliance Assessment

AS/NZS 3580.1.1 Requirement (Neighbourhood and Background Monitoring Stations)	**Residence 1**	**Residence 2**
	PM$_{10}$, PM$_{10}$ Metals and PM$_{2.5}$	**PM$_{10}$, PM$_{10}$ Metals**
Height above ground to sampling inlet 1.0 – 1.5 m	OK	OK
Clear sky angle 120°	OK	OK
Unrestricted airflow of 270°	OK	OK
10 m from the nearest object or dripline of trees that are higher than 2 m below the height of the sample inlet.	OK	OK
No extraneous sources nearby	OK	OK
Greater than 50 m from road	OK	OK

3.4 Assessment Criteria

The State Environment Protection Policy (Air Quality Management) (SEPP (AQM)) is relevant to an assessment of air quality impacts associated with new or expanded sources of emissions such as industrial premises. The objective of the SEPP (AQM) is to manage emissions to the air environment such that beneficial uses are protected.

The Mining and Extractive Industries Protocol for Environmental Management (Mining PEM) is an incorporated document of the SEPP (AQM). It supports the interpretation of SEPP (AQM) and sets out the statutory requirements for the management of emissions to the air environment arising from activities undertaken in the operation of mining and extractive sites.

The National Environment Protection (Ambient Air Quality) Measure (NEPM (AAQ)) sets out standards and goals to be met with the desired environmental outcome being ambient air quality that allows for the adequate protection of human health and well-being and provides more conservative PM$_{10}$ and PM$_{2.5}$ levels to be met than the SEPP (AQM) or the Mining PEM. The ambient air quality criteria adopted for the current assessment is provided in Table 5.

Table 5: Ambient Air Quality Criteria (µg/m^3)

Contaminant	**Averaging Period**	**SEPP (AQM)**	**Mining PEM**	**NEPM (AAQ)**	**Adopted for Assessment**
PM$_{10}$	24 h	60	60	50	50
Antimony (as PM$_{10}$)	24 h	-[A]	-[A]	-[A]	1[B]
PM$_{2.5}$	24 h	36	36	25	25
	Annual	-[A]	-[A]	8	8
RCS (as PM$_{2.5}$)	Annual	-[A]	3	-[A]	3

Notes

A Not provided.

B Human health risk screening level derived by Golder (refer Appendix F).

4.0 RESULTS AND DISCUSSION

Full results are included in '*Costerfield Ambient Air Monitoring Study*' (Golder 2016b). The sections below provide a summary of the results and an analysis of the results with respect to wind direction, wind speed and precipitation. It also provides a summary of the inputs used for modelling in the HRA.

For the purposes of this assessment, the wind direction has been divided into two categories: '*from the direction of current mining activities*' and '*not from the direction of current mining activities*'. These directions differ for the two monitoring locations, as described in Table 6.

Table 6: Monitoring Location Wind Directions

Location	From the Direction of Current Mining Activities	Not From the Direction of Current Mining Activities
Residence 1	135° - 190°	0° - 134°; 191° - 359°
Residence 2	310° – 359°; 0° - 160°	161° - 309°

4.1 PM$_{10}$ and PM$_{10}$ Metals

4.1.1 Residence 1

Of the 95 samples taken between October 2014 and September 2015 at Residence 1, there was one exceedance of the PM$_{10}$ NEPM (AAQ) Standard (Figure 1) on 26 May 2015. On this day, the local wind conditions were reported to be predominantly not from the direction of current mining activities (north).

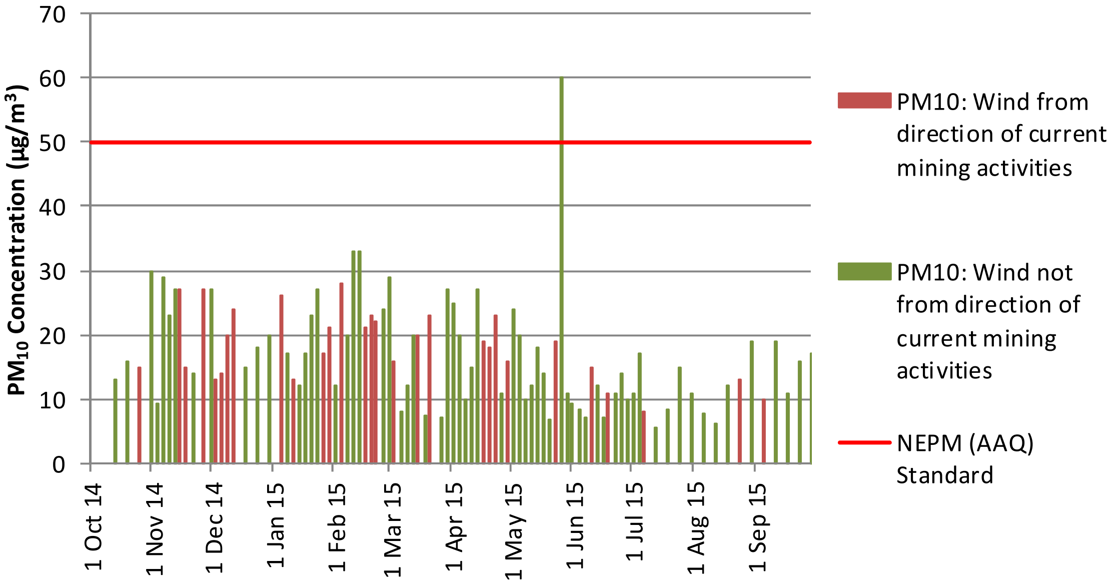


Figure 1: Residence 1 24hr Average PM$_{10}$ by Wind Direction.

Of the days when sampling occurred, winds were from the direction of current mining activities 31% of the time. The data indicates that the PM$_{10}$ concentrations reported on these days were similar in magnitude when compared to concentrations on those days when the wind was not from the direction of current mining activities (Table 7).

Table 7: Residence 1 PM_{10} by Wind Direction

	Overall	Wind from the Direction of Current Mining Activities	Wind not from the Direction of Current Mining Activities
Samples	95	29	66
	100%	31%	69%
Average (µg/m^3)	17.3	18.5	16.8
Maximum (µg/m^3)	60	28	60
Minimum (µg/m^3)	5.5	8.0	5.5

The seasonal averages PM_{10} concentrations presented in Figure 2 indicate that the highest PM_{10} concentrations were reported during summer and lowest in winter, regardless of wind direction.

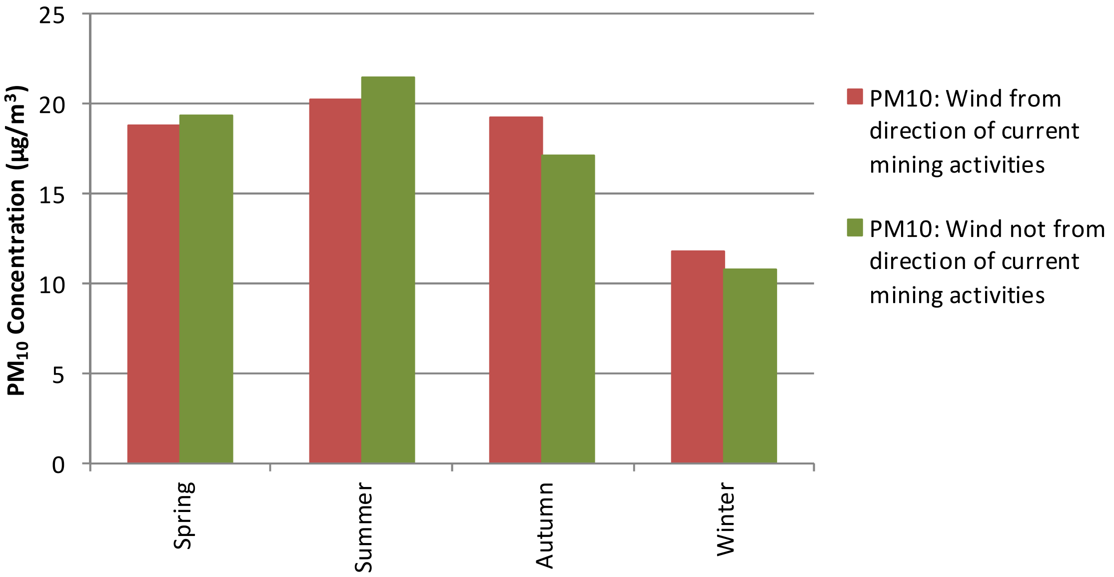


Figure 2: Residence 1 24hr Average PM_{10} by Wind Direction: Seasonal Averages

Comparing the data with the daily average meteorological conditions (Figure 3 and Figure 4), the PM_{10} concentrations were not significantly influenced by wind speeds , though the average concentration on days when precipitation occurred was lower at 14.9 µg/m^3 compared with 17.8 µg/m^3 on days when precipitation did not occur.

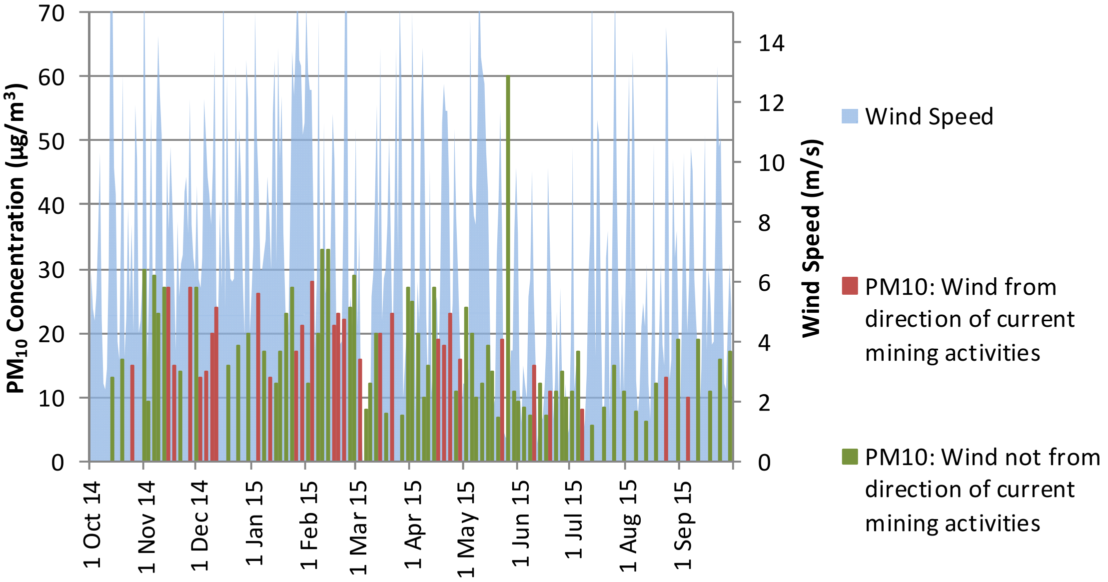


Figure 3: Residence 1 Wind-Speed and 24hr Average PM_{10} by Wind Direction.

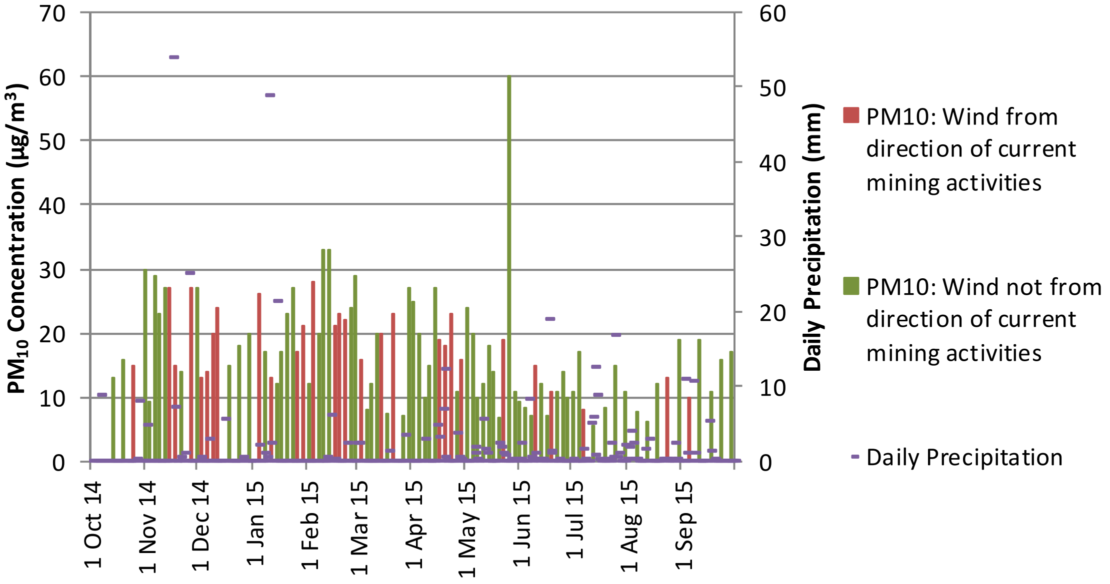


Figure 4: Residence 1 Precipitation and 24hr Average PM_{10} by Wind Direction.

PM_{10} metals concentration statistics for the monitoring campaign are summarised in Table 8.

Table 8: Residence 1 PM_{10} and PM_{10} Metals 24 hr Average Concentrations

Statistic	Concentration (µg/m^{3})^{A}										
	PM_{10}^{B}	Mercury^{c}	Arsenic^{c}	Cadmium^{c}	Copper^{c}	Manganese^{c}	Nickel^{c}	Lead^{c}	Antimony^{c}	Zinc^{c}	Iron^{c}
Maximum	60	<0.0003	0.0014	<0.0003	0.0030	0.025	0.0033	0.011	0.072	0.079	0.70
95th Percentile	29	0.00040	0.00079	0.00040	0.0021	0.012	0.0011	0.0032	0.030	0.014	0.47
Annual Average	17	<0.0004	0.000064	<0.0004	0.00061	0.0044	0.00044	0.0011	0.0087	0.0045	0.19
Minimum	5.5	<0.0006	<0.0006	<0.0006	<0.002	<0.002	<0.0005	<0.0004	<0.02	<0.009	<0.02

Notes

	Statistic calculations include results reported as below limit of reporting (LOR).
A	Concentration corrected to 0°C and 101.3 kPa.
B	Sample analysis conducted by Golder, NATA Accreditation Number 1910.
C	Sample analysis conducted by ALS Sydney, NATA Accreditation Number 825.

PM_{10} antimony concentrations (Figure 5) range from 0.000087 µg/m^{3} to 0.072 µg/m^{3}, well below the 24 hr health based screening criterion of 1 µg/m^{3} (Figure 6). Of the five highest reported 24 hour concentrations, two (including the highest concentration) occurred during days when the wind was from the direction of current mining activities.

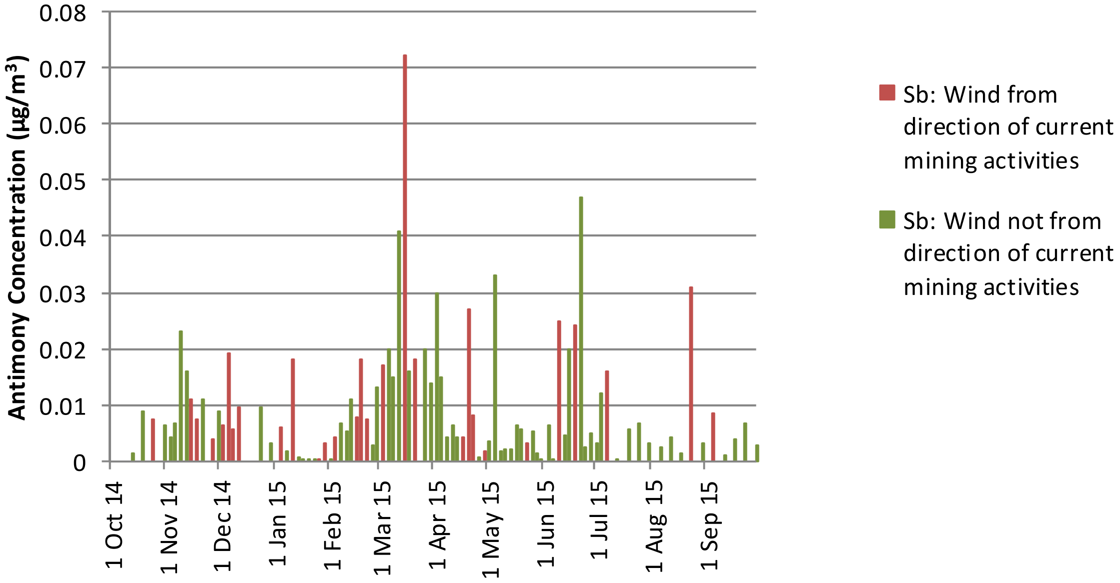


Figure 5: Residence 1 24hr Average PM_{10} Sb by Wind Direction.

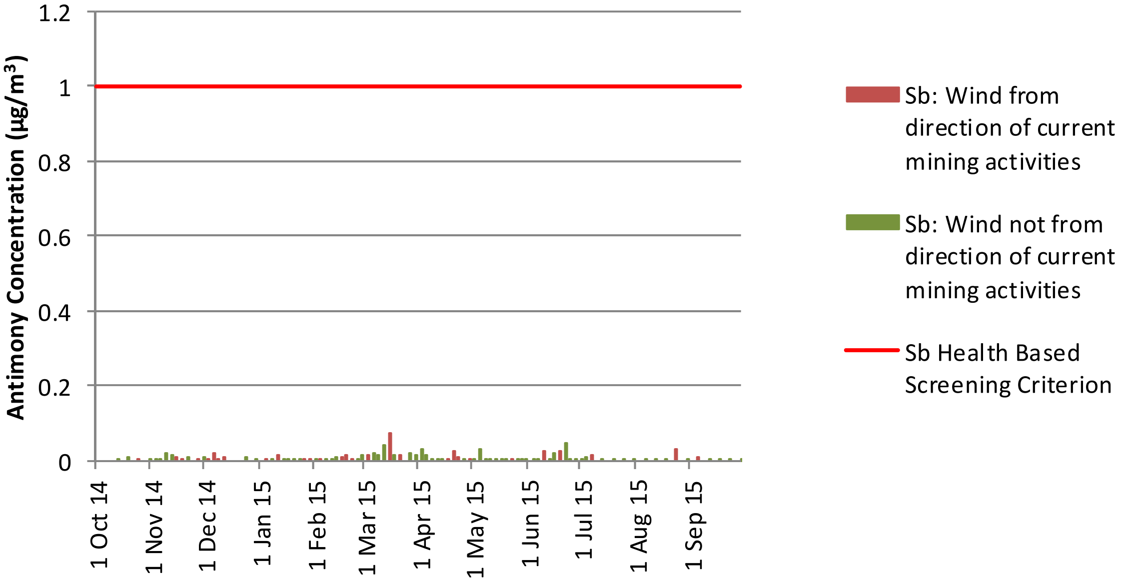


Figure 6: Residence 1 24hr Average PM₁₀ Sb by Wind Direction with Criterion.

Comparing the data with the daily average meteorological conditions (Figure 7 and Figure 8), the PM_{10} antimony concentrations were not significantly influenced by wind speeds or precipitation. The average antimony concentration on days when there was no precipitation was 0.0094 µg/m^3 compared with the 0.010 µg/m^3 on days when precipitation did occur. Unlike PM_{10}, however, the PM_{10} antimony concentrations were near or at the limit of reporting for the days following the significant rain event on 8 January 2015.

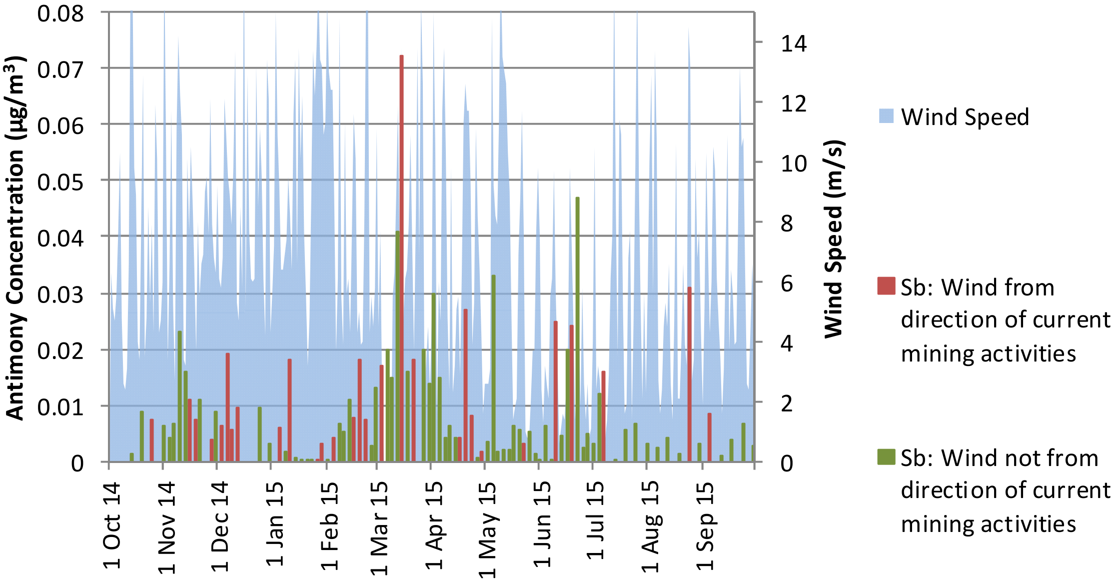


Figure 7: Residence 1 Wind-Speed and 24hr Average PM_{10} Sb by Wind Direction.

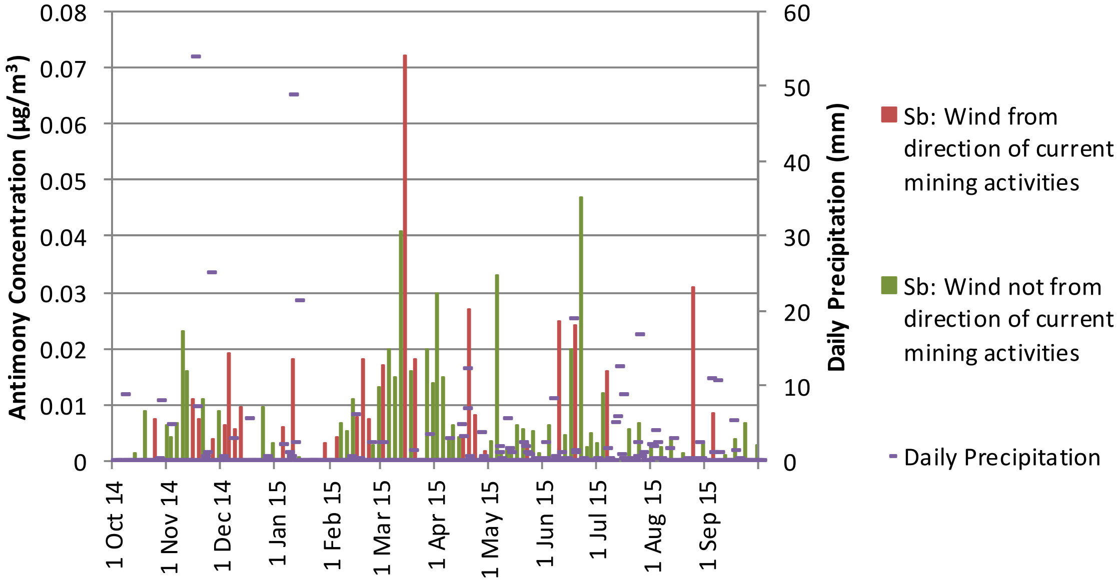


Figure 8: Residence 1 Precipitation and 24hr Average PM_{10} Sb by Wind Direction.

4.1.2 Residence 2

Of the 97 samples taken between October 2014 and September 2015 at Residence 2, there was one exceedance of the PM_{10} NEPM (AAQ) Standard (Figure 9) on 7 February 2015. On this day, wind conditions were reported to be predominantly from the direction of current mining activities.

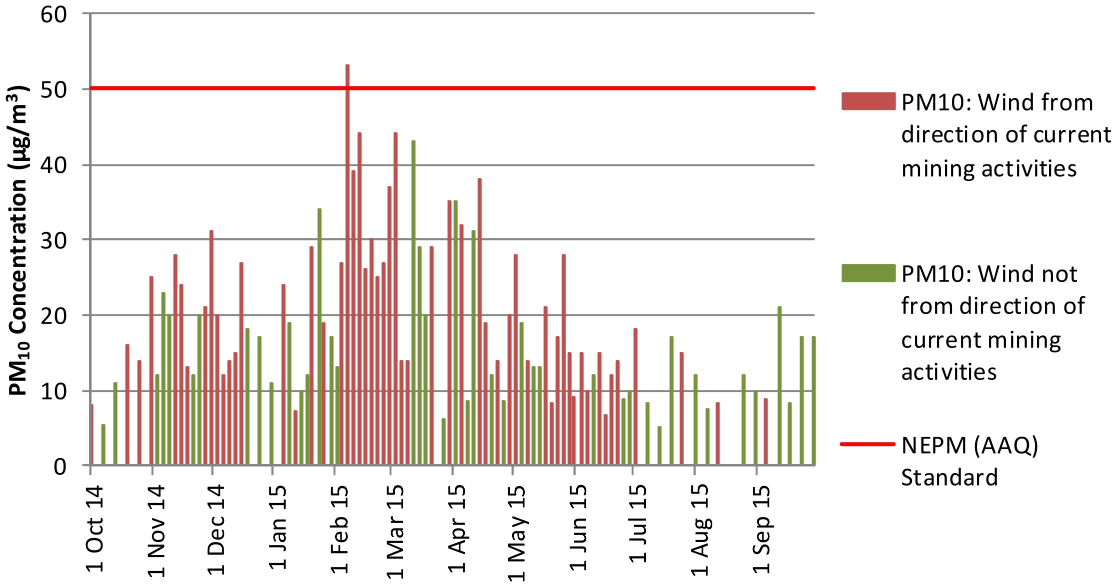


Figure 9: Residence 2 24hr Average PM_{10} by Wind Direction.

Of the days when sampling occurred, winds were from the direction of current mining activities 57% of the time. The data indicates that the PM_{10} concentrations reported on these days were in general greater than concentrations reported on days when the wind was not from the direction of mining activities (Table 9).

Table 9: Residence 2 PM_{10} by Wind Direction

	Overall	Wind from the Direction of Current Mining Activities	Wind not from the Direction of Current Mining Activities
Samples	97	55	42
	100%	57%	43%
Average (µg/m^3)	18.9	21.4	15.7
Max (µg/m^3)	53	53	43
Min (µg/m^3)	5.2	6.8	5.2

Figure 10 indicates that the highest PM_{10} concentrations were reported during summer and autumn.

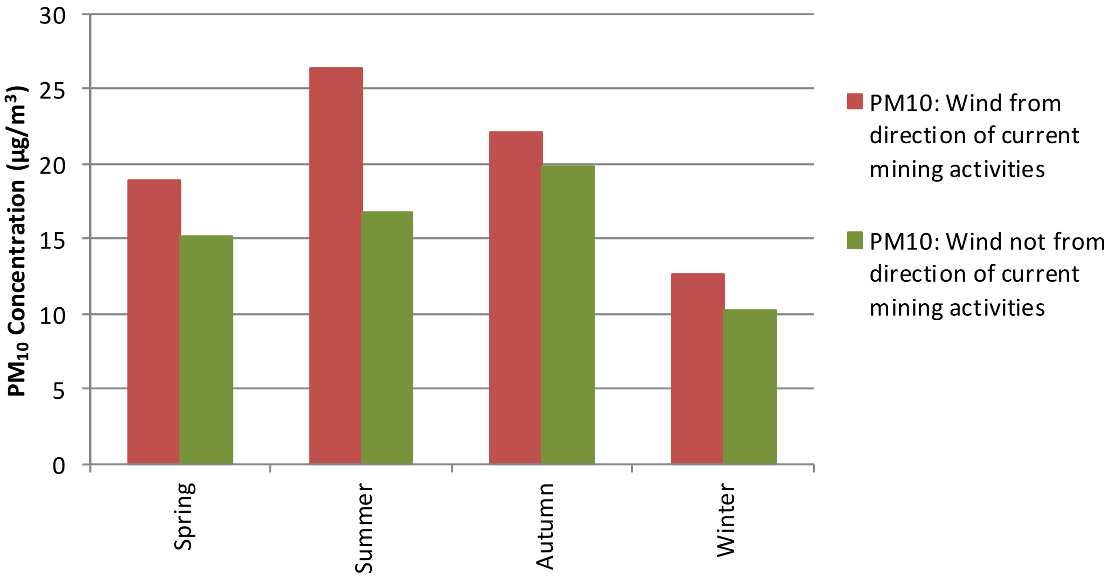


Figure 10: Residence 2 24hr Average PM_{10} by Wind Direction: Seasonal Averages

Comparing the data with the daily average meteorological conditions (Figure 11 and Figure 12), just as for Residence 1, the PM_{10} concentrations were not significantly influenced by wind speeds though the average concentration on days when there was precipitation was lower at 17.4 µg/m^3 compared with 19.1 µg/m^3 on days when precipitation did not occur...

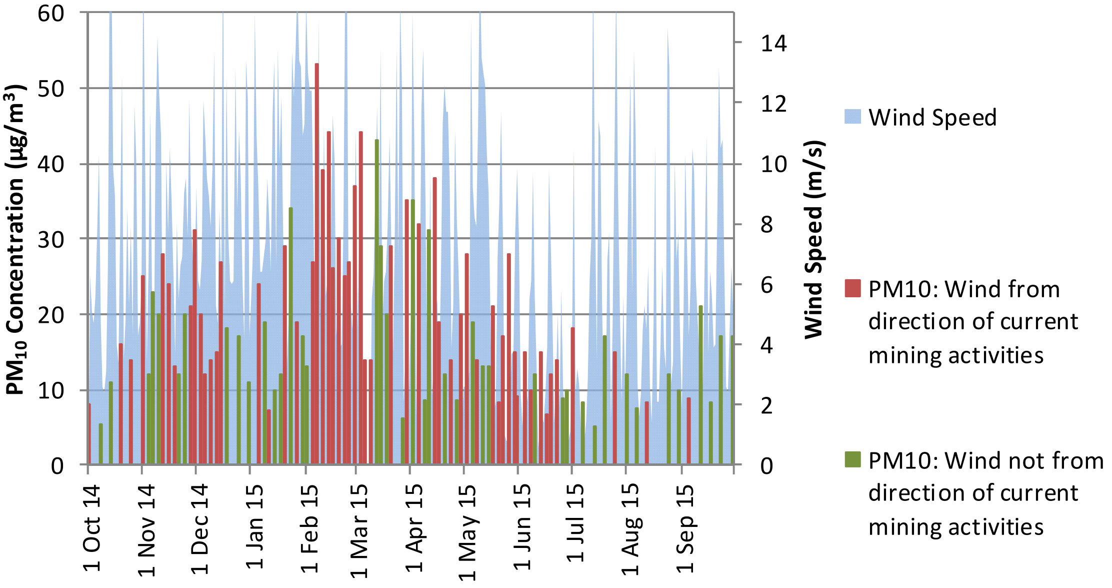


Figure 11: Residence 2 Wind-Speed and 24hr Average PM$_{10}$ by Wind Direction

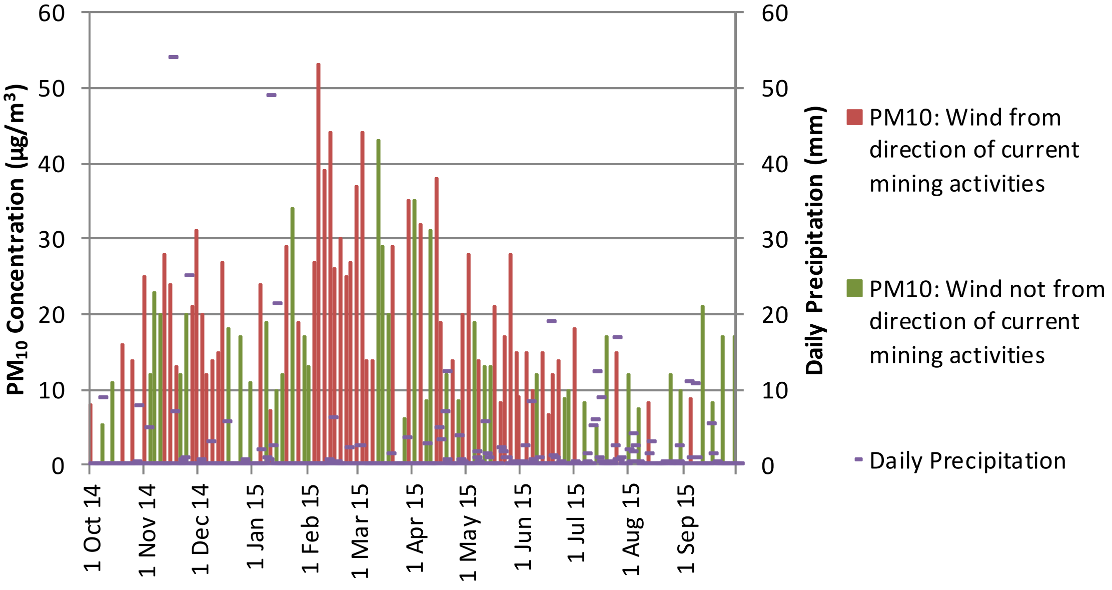


Figure 12: Residence 2 Precipitation and 24hr Average PM$_{10}$ by Wind Direction

PM$_{10}$ metals concentration statistics for the monitoring campaign are summarised in Table 10

Table 10: Residence 2 PM_{10} and PM_{10} Metals 24 hr Average

Statistic	Concentration (µg/m^{3})^{A}										
	PM_{10}^{B}	Mercury^{c}	Arsenic^{c}	Cadmium^{c}	Copper^{c}	Manganese^{c}	Nickel^{c}	Lead^{c}	Antimony^{c}	Zinc^{c}	Iron^{c}
Maximum	53	0.00034	0.0015	<0.0003	0.0032	0.031	0.0018	0.011	0.077	0.021	1.1
95th Percentile	39	0.00040	0.00095	0.00040	0.0023	0.022	0.0014	0.0035	0.049	0.014	0.76
Annual Average	19	<0.0004	0.00023	<0.0004	0.00087	0.0059	0.00048	0.0014	0.014	0.0043	0.22
Minimum	5.2	<0.0005	<0.0005	<0.0005	<0.002	<0.0004	<0.0006	<0.0006	<0.02	<0.01	<0.04

Notes

Statistics calculations include results reported as below limit of reporting (LOR).
A Concentration corrected to 0°C and 101.3 kPa.
B Sample analysis conducted by Golder, NATA Accreditation Number 1910.
C Sample analysis conducted by ALS Sydney, NATA Accreditation Number 825.

Of the five highest reported 24 hour average PM_{10} antimony concentrations, four (including the highest concentration) occurred during days when the wind was from the direction of current mining activities. However, PM_{10} antimony concentrations (Figure 13) are generally low, well below the 24 hr health based assessment criterion of 1 µg/m^{3} (Figure 14).

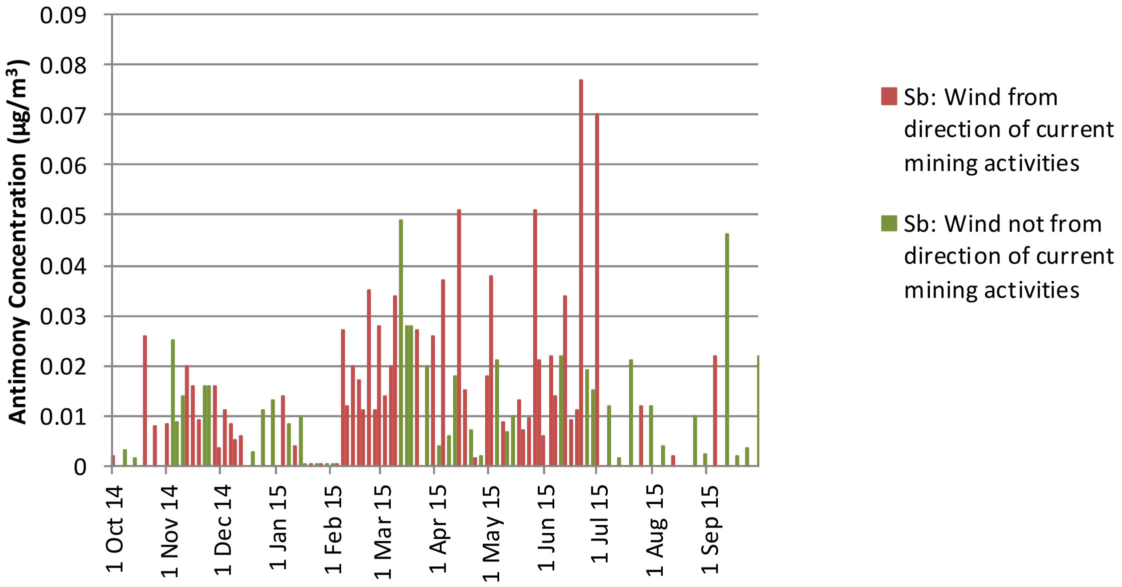


Figure 13: Residence 2 24hr Average PM_{10} Sb by Wind Direction.

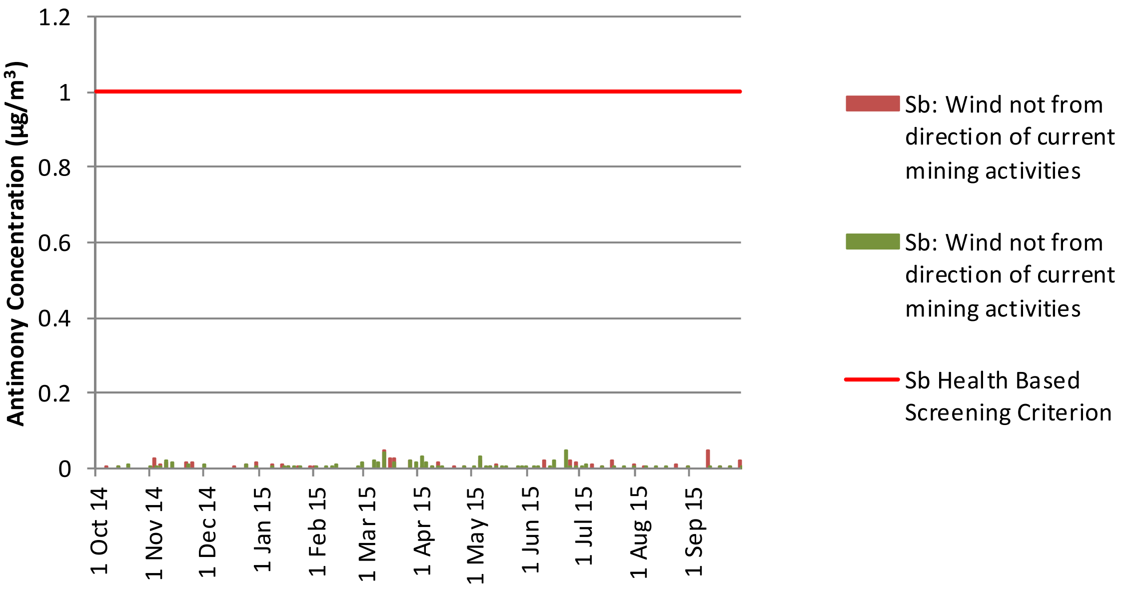


Figure 14: Residence 2 24hr Average PM$_{10}$ Sb by Wind Direction with Criterion.

As with the Residence 1 data, comparing the data with the daily average meteorological conditions (Figure 15 and Figure 16), the PM$_{10}$ antimony concentrations were not significantly influenced by wind speeds or precipitation. The average antimony concentration on days when there was no precipitation was 0.015 µg/m^3 compared with the 0.019 µg/m^3 on days when precipitation did occur.

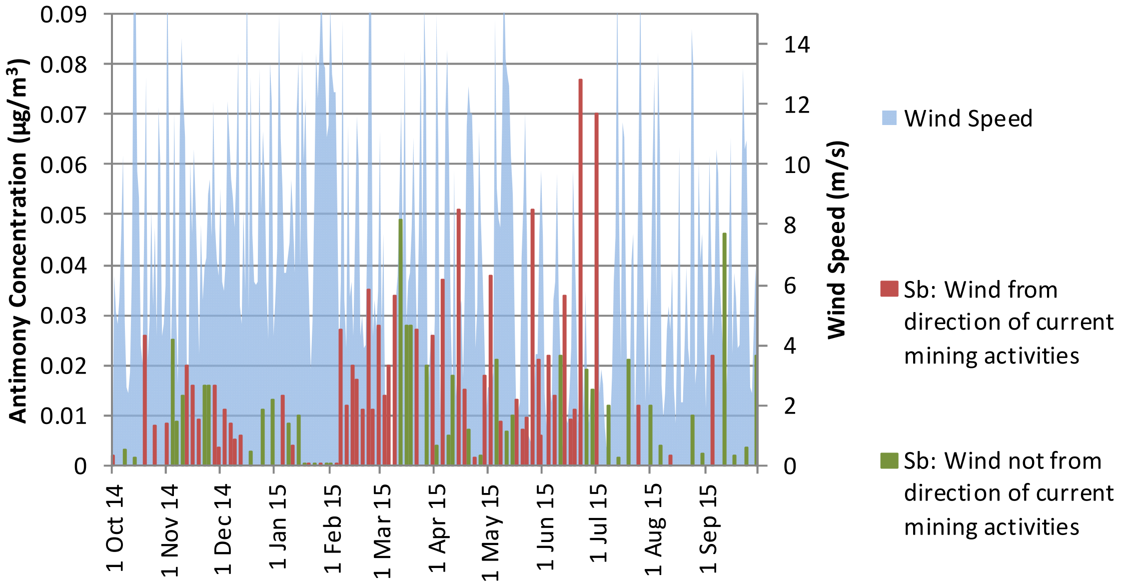


Figure 15: Residence 2 Wind-Speed and 24hr Average PM$_{10}$ Sb by Wind Direction.

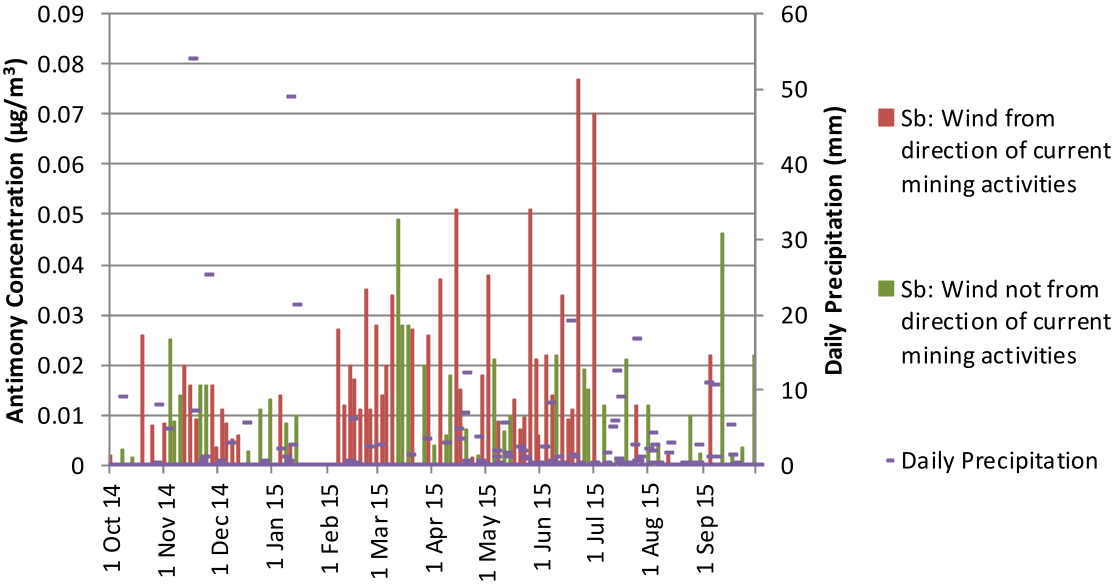


Figure 16: Residence 2 Precipitation and 24hr Average PM10 Sb by Wind Direction.

4.1.3 Comparison of Residence 1 and Residence 2

4.1.3.1 Overall

Over half of the monitoring at Residence 2, and less than a third of that at Residence 1, occurred during days when the wind was blowing from the direction of current mining activities towards those residences. Coupled with the greater distance between the mining activities and Residence 1, Residence 2 is more likely to be impacted to some degree by dust generated from mine activities than Residence 1.

During days when the winds were not from the direction of current mining activities, the average concentrations were comparable at Residence 1 and Residence 2 (16.8 µg/m^3 and 15.7 µg/m^3, respectively). During days when the monitoring locations have experienced wind conditions from the direction of current mining activities, the average PM$_{10}$ 24 hour average concentration was approximately 15% greater for Residence 2 (21.4 µg/m^3) than for Residence 1 (18.5 µg/m^3). The monitoring data from Residence 2 suggests that, as expected, this location is impacted by mining activities more than Residence 1.

A similar outcome is found when comparing the PM$_{10}$ antimony concentration data. The average 24 hour average concentration was approximately 30% greater for Residence 2 (0.018 µg/m^3), when compared with Residence 1 (0.014 µg/m^3).

Only one exceedence of the NEPM (AAQ) PM$_{10}$ Standard was recorded at each location, only Residence 2 recorded this during wind conditions blowing from mining activities.

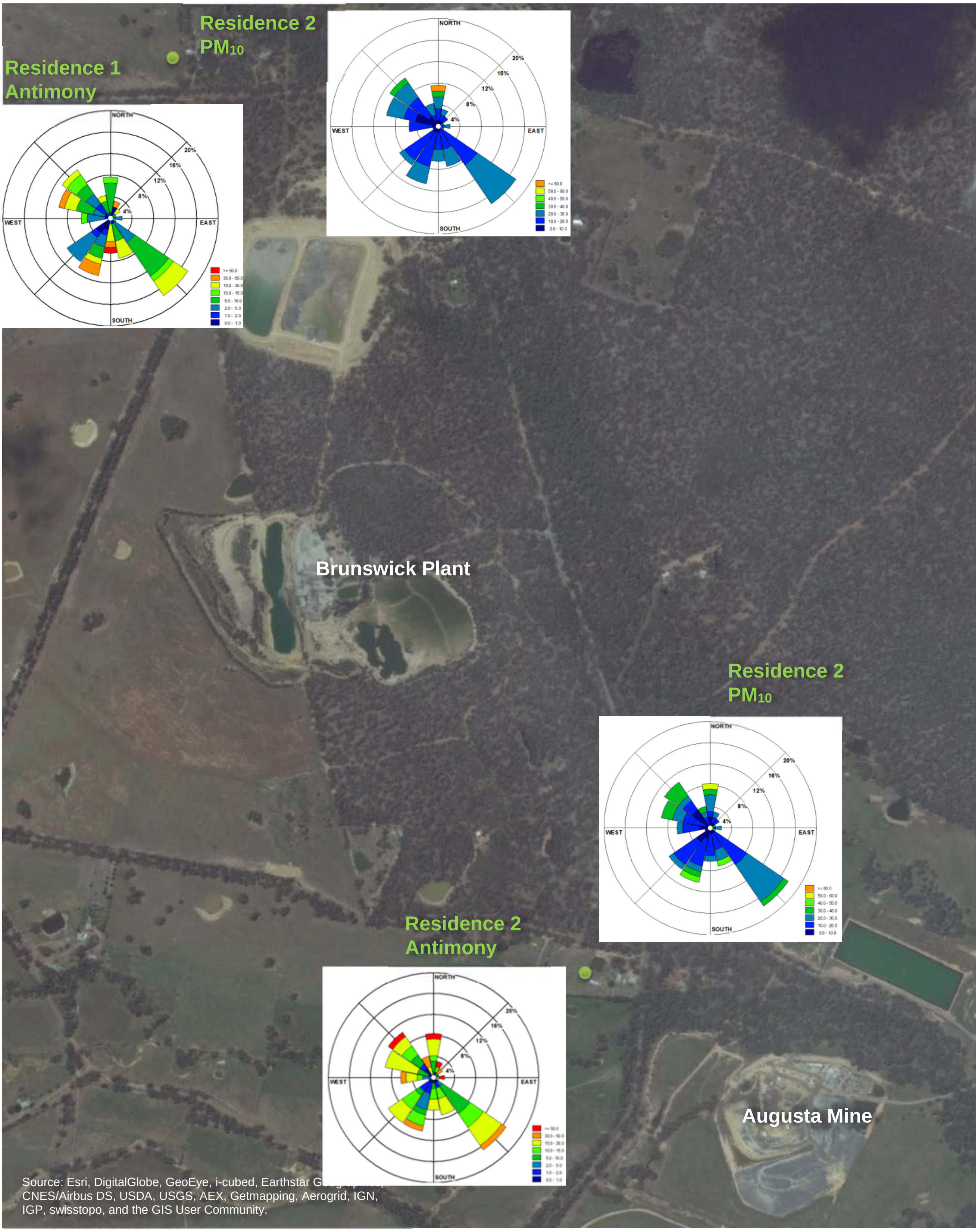
Figure 17 presents wind rose plots indicating PM$_{10}$ and PM$_{10}$ antimony concentrations with wind direction. The size of the wind rose ‘petals’ indicates the frequency of the winds from that direction. The wind roses suggest that the least common wind directions are from the north-east and east. The colour scaling of the petals indicates the frequency of the PM$_{10}$ and PM$_{10}$ antimony concentrations recorded during the given wind direction. The following is noted:

- The highest PM$_{10}$ concentrations monitored at Residence 1 were during winds blowing from the north and northwest, unlikely to be as a result of the mining activities which were to the south and southeast of Residence 1.
- The highest PM$_{10}$ concentrations monitored at Residence 2 were also during winds blowing from the north, however in this case, this was potentially due to the mining activities to the north of Residence 2.

There were high concentrations which were unlikely to be due to mining activities experienced on days when the wind was blowing from the south-southeast.

- The highest antimony concentrations monitored at Residence 1 were during winds blowing from the south, however, there were high concentrations monitored during winds from the north-northeast and west-north-west suggesting impacts from sources unrelated to the current mining activities.
- The highest antimony concentrations monitored at Residence 2 were during winds from the north and northwest, potentially due to the mining activities to the north of Residence 2., There were high concentrations which were unlikely to be due to mining activities experienced on days when the wind was blowing from the west and southwest..

In summary, the wind roses indicates that elevated PM_{10} and PM_{10} antimony concentrations were measured on days when winds were blowing from the direction of current mining activities, and also when it was blowing from other directions, suggesting that the source of PM_{10} and PM_{10} antimony is not solely from the current mining activities.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar G
CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN,
IGP, swisstopo, and the GIS User Community.

Figure 17: Monitoring Results by Wind Direction (Blowing From)

4.1.3.2 Crushing Plant Contribution to PM_{10}

An estimation of the possible contribution of the crushing plant activity to the reported PM_{10} has been made using the data from Residence 1 as representative of background conditions and Residence 2 as indicative of conditions downwind of the crushing plant. This scenario is reasonable for conditions where the wind was blowing from the north / northeast only.

It is noted that Philips Lane, an unsealed road immediately north of of Residence 2, will also contribute under these wind conditions.

The average PM_{10} concentrations for each location under these wind conditions are presented in Figure 18 with the calculated 'net contribution' (Residence 2 concentration minus Residence 1 concentration) of the crushing plant.

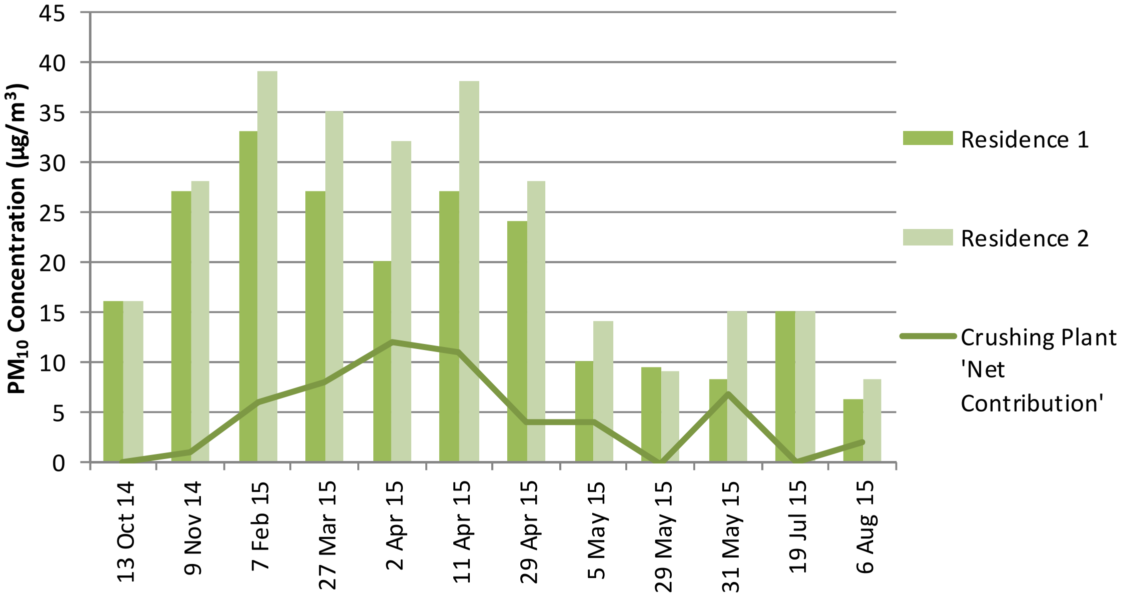


Figure 18: Residence 1 and Residence 2 24hr Average PM_{10} with Wind Direction from North / Northeast Sector.

The maximum PM_{10} 'net contribution' of the crushing plant is conservatively estimated (given the potential contribution of Philips Lane) to be 12 µg/m^3 and the average is estimated to be 4.5 µg/m^3.The maximum PM_{10} contribution is within typical daily PM_{10} concentrations within Costerfield (annual average is 17.3-18.9 µg/m^3) and the average PM_{10} contribution is below typical background levels of PM_{10} in Australia (NEPC 2014). In simple terms this means that on a few days in the year the crushing plant may contribute to PM_{10} within Costerfield but it is not a dominant influence on ambient PM_{10} levels on most days.

4.2 $PM_{2.5}$ and RCS (as $PM_{2.5}$) – Residence 1

$PM_{2.5}$ and RCS (as $PM_{2.5}$) were measured at Residence 1 only. Of the 93 samples taken between October 2014 and September 2015 at Residence 1, there were no exceedances of the SEPP (AQM) $PM_{2.5}$ Standard (Figure 19). A maximum 24 hr concentration of 21 µg/m^3 was recorded on 14 April 2015. Elevated PM_{10} concentrations were also reported on this day (27 µg/m^3 at Residence 1 and 28 µg/m^3 at Residence 2).

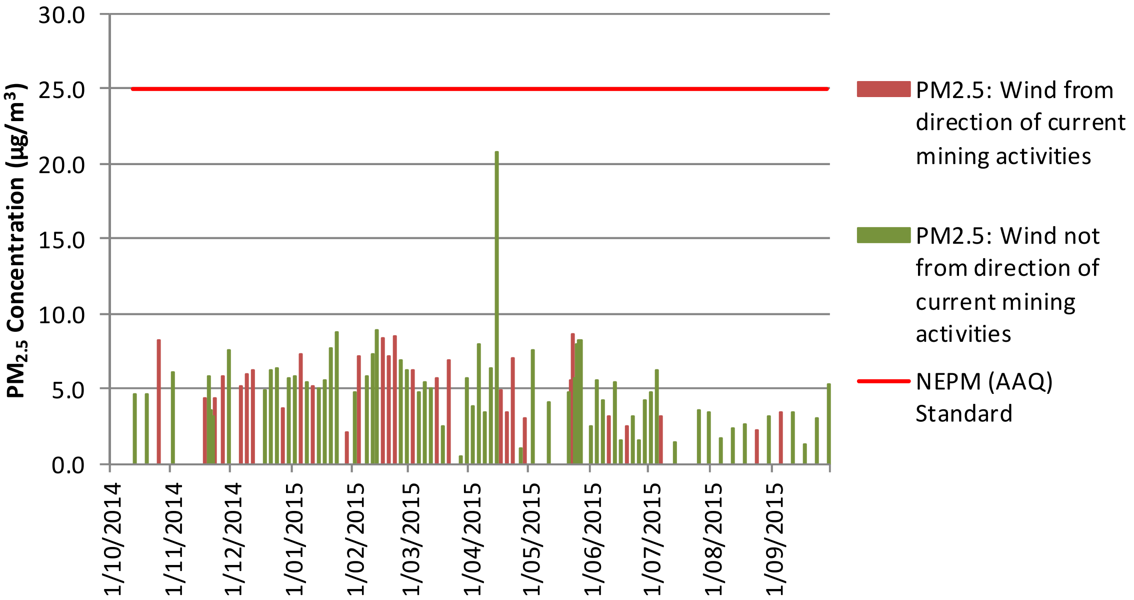


Figure 19: Residence 1 24hr Average $PM_{2.5}$ by Wind Direction.

Of the days when sampling occurred, winds were from the direction of current mining activities 31% of the time. As with the PM_{10}, the average $PM_{2.5}$ concentrations reported were of similar magnitude to the concentrations reported on days when the wind was not blowing from the direction of current mining activities (Table 11).

Table 11: Residence 1 $PM_{2.5}$ by Wind Direction

	Overall	Wind from the Direction of Current Mining Activities	Wind not from the Direction of Current Mining Activities
Samples	93	29	64
	100%	31%	69%
Average (µg/m^3)	5.2	5.4	5.1
Max (µg/m^3)	21	8.7	21
Min (µg/m^3)	0.5	2.2	0.5

A Concentration corrected to 0°C and 101.3 kPa.
B Sample analysis conducted by Golder, NATA Accreditation Number 1910.

The average $PM_{2.5}$ concentrations are comparable with typical background levels of $PM_{2.5}$ in Australia (NEPC 2014).

As with PM_{10}, the $PM_{2.5}$ concentrations were not significantly influenced by wind speeds or precipitation (Figure 20 and Figure 21).

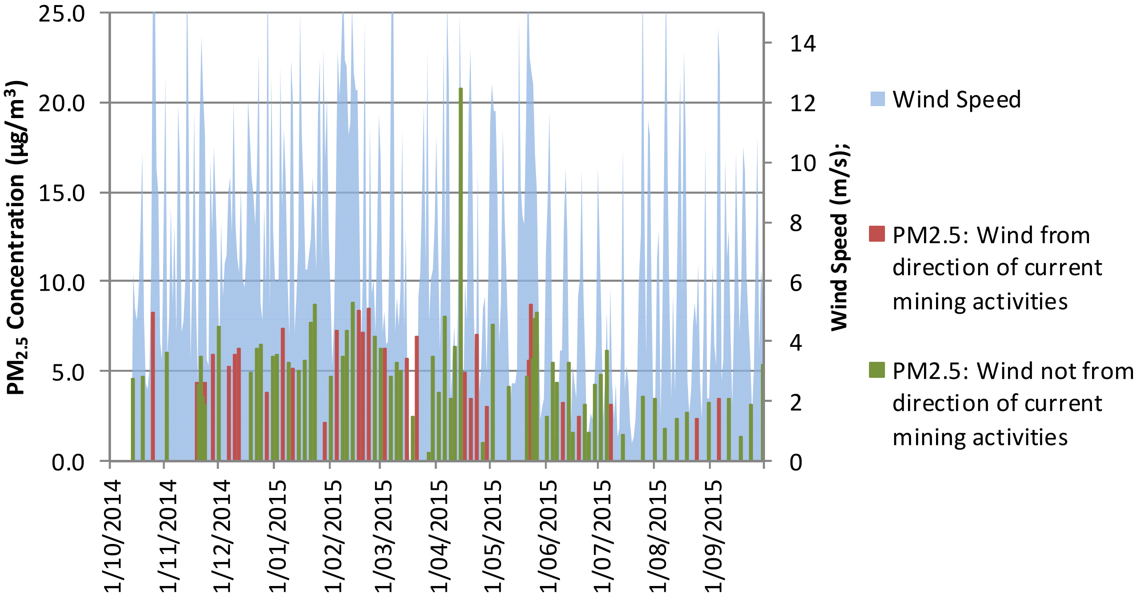


Figure 20: Residence 1 Wind-Speed and 24hr Average PM$_{2.5}$ by Wind Direction.

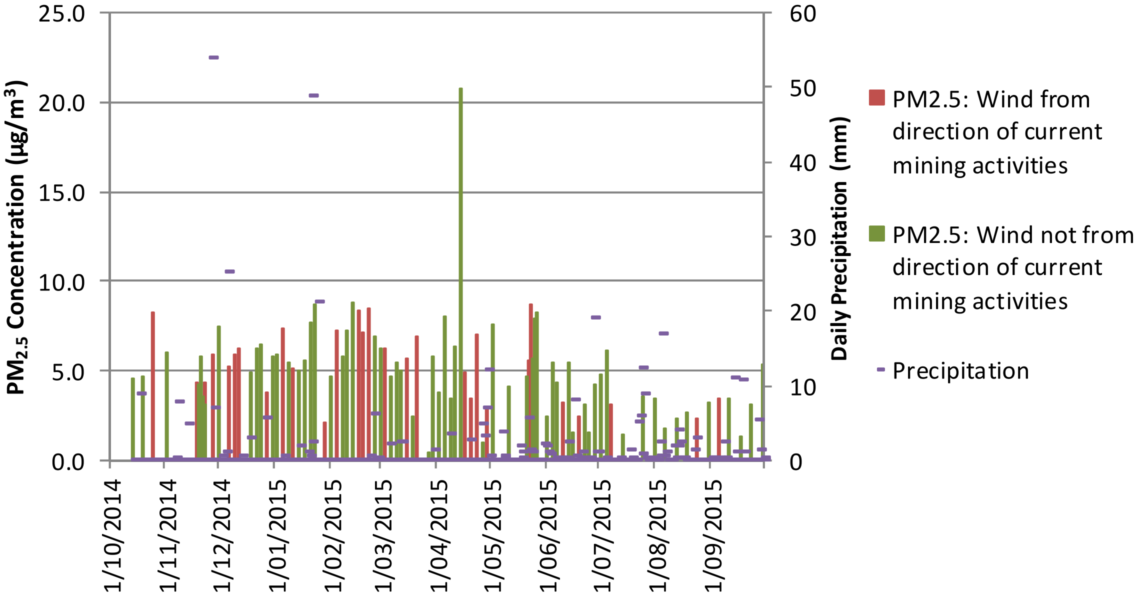


Figure 21: Residence 1 Precipitation and 24hr Average PM$_{2.5}$ by Wind Direction.

All of the filters analysed for RCS (as PM$_{2.5}$) returned results below the laboratory limit of reporting. The laboratory limit of 0.8 µg/m^3 is well below the Mining PEM criterion of 3 µg/m^3. The results are summarised in Figure 22.

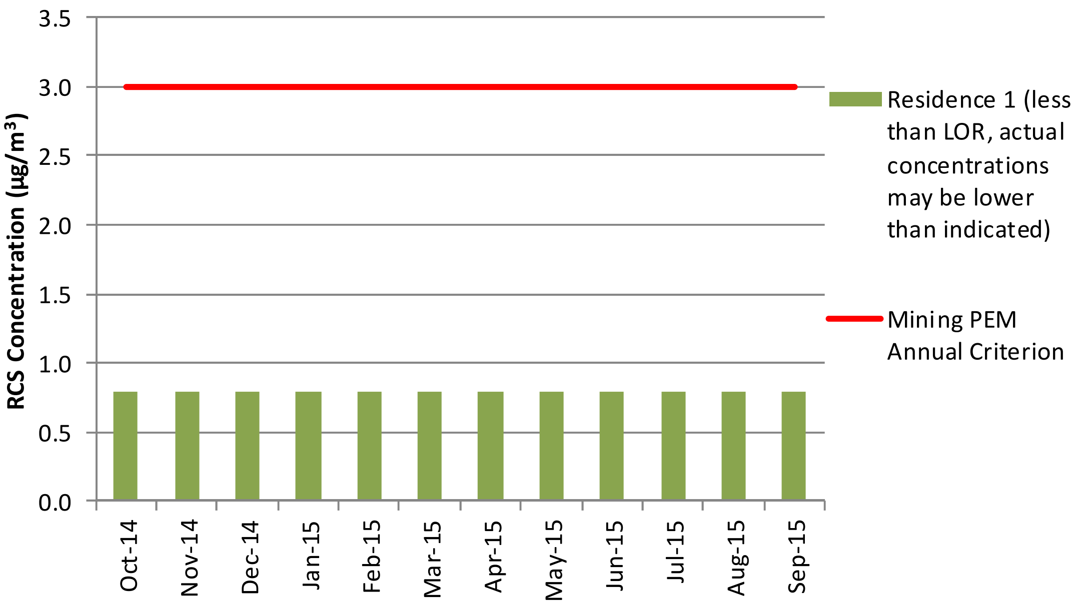


Figure 22: Residence 1 24hr Average RCS (as $PM_{2.5}$).

5.0 ADDITIONAL MONITORING DATA

5.1 Dust Deposition (Insoluble Solids and Metals)

Monthly dust deposition monitoring using dust deposit gauges (DDGs) was conducted by Mandalay Resources.

Particles settling from the air are collected in a vessel and contained with any rainwater from the sample period. Sample analysis involves sieving to remove extraneous matter followed by filtration and drying. Insoluble solids content is determined gravimetrically. Metals content was determined by ICP-MS.

Monitoring locations are presented in Figure 23 and data collected between October 2014 and September 2015 is provided in Figure 24. A summary of the deposited insoluble solids and antimony is provided in Table 12.

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 23: Dust Deposition Monitoring Locations (Mandalay Resources)

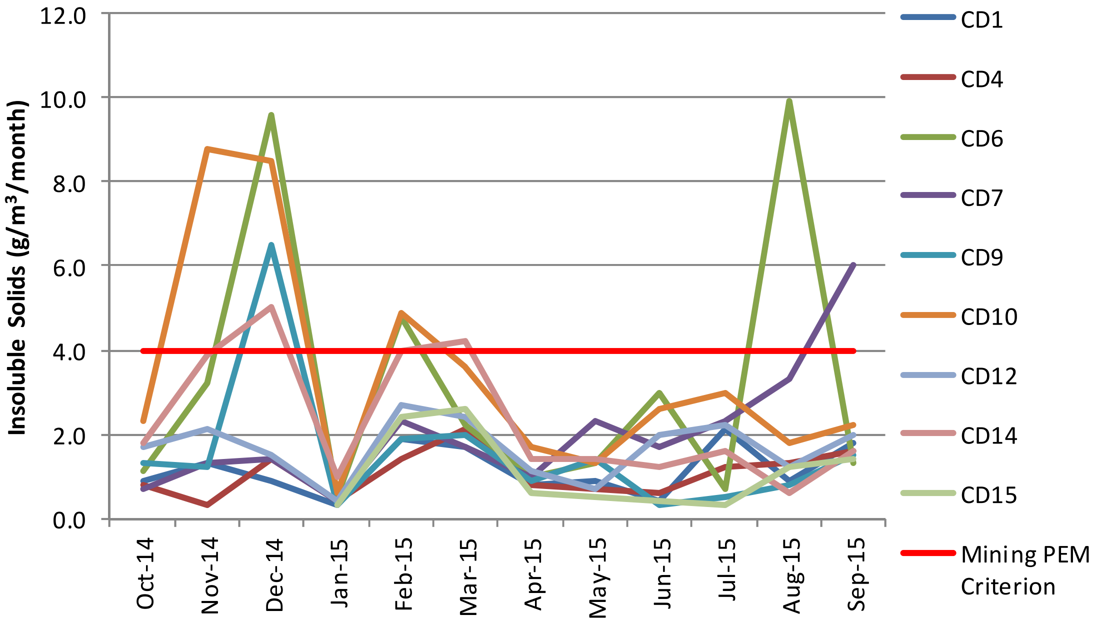


Figure 24: Dust Deposition Data (Mandalay Resources)

Table 12: Dust Deposition (Mandalay Resources) Results Statistics

Location	CD1	CD4	CD6	CD7	CD9	CD10	CD12	CD14
Insoluble Solids (g/m²/month)								
Average	1.2	1.1	3.2	2.0	1.6	3.4	1.7	2.3
95th Percentile	2.0	1.8	9.7	4.5	4.0	8.6	2.5	4.6
Max	2.1	2.1	9.9	6.0	6.5	8.8	2.7	5.0
Min	0.3	0.3	0.5	0.4	0.3	0.6	0.4	0.6
Antimony (µg/m²/month)								
Average	2000	1400	1400	9400	2300	1900	1700	750
95th Percentile	4800	2800	2500	26000	4100	4100	3600	1900
Max	5200	2900	2600	41000	4300	4700	3800	2600
Min	62	210	200	160	47	26	40	220

Monitoring location CD10 located within (and therefore representative of) the township of Costerfield returned the second highest insoluble solid deposition statistics. The highest statistics were recorded at CD6 in a paddock to the south west of Mandalay Resource's processing plant. A dust deposition modelling study conducted by Golder (Golder 2014, refer to attachment 1 of this Appendix) indicated that deposited dust from all current mining activities would have minimal impact at these locations (<0.5 g/m^2/month at CD10, 0.5 - 1.0 g/m^2/month at CD6; Figure 25) suggesting that impacts at CD10 and CD6 are primarily due to sources other than the current mining activities.

The highest antimony deposition statistics were recorded at CD7 on the boundary of the processing plant. All other monitoring locations recorded similar statistics with little relationship between deposited antimony and distance to current mining activities evident. This suggests minimal influence by current mining activities on the majority of the locations (with the exception of CD7 on the Mandalay Resources boundary).

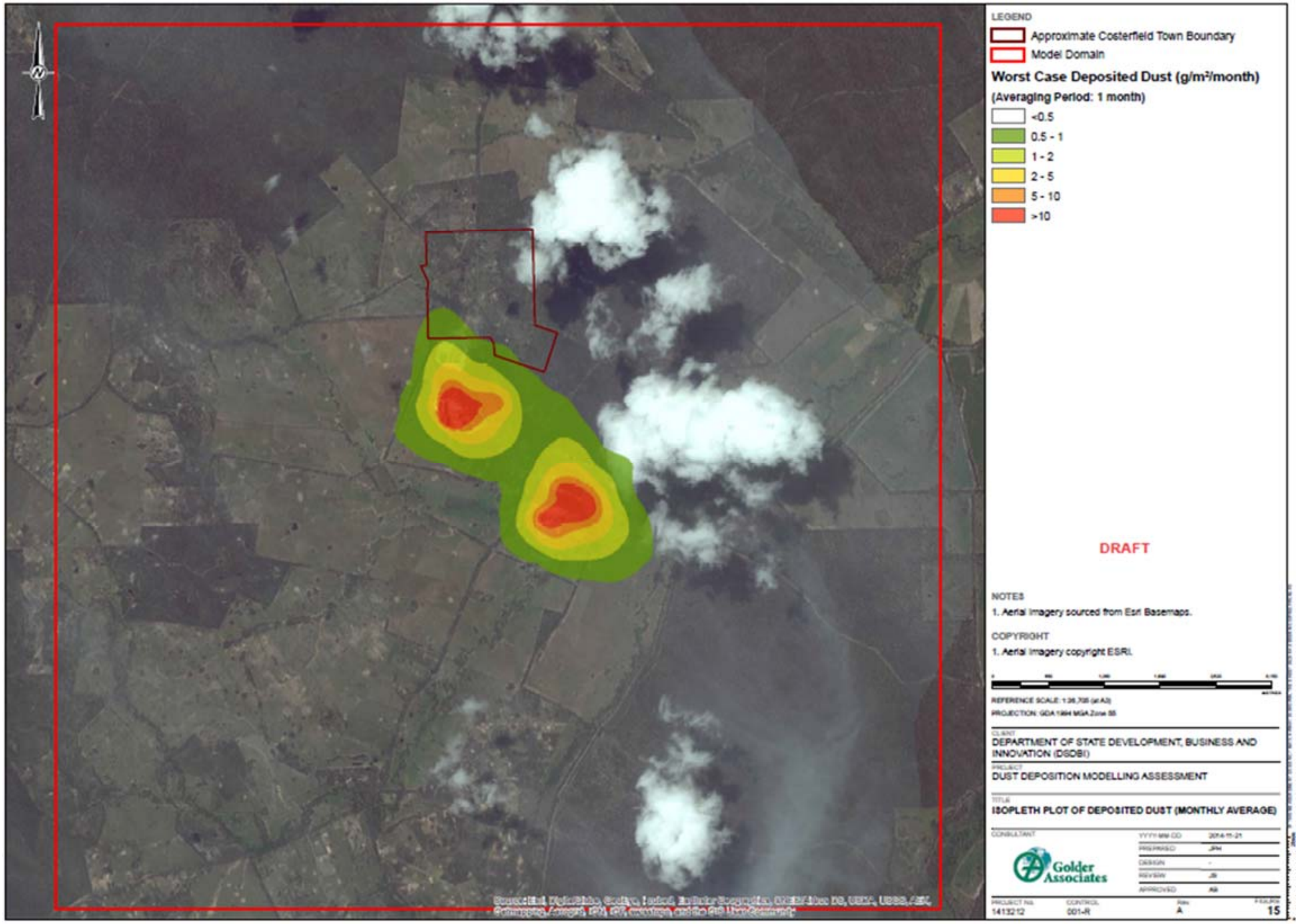


Figure 25: Dust Deposition Modelling Results (Golder Document 1413212-001-R).

Comparing the predicted average dust deposition rates reported in dust deposition modelling study with dust deposition data collected between September 2014 and October 2015 indicates no relationship between the two datasets (Figure 26). In general, the observed deposition rates are greater than the predicted. Meteorological differences aside, the difference between the two sets of data can in part be explained by fact that the model only includes the influence of the various current mining activities and does not include background impacts (other sources), whereas the monitoring data does.

The conclusion from the review of the insoluble solids and deposited antimony data is that other sources (e.g. windblown dust from exposed surfaces) make a more significant contribution to the measured dust deposition than the current mining activities.

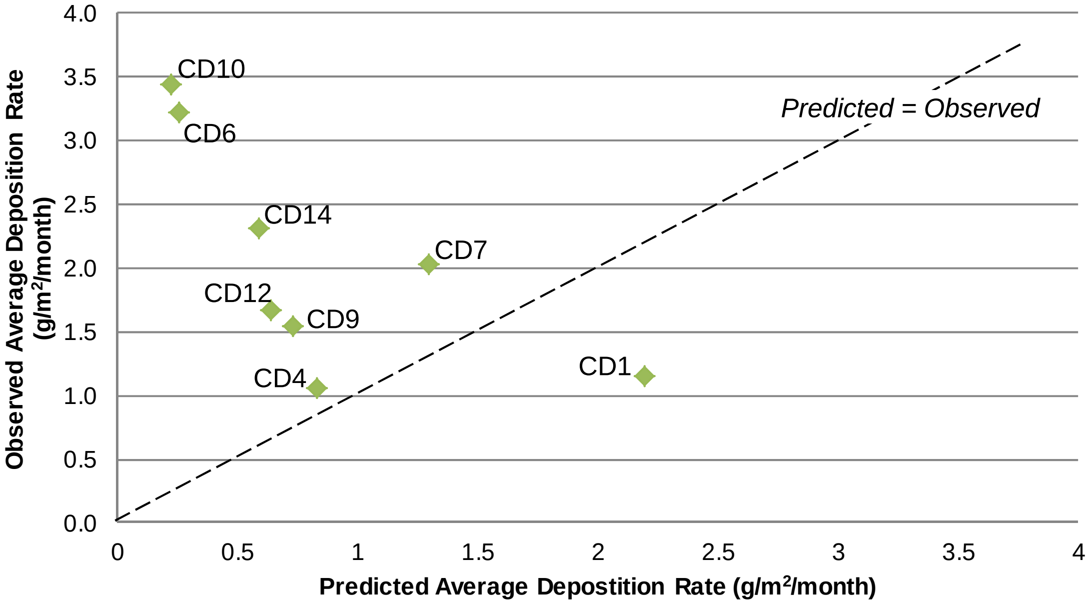


Figure 26: Predicted and Observed Average Dust Deposition

6.0 INPUTS TO THE HRA

The sections above reviewed data for:

- PM_{10} and PM_{10} metals - Residence 1 and Residence 2
- $PM_{2.5}$ and RCS (as $PM_{2.5}$) – Residence 1
- Dust Deposition (Insoluble Solids and Metals).

The assessment identified that the following parameters were above the adopted assessment criteria:

- PM_{10} concentrations in one sample (26 May 2015) from a total of 95 samples at Residence 1
- PM_{10} concentrations in one sample (7 February 2015) from a total of 97 samples at Residence 2.

Given that there were only two individual exceedance of the PM_{10} assessment criteria, it is not considered necessary to include PM_{10} as a separate chemical of potential concern (COPC) in the HRA.

The soil and water assessments (Appendix D1 and D2) identified arsenic, antimony and lead as the COPC in these media. Therefore the HRA will also consider the concentrations of these metals in ambient air.

As for soil and water, the HRA inputs were an ‘average’ concentration and an ‘upper estimate’. For air, these concentrations are taken as larger of the annual averages for Residence 1 and Residence 2, and the larger of the 95th percentile values for Residence 1 and Residence 2. These are summarised in Table 13.

Table 13: Summary of Ambient Air Metals Concentrations

Statistic	**Location**	**Concentration ($\mu g/m^3$)**		
		Arsenic	**Lead**	**Antimony**
95th Percentile	Residence 1	0.00079	0.0032	0.03
	Residence 2	0.00096	0.0035	0.049
	HRA Input [A]	**0.00096**	**0.0035**	**0.049**
Annual Average	Residence 1	0.00047	0.0012	0.0099
	Residence 2	0.00056	0.0014	0.017
	HRA Input [B]	**0.00056**	**0.0014**	**0.017**

Notes

A Upper estimate of Residence 1 and Residence 2.

B Average of Residence 1 and Residence 2.

7.0 CONCLUSION

The ambient air monitoring program included monitoring of PM_{10}, particulate metals (PM_{10} fraction), $PM_{2.5}$, RCS (as $PM_{2.5}$), and dust deposition (conducted by Mandalay).

A statistical analysis of the data, and consideration of the wind directions with respect to the location of current mining activities and monitoring location concluded the following:

- Overall, whilst ambient air concentrations of PM_{10} and $PM_{2.5}$ monitoring at Residence 1 and Residence 2 suggests some air quality impact from current mining activities, the concentrations reported are not significantly above background levels. The estimated increase in PM_{10} concentrations above background levels due to current mining activities is approximately 15%.
- Of 95 PM_{10} samples from Residence 1, there was only one exceedance of the NEPM (AAQ) PM_{10} Standard. This occurred during wind conditions blowing from a direction other than current mining activities. Of 97 PM_{10} samples from Residence 2, there was only one exceedance of the NEPM (AAQ) PM_{10} Standard. This occurred during wind conditions blowing from current mining activities. Although the current mining activities appear to have increased the PM_{10} concentrations above background levels, the concentrations are typically below the relevant national air quality guidelines and as such, PM_{10} is not considered to be a significant health issue for the residents of Costerfield.
- Antimony (as PM_{10}) was significantly below the health based assessment criterion for all samples at Residence 1 and Residence 2. From the analysis of the data at the two locations, it is estimated that the current mine activities contributed to an increase of up to 30% of the antimony concentrations above the background levels in Costerfield. Given that antimony (and other metals) are chemicals of potential concern in other environmental media considered in the HRA, the ambient air concentrations for arsenic, antimony and lead have been carried through into the HRA modelling (refer Appendix E).
- Of 93 samples $PM_{2.5}$ from Residence 1, there were no exceedances of the NEPM (AAQ) $PM_{2.5}$ Standard, and there were no detectable concentration of RCS (as $PM_{2.5}$) reported. As $PM_{2.5}$ was not monitored at Residence 2, an assessment of the potential contribution of the current mining activities to the reported $PM_{2.5}$ concentrations cannot be made. However, as the concentrations are below the national air quality guideline, $PM_{2.5}$ is not considered to be a significant health issue for the residents of Costerfield.

- Mandalay's deposited dust monitoring data suggests that although there is some dust impact on the boundary of the processing plant, current mining activities have not had a significant influence further away, specifically within Costerfield township given the following findings:
    - The highest deposited dust (insoluble solids) statistics were reported at CD10, the furthest monitoring location from current mining activities. In comparison, dust deposition modelling predicts insignificant impacts from current mining activities at CD10, inferring that other sources and/or background levels are the likely cause of the elevated results at CD10.
    - The highest deposited antimony statistics were reported at CD7, on the boundary of the processing plant. All other locations reported similar antimony statistics suggesting significant influence by background antimony levels compared to that of mining activities.
    - Predictive modelling of dust deposition (refer attachment 1) suggests significant dust impacts are limited to a few hundred meters (<500 m) from current mining activities. Therefore it is likely that other sources and/or background levels are contributing significantly to the monitoring data.

8.0 REFERENCES

Golder 2014. *Costerfield Dust Deposition Modelling Assessment*, November 2014. Report Ref: 1413212-001-R-RevA (included as attachment 1).

Golder 2016b. *Costerfield Ambient Air Quality Monitoring Program Oct 2014 – Sep 2015* February 2016. Report Ref: 1413212-033-R-RevA.

ISO/IEC 17025. '*General requirements for the competence of testing and calibration laboratories*', 2005.

Mining PEM. State Environment Protection Policy (Air Quality Management), '*Protocol for Environmental Management: Mining and Extractive Industries*', December 2007.

NEPM (AAQ). National Environment Protection Council, '*National Environment Protection (Ambient Air Quality) Measure*, 7 July 2003*.*

SEPP (AQM). Victoria Government Gazette No. S 240, *'State Environment Protection Policy (Air Quality Management'*, 21 December 2001

APPENDIX D3

Air Quality

Attachments

1. Golder (2014) Costerfield Dust Deposition Modelling Assessment Report Ref: 1413212-001-R-RevA, November 2014

21 November 2014

COSTERFIELD, VICTORIA

Dust Deposition Modelling Assessment

Submitted to:
Victorian Government Reference Group
c/o Department of State Development, Business and Innovation
Level 9, 121 Exhibition Street,
Melbourne, 3000

REPORT

Report Number. 1413212-001-R-RevA

Distribution:

Electronic distribution only

Golder Associates

Record of Issue

Company	Contact	Version	Date Issued	Method of Delivery
EPA Victoria EPA Macleod Ernest Jones Drive Macleod VIC 3085	Paul Torre	RevA	21/11/2014	Electronic

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APPENDICES

1.0 INTRODUCTION

Golder Associates Pty Ltd (Golder) was commissioned by the Government of Victoria Reference Group, chaired by the Department of State Development, Business and Innovation (DSDBI), to prepare a deposited dust impact assessment for the Costerfield Gold-Antimony Mine. Mandalay Resources (Mandalay) owns and operates the Costerfield mine, located at McNicols Lane, Costerfield, Victoria.

This technical report provides an assessment of deposited dust impacts from the mine for the current operating scenario. The impact assessment was conducted using a standard air dispersion modelling approach, where dust deposition rates were predicted beyond the site boundary. The purpose of the assessment was to estimate the geographical extent of deposited dust impacts from Mandalay emission sources.

2.0 ASSESSMENT METHODOLOGY

The *Environment Protection Act, 1970* is the legislative framework for the protection of the environment in Victoria. Section 16(1) details the provision for environment protection policies to stipulate environment protection for any element or segment of the environment. The State Environment Protection Policy (Air Quality Management) [SEPP(AQM)] is relevant to deposited dust impacts at Costerfield as it defines the objectives, actions and management goals required to protect beneficial uses of the air environment. In particular, Schedule C together with Environment Protection Authority of Victoria (EPAV) draft Publication No. 1551 *"Guidance Notes for Using the Regulatory Air Pollution Model AERMOD in Victoria"* details the modelling methodology to be applied in Victoria. The modelling methodology utilised by Golder for the dust deposition assessment is consistent with Schedule C requirements and uses the current regulatory model, AERMOD.

The SEPP(AQM) also enables the Authority to develop protocols for environmental management as incorporated documents to the policy (State Environment Protection Policy (Air Quality Management), 2001). The *Protocol for Environmental Management - Mining and Extractive Industries* (Mining PEM) is applicable to mining activities at Costerfield. The Protocol defines deposited dust as "an indicator of the effectiveness of site management practices and potential for off-site nuisance" and recommends the conduct of a deposited dust monitoring programme at most operations (EPA Victoria, 2007). The monitoring programme results are compared to a deposition rate criterion of 4 g/m^2/month, not more than 2 g/m^2/month above background. The Mining PEM does not stipulate a deposited dust modelling methodology, however a monthly averaging period has been used. Comparison with the monitoring criterion is not required as the purpose of the assessment is to determine the geographical extent of deposited dust impacts.

3.0 SITE DESCRIPTION

The Costerfield Mine comprises the Augusta underground mine and the Brunswick processing plant located on approximately 7,541 hectares of mining tenements (Mandalay Resources, 2013). Operation of the mine is undertaken in accordance with Mining Licence 4644 and Exploration Licence 3310.

Ore is mined from upper levels of the Augusta Mine by extraction of remnant ore and pillars from historical mining, with mining on new levels by rock fill blast-hole stope methods (Mandalay Resources, 2013). The underground mine is serviced by two ventilation shafts; Cuffley and Augusta which exhaust mine air on a continuous basis. Blasting is typically conducted twice per day, at 6:30 am and 6:30 pm, with blast emissions primarily consisting of particulate matter, sulphur dioxide, carbon dioxide, carbon monoxide and oxides of nitrogen. Ore is brought to the surface by mine trucks, which exit into a box cut area and unload. The box cut is a bunded 30 m cutting, housing the mine portal, exit ramp and ore stockpile. Within the box cut, a front end loader loads 23 tonne trucks which transport the ore to the Brunswick plant.

The truck route is approximately three kilometres and includes the box cut ramp, Augusta Mine access road, McNichols Lane, Heathcote-Nagambie Road and the Brunswick Plant access road. The access roads and ramp are unsealed and maintained by regular grading, continuous watering and application of river stone.

Mine waste rock was historically used for road construction; however this practice was changed in April 2014. Similarly covers have recently been introduced to haul trucks and wheel washing stations installed at the mine and plant sites. McNichols Lane and the Heathcote-Nagambie Road are sealed and maintained by regular cleaning. Water for suppression of dust from unpaved roads was historically mine water, but is now Heathcote standpipe water. This will eventually be replaced by treated water from the proposed reverse osmosis treatment plant at the mine site.

Waste rock is stored at the Augusta Mine in a stockpile outside the boxcut area. The stockpile is currently inactive and fitted with sprinklers for dust suppression using mine water during the summer months. Future activities will include working of the currently inactive stockpile and increasing the stockpile height from six metres to nine metres.

The Brunswick Plant consists of a Run of Mine (ROM) pad stockpile, mobile impaction crusher, two ball mills in series and a gravity concentration circuit and flotation circuit. The ROM pad is approximately one hectare and is worked by a front end loader, which transfers ore to the mobile crusher. The crusher has recently been relocated from an elevated position to a depression shielded by site buildings and topography. The crusher is also partially covered by a tent which is open on two sides. The crusher grizzly screen hopper and crushed product conveyor are located outside the tent structure. Crushed ore is transferred by open conveyor to a series of stockpiles located throughout the plant area. The front end loader transfers crushed ore to the fine ore bin hopper which connects via open conveyors to the fine ore bins. The bins are enclosed, with particulate matter emissions to air controlled by a fabric filter. Crushed ore forms a slurry in the ball mill circuits and processed ore is transferred to bags and stored near to the ROM pad for road transport to Melbourne and shipment to China. The dispatch area is worked by a forklift.

The Brunswick Plant and Augusta Mine are unpaved areas which are maintained by regular watering and housekeeping to minimise dust generation.

Tailings are disposed to the tailings storage facility to the north of the Brunswick Plant. Deposition of the tailings is rotated around the facility to ensure an even distribution.

The relative locations of the Augusta Mine and Brunswick Plant are presented in Figure 1.

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

Figure 1: Site Layout

4.0 EMISSIONS TO AIR

Dust deposition is the removal of particles from the air due to gravitational settling (dry deposition) or precipitation (wet deposition). Dry deposition is the focus of this technical assessment as the purpose is to determine the extent of deposited dust impacts and exclusion of wet deposition provides a worst case assessment. The rate of dry deposition is dependent on particle characteristics, distance from the source and meteorological conditions. Larger particles deposit closer to the emission source whilst small particles remain entrained in the air column. For the purpose of the assessment total suspended particulate matter (TSP) was assumed to be the particulate matter fraction subject to the highest rates of dry deposition and hence forms the basis for the emissions inventory. TSP refers to particles with an equivalent aerodynamic diameter (EAD) less than 100 µm, as defined by the high volume sampler, with collection efficiencies for particles larger than 20 µm decreasing with increasing EAD. For the purposes of this exercise TSP is taken to be particles with an EAD of less than 30 µm, corresponding to the United States Environmental Protection Agency (USEPA) emission factor definition.

Costerfield mine activities have the potential to generate TSP emissions to air. Activities including ore transfers, trucks travelling on unpaved roads and stockpiling are potential dust emission sources, as are exposed surfaces subject to wind erosion.

Processing plant activities downstream of the fine ore bin are considered to be minor sources due to the high moisture content of the processed material and enclosure of the fine ore bin and consequently have been excluded from the assessment. Similarly the surface of the tailings storage facility is generally 70% water and 30% dried and crusted tailings, with a low potential for dust generation. Haul truck travel on paved roads has also been excluded as the roads are regularly cleaned and considered a minor source.

4.1 Emissions Inventory

The emissions inventory is a list of TSP emission rates for each of the sources identified as significant. The inventory has been prepared using published emission factors and site specific activity data.

The emission sources included in the inventory are:

- Augusta Mine ventilation shafts
- Exposed surfaces at the Augusta Mine and Brunswick Plant
- Augusta Mine waste rock stockpile
- Material transfers (trucks dumping ore/front end loaders/conveyor drop points)
- Stockpiles
- Unpaved section of the haul route between the Augusta Mine and Brunswick Plant
- Crushing plant.

The emission estimation technique used for each source is presented in the sections below. An overview of the emissions inventory is presented in Table 1, with relative contributions by groups of sources summarised in Figure 2.

Table 1: Emission Inventory

Source ID	Location	Source Description	Type of Source	TSP Emission Rate (kg/h)	Modelled Hours of Emission
Vnt_A01	Augusta	Ventilation shaft – Cuffley	Point	2.0	6 am – 7 am 6 pm to 7 pm
Vnt_B01	Augusta	Ventilation shaft – Augusta	Point	2.0	6 am to 7 am 6 pm to 7 pm
TrD_A01	Augusta	Material transfers – off-highway trucks dumping ore	Volume	0.22	24 h
ExS_A01	Augusta	Box cut ore stockpile and exposed areas	Volume	0.080	24 h
FEL_A01	Augusta	Material transfers – front end loader loading highway trucks	Volume	1.5	7 am – 5 pm
WGD_A01	Augusta	Haul route (wheel generated dust)	Line volume	32	7 am – 5 pm
ExS_A02	Augusta	Waste rock stockpile	Volume	0.50	24 h
ExS_A03	Augusta	Waste rock stockpile	Volume	0.50	24 h
ExS_A04	Augusta	Exposed areas	Volume	0.30	24 h
WGD_A02	Augusta	Light vehicle route (wheel generated dust)	Line volume	48	7 am – 8 am 5 pm – 6 pm
WGD_B01	Brunswick	Haul route (wheel generated dust)	Line volume	11	7 am – 5 pm
TrD_B01	Brunswick	Material transfers – haul trucks dumping ore	Volume	0.70	7 am – 5 pm
ExS_B01	Brunswick	ROM pad stockpile, ore stockpiles and exposed surfaces	Volume	0.36	24 h
FEL_B01	Brunswick	Material transfers – front end loader loading crushing plant hopper	Volume	1.3	7 am – 7 pm
FEL_B02	Brunswick	Material transfers – front end loader loading fine ore hopper	Volume	1.3	7 am – 7 pm
CrP_B01	Brunswick	Crushing plant	Volume	5.0	7 am – 7 pm
CDP_B01	Brunswick	Conveyor drop point	Volume	3.0	7 am – 7 pm
CDP_B02	Brunswick	Conveyor drop point	Volume	3.0	7 am – 7 pm
CDP_B03	Brunswick	Conveyor drop point	Volume	3.0	7 am – 7 pm
WGD_B02	Brunswick	Forklift in bagging area	Volume	1.2	7 am – 7 pm

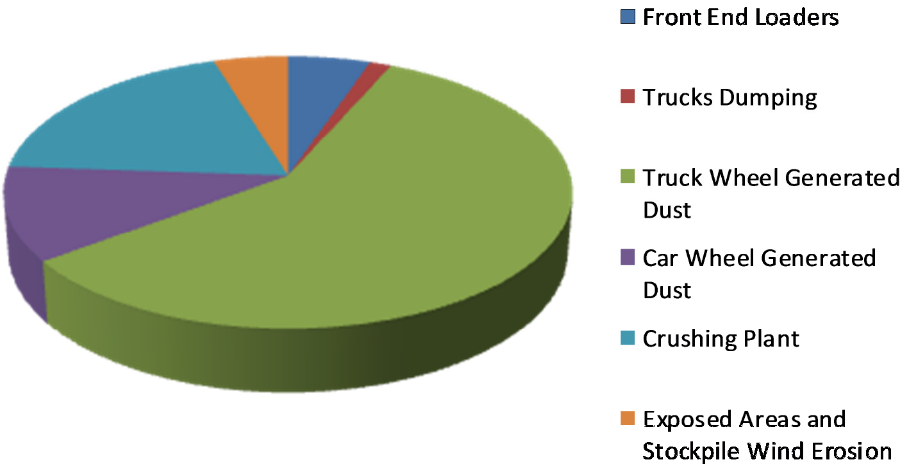


Figure 2: Emission Inventory - Daily Relative Contributions

4.1.1 Ventilation Shafts

Emissions to air from Cuffley and Augusta ventilation shafts have been assumed to be the same, with emission estimates based on the results of a stack emission monitoring programme conducted on the Cuffley shaft on 15 July 2014.

The test results are summarised in Table 2.

Table 2: Ventilation Shaft Emission Test Results

Test Condition	Background	Blast Period
Velocity at the sampling plane (m/s)	13	
Temperature (℃)	20	
Particulate matter mass rate (g/min)	<7	34

Source: (Emission Testing Consultants, 2014)

The emission testing programme also included continuous analysis of oxygen, carbon dioxide, carbon monoxide, oxides of nitrogen and sulphur dioxide during the background and blast periods. The results from the continuous analysers demonstrated that blast conditions exist for approximately one hour after firing, with concentrations then returning to background levels.

For the purpose of the modelling assessment, the measured blast period particulate matter rate will be used to represent emissions from the Cuffley and Augusta ventilation shafts for the period 6 am to 7 am.

4.1.2 Material Transfers

Material transfers include trucks dumping ore and front end loader loading activities.

Material transfers associated with truck dumping have been estimated using the default emission factor published by the National Pollutant Inventory (NPI) for trucks dumping overburden. The factor is recommended by the NPI for loading and unloading operations in preference to batch loading equations published by the USEPA, due to unrealistically low estimates provided by the USEPA factors (Australian Goverment, 2012).

Emissions from front end loader activities were estimated using the NPI factor for front end loaders working overburden.

The factors require an assessment of the volume of material handled in each process. The assumed volumes were based on the hours of operation and plant throughput, as presented in Table 3.

Table 3: Material Transfer Assumptions

Source ID	Location	Source Description	Volume of Material Handled (t/h)
TrD_A01	Augusta	Off-highway trucks dumping ore	19
FEL_A01	Augusta	Front end loader	58
TrD_B01	Brunswick	Haul trucks dumping ore	58
FEL_B01	Brunswick	Front end loader – crushing plant loading	50
FEL_B02	Brunswick	Front end loader – fine ore hopper loading	50

4.1.3 ROM Pad, Stockpiles and Exposed Surfaces

The ROM pad, stockpiles and exposed surfaces at the Augusta Mine and Brunswick Plant are subject to wind erosion. The NPI default emission factor for wind erosion at Australian mines has been used to represent these sources.

The assumed area for calculation of emission rates for these sources is presented in Table 4.

Table 4: Exposed Surfaces – Assumed Areas

Source ID	Location	Description	Assumed Area (m^2)
ExS_A01	Augusta	Box cut ore stockpile and exposed surfaces	2,000
ExS_A02	Augusta	Waste rock stockpile	12,500
ExS_A03	Augusta	Waste rock stockpile	12,500
ExS_A04	Augusta	Exposed surfaces	7,600
ExS_B01	Brunswick	ROM pad stockpile, crushed ore stockpiles and exposed surfaces	9,000

4.1.4 Wheel Generated Dust

Wheel generated dust from unpaved sections of the haul route were calculated using the NPI emission factors for unpaved roads at industrial sites and unpaved roads used by light duty vehicles (Australian Goverment, 2012).

The haul road emission factor requires the estimated silt content and vehicle weight for the trafficked road as well as the distance travelled per hour. The silt contents for the unpaved roads at the Augusta Mine and Brunswick Plant were determined through collection of a sample from each road section on 8 October 2014. Samples were collected in general accordance with USEPA AP42 Appendix C.1 *Procedures for Sampling Surface/Bulk Dust Loading* (United States Environmental Protection Agency, 1993). In order to collect sufficient sample volume, the collection method was adjusted to include surface scraping as well as the broom collection method. The samples were analysed by ALS Newcastle using a laser sizing technique.

The vehicle weight was assumed to be the average of the loaded and unloaded haul trucks travelling between the mine and plant.

The distance travelled per hour was assumed to be 14 km for the Augusta Mine access road and 5 km for the Brunswick Plant access road, based on 12 tonne truck capacity, ten hour shifts and an estimated trucked volume of 13,000 dry tonnes per month.

Light vehicles travelling to the Augusta Mine were included at the beginning and end of each shift. The emission factor for light vehicles requires silt content, moisture content, mean vehicle speed and distance travelled per hour. Silt and moisture content inputs were the Augusta Mine road sample results. A mean vehicle speed of 25 km/h and 60 km travelled per hour were also assumed. The distance travelled was based on 75 light vehicles each travelling 0.8 km.

The assessment also included an emission source for wheel generated dust from forklift operations in the dispatch area. For the purpose of emission estimation, the forklift was assumed to be equivalent to a light vehicle.

An overview of the assumed parameters for wheel generated dust from unpaved roads is presented in Table 8.

Table 5: Wheel Generated Dust Assumptions

Parameter	Mine Access Road	Plant Access Road
Silt content (%) [A]	21	20
Moisture content (%)	1.4	2.3
Mean light vehicle speed (km/h)	25	10
Mean highway truck weight (tonnes)	17	17
Highway truck kilometres travelled per hour	14	4.9
Light vehicle kilometres travelled per hour	60	1 (Forklift)
Emission reduction associated with watering [B] (%)	50	50

Note:

A Silt content is defined as particles smaller than 75 microns (United States Environmental Protection Agency, 2006)

B Routine watering has been assumed to be consistent with Level 1, 2 L/m^2/hour, as defined by the NPI (Australian Goverment, 2012).

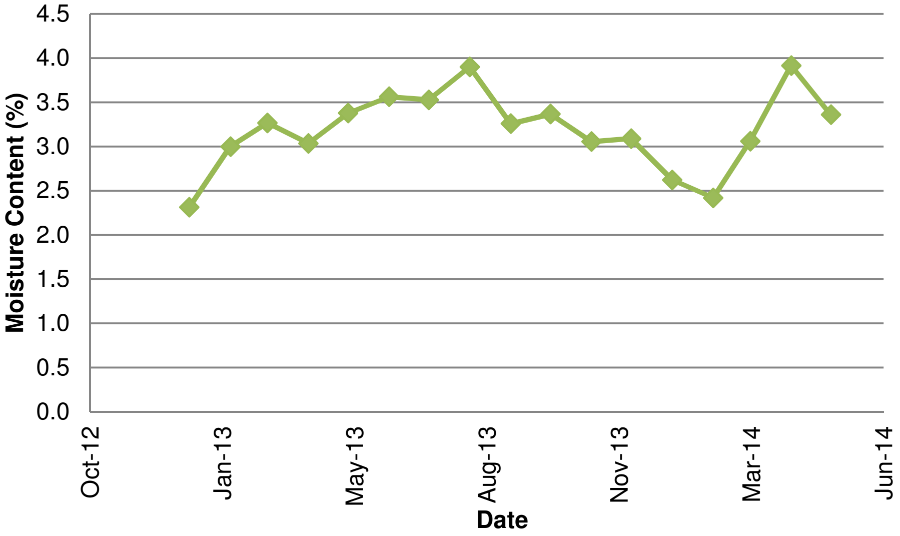
4.1.5 Crushing Plant

The crushing plant reduces ore to a target range of 25 mm for input into the series of ball mills. Emissions to air from the crushing plant are controlled by water sprays used continuously. The plant is located in an open tent with the feed hopper and conveyed product outside the tent, hence it has been conservatively assumed that the structure does not control crushing emissions.

The ore moisture content fluctuates between two and four percent water content as displayed in Figure 3.

Emissions to air from the crushing plant have been calculated using emission factors published in the USEPA AP-42 Publication 11.24 *Metallic Minerals Processing.* For the purpose of emission calculations the activity has been defined as uncontrolled primary crushing of low moisture content ore. AP-42 defines low moisture as “less than 4 weight percent or less” and controlled processes as those which are equipped with a wet scrubber or baghouse (United States Environmental Protection Agency, 1995). To reflect the dust control achieved by water sprays a 50% reduction has been assumed. This assumption is consistent with the control rates for water sprays published by the NPI in the *Emission Estimation Technique Manual for Mining*.

The crushing plant throughput is 50 tonnes per hour during the hours 7 am to 7 pm.



Source: (Mandalay Resources, 2014)

Figure 3: Crushing Plant Moisture Content (January 2013 to June 2014)

4.1.6 Conveyor Drop Points

Emissions to air from the conveyor drop points between the fine ore hopper and fine ore bin were estimated using the material handling and transfer emission factor published by the USEPA for low moisture ore used in metallic minerals processing (United States Environmental Protection Agency, 1995).

A material throughput of 50 tonnes per hour has been assumed, during the hours 7 am to 7 pm.

4.2 Source Characterisation

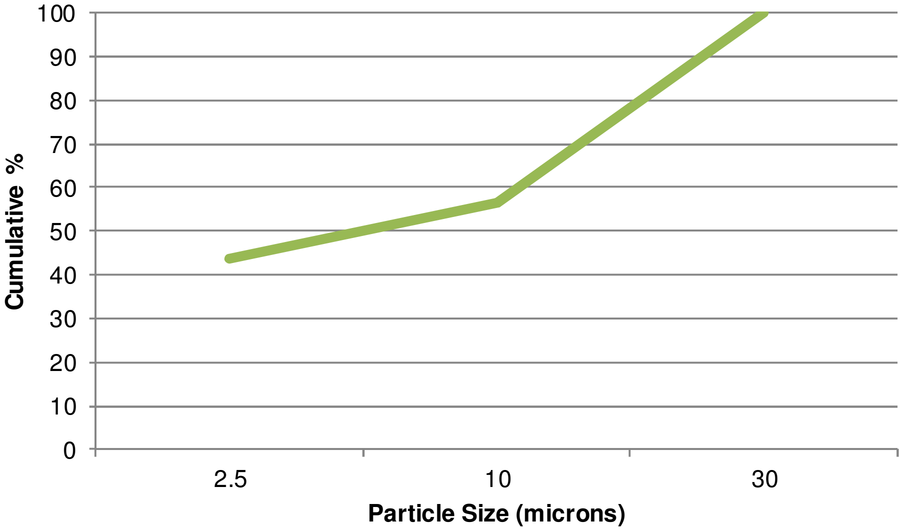
The identified emission sources were modelled as volume sources, with the exception of the mine ventilation shafts which were input as point sources. Volume sources are bulky diffuse sources that emit or release pollutants over large areas in three dimensions. Point sources emit pollutants from a single location, usually with a degree of elevation and a mechanism for creating plume rise.

The volume source model input data, including initial vertical and horizontal spread and effective release height, were based on the source dimensions. Haul roads were included as volume line sources in accordance with the USEPA Haul Road Working Group Recommendations (United States Environmental Protection Agency, 2012).

Point source model input data was based on the dimensions of the ventilation shafts and the results of the emission testing programme described in Section 4.1.1.

4.2.1 Particle Size Distribution and Particle Density

Calculation of deposition rates requires information regarding the particle size distribution and particle density for each source. Limited site specific information is available for Mandalay emission sources, with data only available for the size distribution of airborne dust emitted from the ventilation shaft exhausts. The distribution is presented in Figure 4.

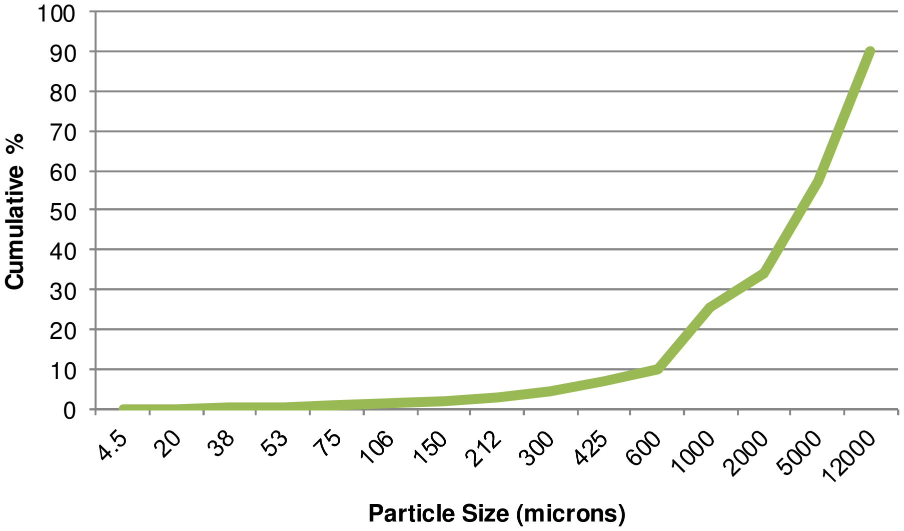


Source: (Emission Testing Consultants, 2014)

Figure 4: Ventilation Shaft Exhaust Particle Size Distribution

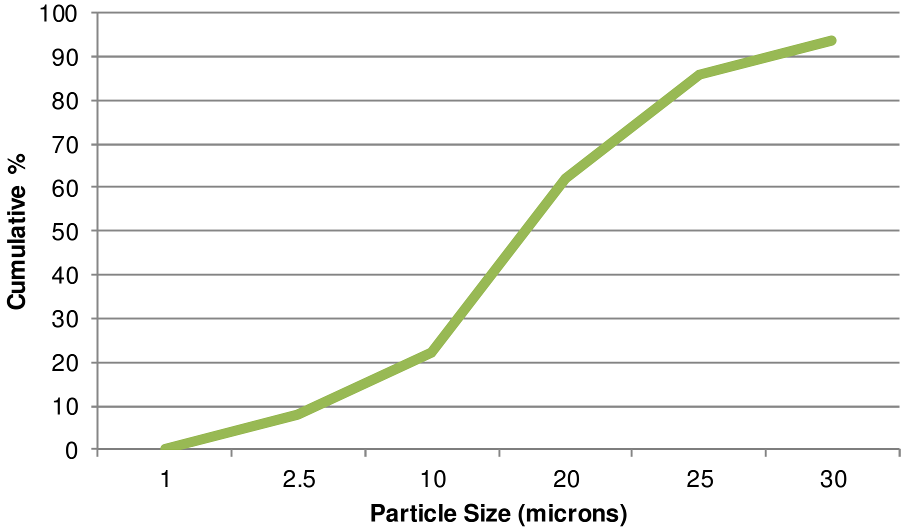
Data is also available for crushed ore and the surfaces of the mine access road and plant access road. The data is for the in-situ material; hence use of this information assumes the distribution of airborne particles is the same as the source.

The particle size distribution for each source is presented in Figure 5 to Figure 7. The measured particle density for these sources is presented in Table 6.



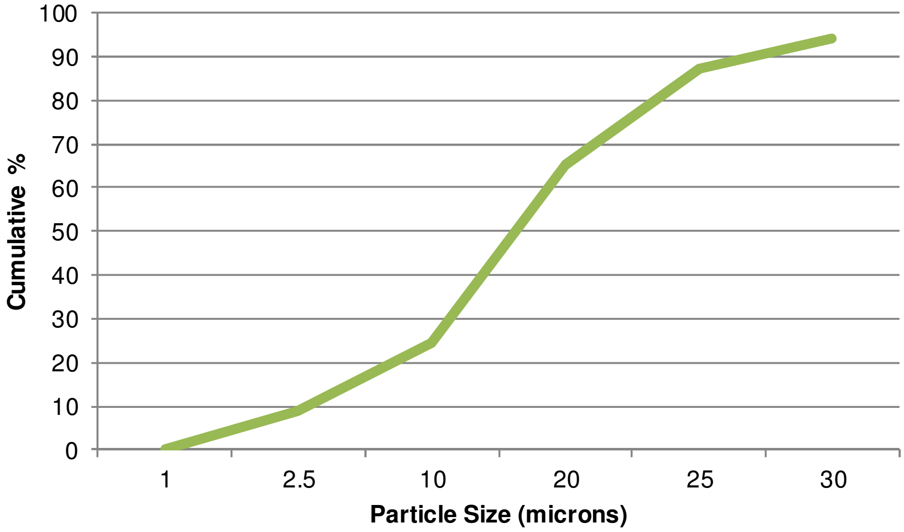
Source: (Mandalay Resources, 2014)

Figure 5: Crushed Ore Particle Size Distribution



Source: (ALS Environmental, 2014)

Figure 6: Mine Access Road Surface Particle Size Distribution



Source: (ALS Environmental, 2014)

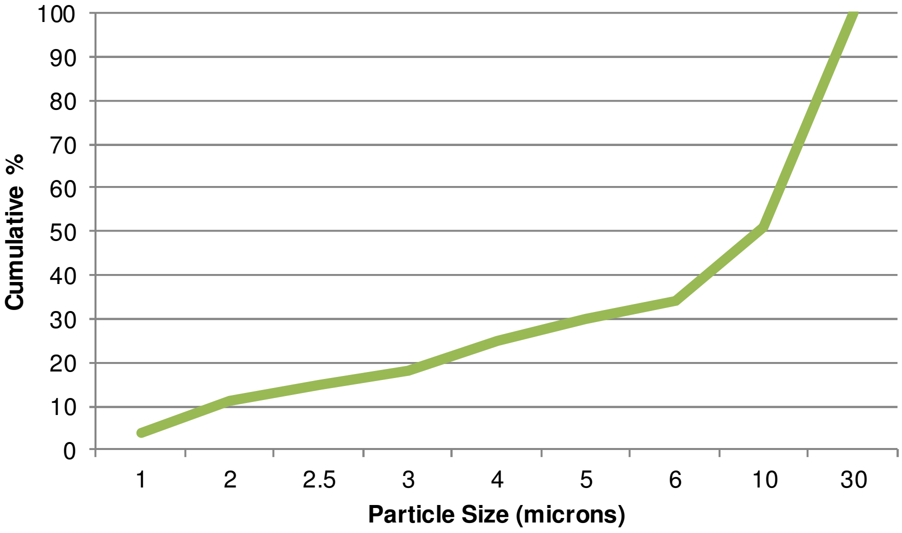
Figure 7: Plant Access Road Surface Particle Size Distribution

Table 6: Particle Density

Source	Particle Density (g/cm^3)
Mine access road	2.70 **Source:** (ALS Environmental, 2014)
Plant access road	2.69 **Source:** (ALS Environmental, 2014)
Crushed ore	2.6 to 2.75 **Source:** (Mandalay Resources, 2014)

The mine access road and plant access road particle data is very similar so averages of the two datasets are used to describe these sources in the model.

USEPA publishes generalised particle size distributions for preparation of size specific emission inventories. The distribution for mechanically generated emissions from aggregate or unprocessed ore is relevant to Mandalay emission sources as it covers emissions “generated through either the movement of the material or the interaction of the material with mechanical devices” (United States Environmental Protection Authority, 1990). The USEPA distribution reports 51% of particles less than 10 microns. In order to determine deposition impacts for TSP, it has been assumed that the remaining fraction is less than 30 microns. The modified distribution is reproduced in Figure 8.



Source: (United States Environmental Protection Authority, 1990)

Figure 8: Particle Size Distribution for Mechanically Generated Dust from Aggregate or Unprocessed Ores

In order to calculate deposition rates for all the identified emission sources, particle size distributions have been assumed for each source, based on the available data. Similarly, the measured particle density results from the limited sources have been assumed to be consistent for the range of sources included in the model. Where the measured particle density results represent a range, the lower value has been included to represent a worst case assessment approach. The assumptions are summarised in Table 7.

.

Table 7: Assumed Particle Size Distributions and Particle Density

Source ID	Location	Source Description	Assumed Particle Size Distribution	Assumed Particle Density (g/cm^3)
Vnt_A01	Augusta	Ventilation shaft – Cuffley	Test results from the Cuffley emission testing	2.6
Vnt_B01	Augusta	Ventilation shaft – Augusta	Test results from the Cuffley emission testing	2.6
TrD_A01	Augusta	Material transfers – off-highway trucks dumping ore	USEPA mechanically generated dust from aggregate and unprocessed ores	2.6
ExS_A01	Augusta	Box cut ore stockpile and exposed areas	USEPA mechanically generated dust from aggregate and unprocessed ores	2.6
FEL_A01	Augusta	Material transfers – front end loader loading highway trucks	USEPA mechanically generated dust from aggregate and unprocessed ores	2.6
WGD_A01	Augusta	Haul route (wheel generated dust)	Test results for the access routes	2.7
ExS_A02	Augusta	Waste rock stockpile	USEPA mechanically generated dust from aggregate and unprocessed ores	2.6
ExS_A03	Augusta	Waste rock stockpile	USEPA mechanically generated dust from aggregate and unprocessed ores	2.6
ExS_A04	Augusta	Exposed areas	Test results for the access routes	2.7
WGD_A02	Augusta	Light vehicle route (wheel generated dust)	Test results for the access routes	2.7
WGD_B01	Brunswick	Haul route (wheel generated dust)	Test results for the access routes	2.7
TrD_B01	Brunswick	Material transfers – highway trucks dumping ore	USEPA mechanically generated dust from aggregate and unprocessed ores	2.6
ExS_B01	Brunswick	ROM pad stockpile, crushed ore stockpiles and exposed areas	USEPA mechanically generated dust from aggregate and unprocessed ores	2.6
FEL_B01	Brunswick	Material transfers – front end loader loading crushing plant hopper	USEPA mechanically generated dust from aggregate and unprocessed ores	2.6
FEL_B02	Brunswick	Material transfers – front end loader loading fine ore hopper	Crushed ore test results	2.6
CrP_B01	Brunswick	Crushing plant	Crushed ore test results	2.6
CDP_B01	Brunswick	Conveyor drop point	Crushed ore test results	2.6
CDP_B02	Brunswick	Conveyor drop point	Crushed ore test results	2.6
CDP_B03	Brunswick	Conveyor drop point	Crushed ore test results	2.6
WGD_B02	Brunswick	Forklift in bagging area	Test results for the access routes	2.7

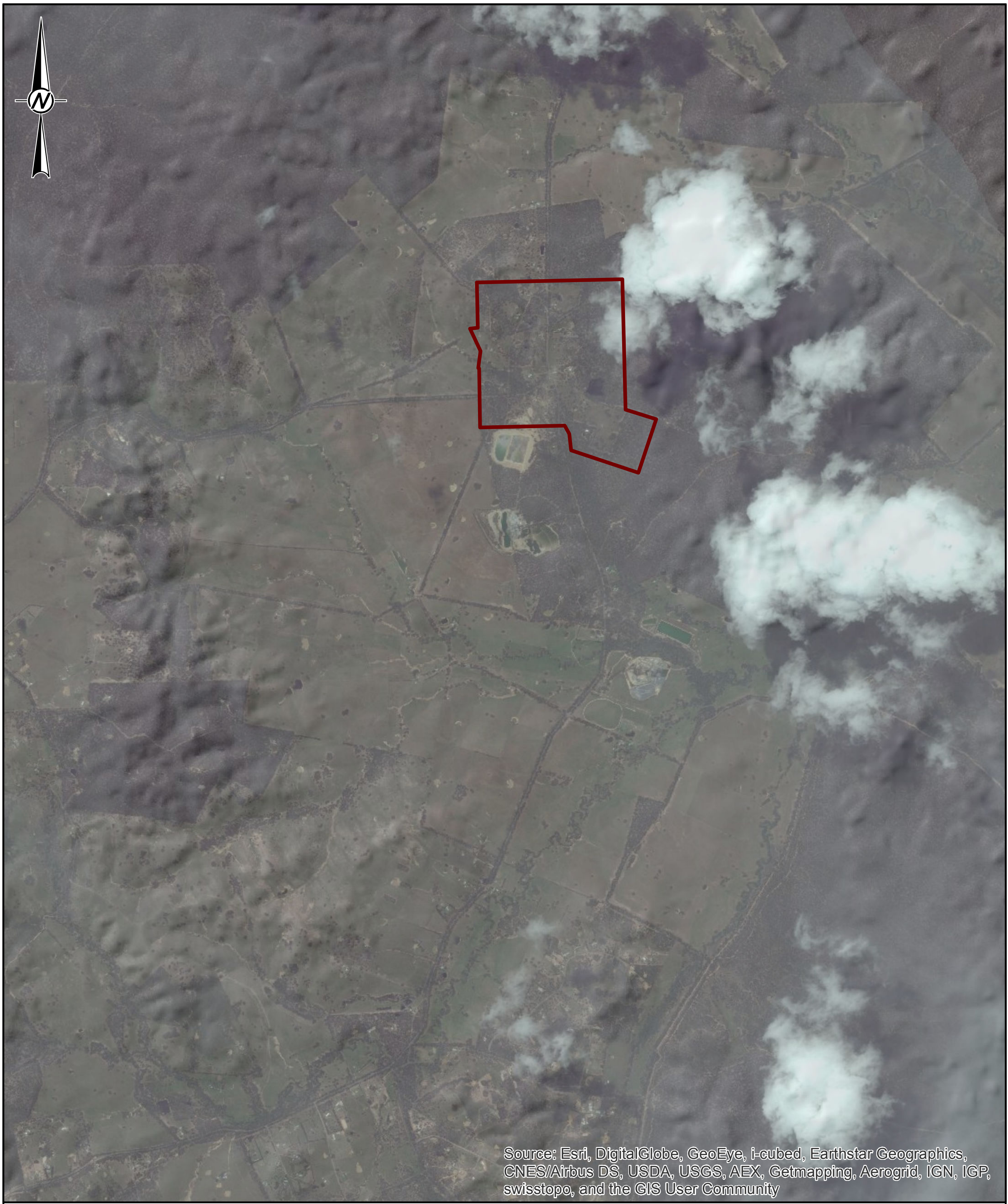
5.0 THE RECEIVING ENVIRONMENT

Costerfield is located approximately 100 km north of Melbourne and approximately 8 km east-north-east of Heathcote. The area immediately to the west of the Costerfield Mine is rural land used for sheep grazing, whilst the area immediately to the east and south is bushland with isolated dwellings. The Costerfield Town Hall and township is approximately 1.5 km north of the Brunswick Plant.

5.1 Topography

The Brunswick Plant and Augusta Mine site elevation ranges between 180 m and 200 m above sea level. The surrounding area has undulating terrain with the hills to the north rising to approximately 280 m and the hills to the west rising to approximately 220 m above sea level.

An overview of the topography of the site and surrounds is presented in Figure 9.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

LEGEND

▭ Approximate Costerfield Town Boundary

NOTES

1. Aerial imagery sourced from Esri Basemaps.
2. Hillshade created using 10 metre contours sourced from VicMap.

REFERENCE

1. Aerial imagery copyright ESRI.

DRAFT

0 125250 500 750 1,000 1,250
Metres

REFERENCE SCALE: 1:45,000 (at A4)
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
DEPARTMENT OF STATE DEVELOPMENT, BUSINESS AND INNOVATION (DSDBI)

PROJECT
DUST DEPOSITION MODELLING ASSESSMENT

TITLE
TOPOGRAPHY

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-11-21
PREPARED	JPH
DESIGN	-
REVIEW	JS
APPROVED	AB

PROJECT	CONSULTANT	Rev.	FIGURE
1413212	001-R	A	9

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: A4

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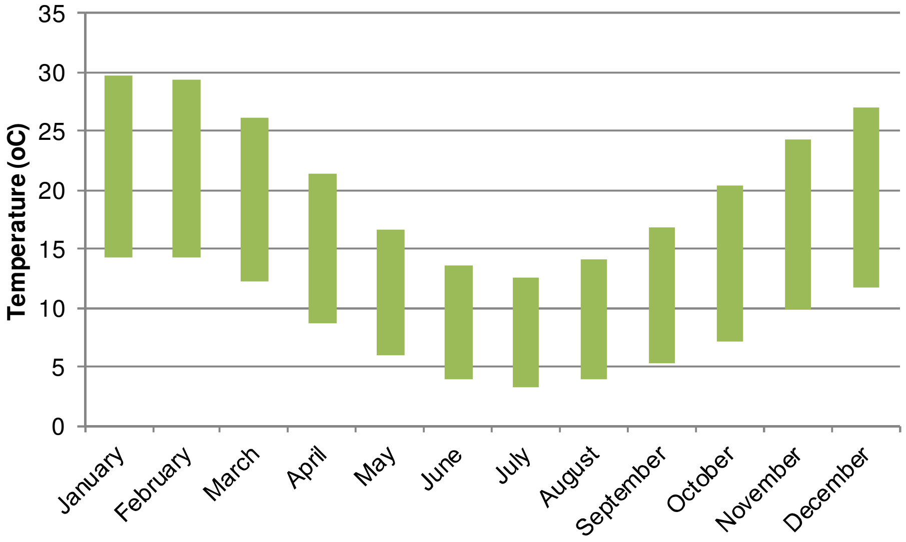
5.2 Meteorology

Meteorological parameters are routinely measured at Bureau of Meteorology (BOM) stations located at Redesdale and Mangalore; both located less than 40 km from the Costerfield Mine. Additionally, Mandalay recently established an onsite meteorological station to measure wind speed, wind direction, rainfall, temperature and humidity.

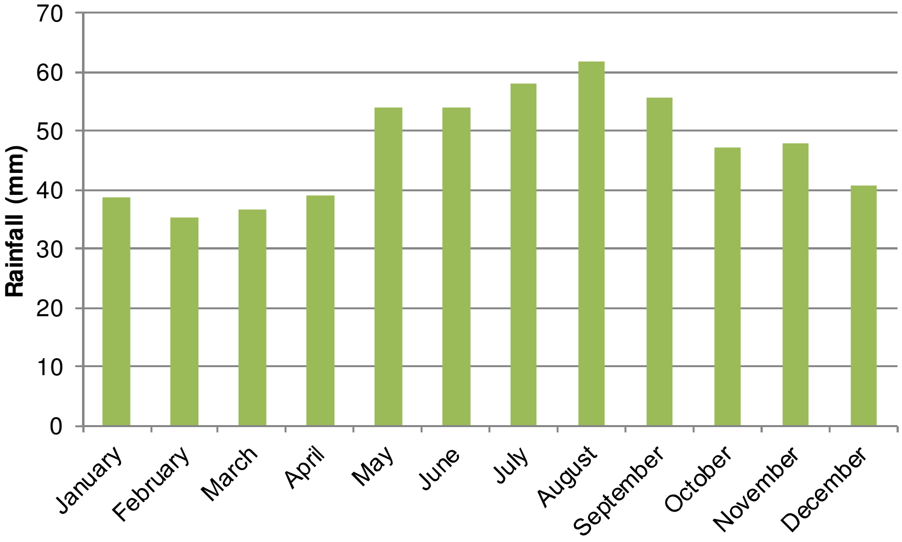
Long term average data is not yet available for the recently established site meteorological station nor for the BOM Redesdale Station. Hence long term receiving environment meteorological data has been sourced from the BOM Mangalore Station.

The monthly average minimum and maximum temperatures for the period 1959 to 2014 are presented in Figure 10. The annual average for the station is a minimum of 8.4℃ and a maximum of 21℃. Rainfall data for the period 1957 to 2014 is presented in Figure 11. A wind rose for the period 2009 to 2013 is presented in Figure 12. The prevailing winds are generally from the south-south-west.



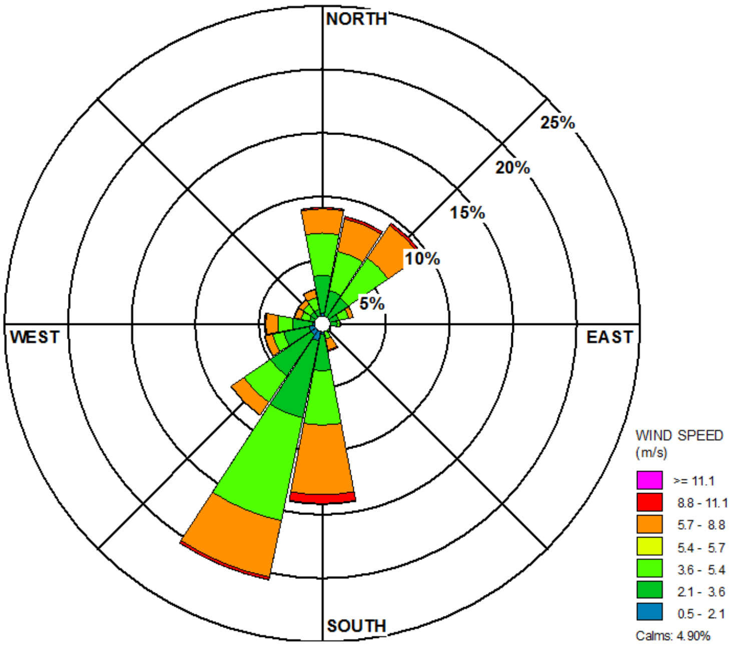
Source: (Bureau of Meteorology, 2014)

Figure 10: Mangalore BOM Station: Average Minimum and Maximum Temperature 1959 to 2014



Source: (Bureau of Meteorology, 2014)

Figure 11: Mangalore BOM Station: Average Rainfall 1957 to 2014



Source: (Bureau of Meteorology, 2014)

Figure 12: Mangalore BOM Station: Wind Rose 2009 to 2013

6.0 AIR QUALITY MODELLING

The assessment of the geographical extent of deposited dust impacts from Mandalay emission sources was undertaken using the AERMOD plume dispersion model. The meteorological component of the model was created using The Air Pollution Model (TAPM).

Further detail on both components, meteorology and air dispersion, are presented in the following sections.

6.1 Meteorological Modelling

AERMOD requires hourly surface meteorological observations and upper air observations for at least one year for input into the model. A site specific meteorological file was generated using the CSRIO prognostic model, TAPM; as the closest observations are recorded at Mangalore and are consequently not regarded as site specific.

The assessment year should represent a recent period and hence selection of the year was based on an analysis of the climate characteristics of 2008 to 2012 at the Mangalore BOM station. Temperature and rainfall data was examined to determine periods of warmer and drier meteorology corresponding to worst case dust generation conditions. The data is presented in Figure 13 and Figure 14, with statistics summarised in Table 8.

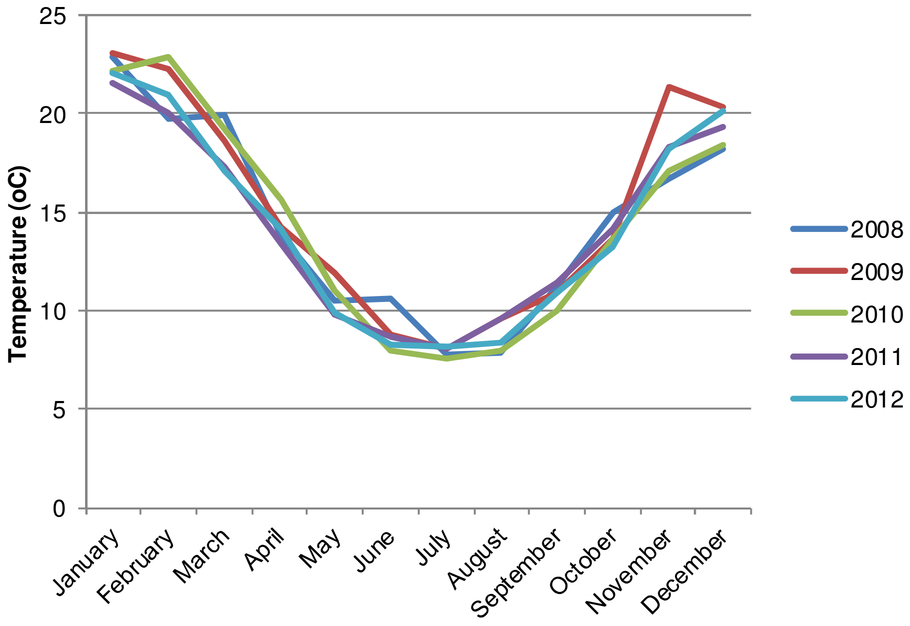


Figure 13: Mangalore BOM Station: Average Daily Temperature (°C)

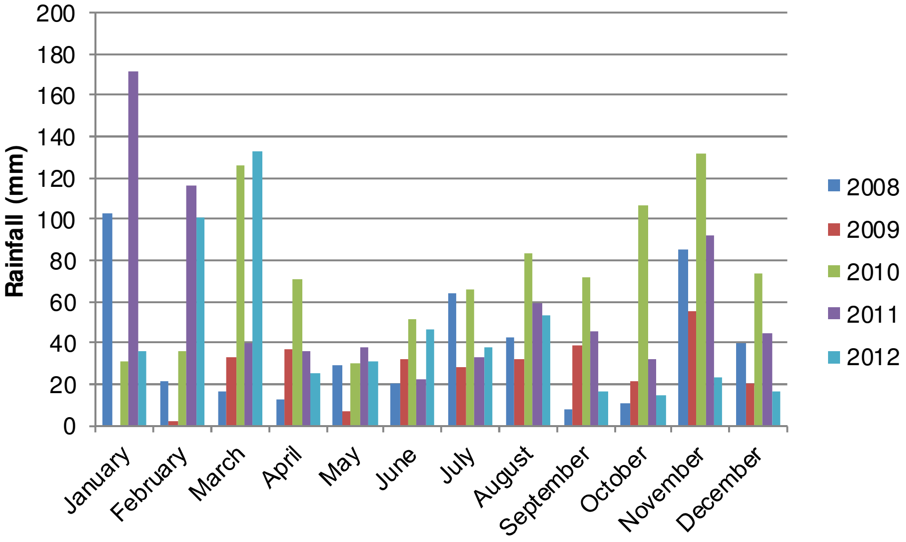


Figure 14: Mangalore BOM Station: Monthly Rainfall (mm)

Table 8: Mangalore BOM Station: Temperature and Rainfall Analysis

	2008	2009	2010	2011	2012
Mean Daily Average Temperature (℃)	14.5	15.3	14.5	14.3	14.3
Minimum Daily Average Temperature (℃)	7.8	8.0	7.6	8.1	8.2
Maximum Average Temperature (℃)	22.8	23.1	22.9	21.5	22.1
Annual Rainfall (mm)	453	307	879	732	536

The climate analysis for 2008 to 2012 indicates that there is little variability in daily average temperatures, with an approximate range of 1℃ between years. On average, 2009 recorded the highest daily average temperature. Rainfall statistics demonstrated greater variability with the wettest year being 2010 and the driest 2009. Consequently 2009 was selected as the prediction year in order to estimate worst case deposition impacts.

Preparation of the meteorological file included assimilation of measured data from the BOM Station located at Bendigo, approximately 50 km west-north-west of the Costerfield Mine. The meteorological file was validated using measured data from the Mangalore BOM Station. The file was prepared in accordance with EPA Victoria's draft publication number 1550 "Construction of Input Meteorological Data Files for EPA Victoria's Regulatory Air Pollution Model (AERMOD)".

Model settings and validation are presented in Appendix A.

6.2 Dispersion Modelling

AERMOD (Version 14134) was used for the calculation of deposited dust impacts associated with the Costerfield Mine. An overview of the model configuration is presented in Table 9, with further detail regarding depletion options and the modelling domain provided in the following sections.

Table 9: AERMOD Model Configuration

Parameter	Model
Model	AERMOD Version 14134
Meteorology	Site specific prepared using TAPM for 2009
Depletion options	Dry depletion
Pollutant	TSP, with the prediction of deposited dust
Background concentration	Not included[A]
Averaging period	Monthly
Exponential decay	None
Dispersion coefficient	Rural
Terrain included	Yes (90 m grid spacing)
Building downwash	Not included[B]
Output type	Deposition rate (g/m^2/month)

Notes

A Background concentrations are not included as the purpose of the assessment is to determine the geographical extent of deposited dust impacts associated with Costerfield Mine emission sources.

B Building downwash is not included as the point source ventilation shafts are not within the zone of influence of adjacent structures.

6.2.1 Depletion Options

Dust deposition impacts were modelled using dry depletion model settings which enable AERMOD to remove particle mass from the plume as it is deposited on the surface. The model enables either method 1 or method 2 for calculation of dry deposition. Method 1 can be applied under the USEPA “regulatory default option” and is used for sources where “a significant fraction of the total particulate mass has a diameter of 10 µm or larger or when the particle distribution is known” (United States Environmental Protection Agency, 2014). Method 1 particle phase options were selected for all sources included in the modelling assessment.

The approach was confirmed with EPA Victoria on 6 October 2014.

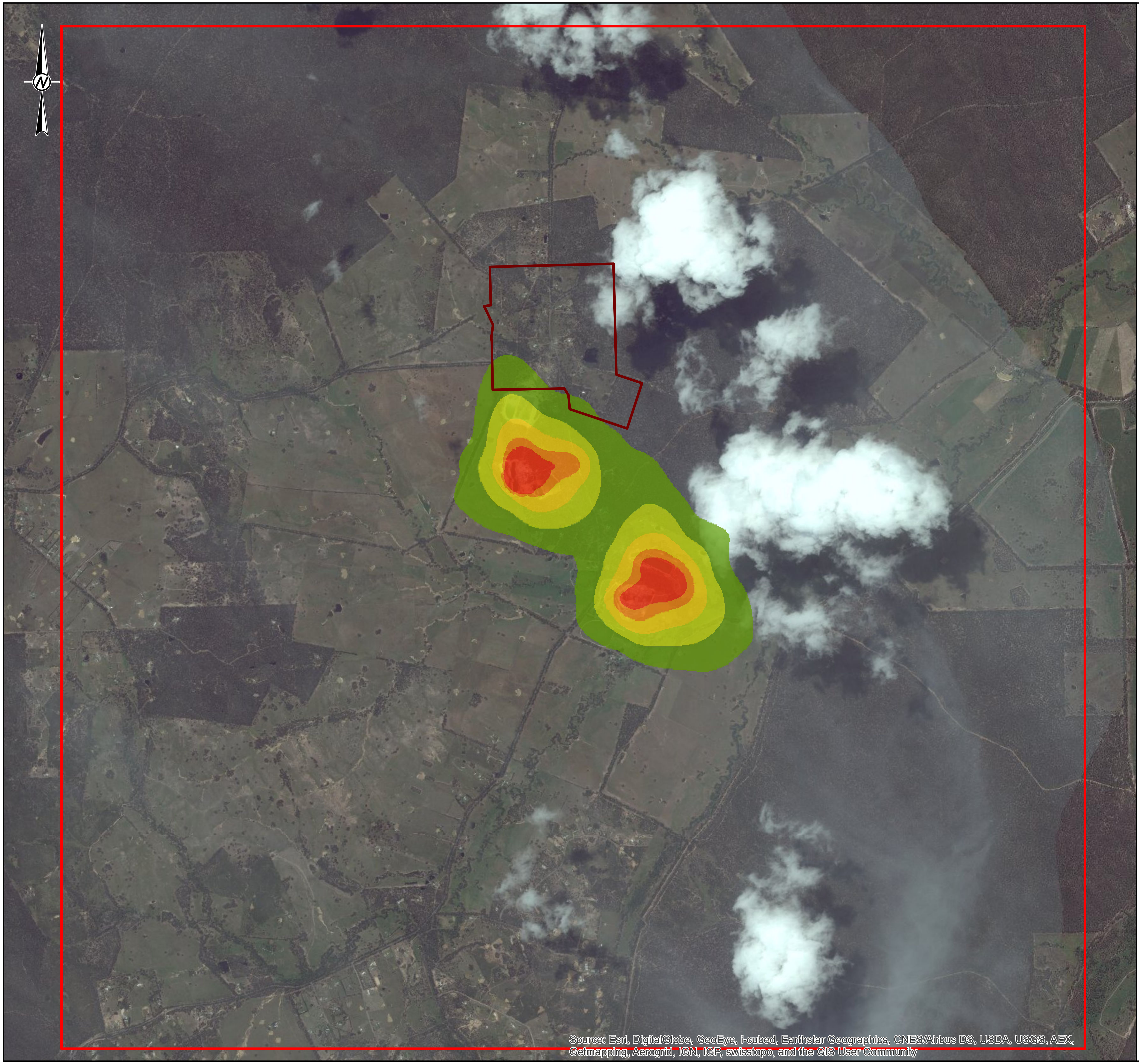
6.2.2 Modelling Domain

The modelling domain consisted of 10 square kilometres centred on the Costerfield Mine. Gridded receptors were placed at 50 m spacing across the domain. Discrete receptors were not included as the purpose of the assessment was to determine the geographical extent of deposited dust impacts rather than a compliance assessment at sensitive receptor locations beyond the site boundary.

The modelled domain included terrain data at 90 m spacing.

6.3 Results

The results of the modelling assessment are presented in the isopleth plot in Figure 15. The results indicate that worst case deposited dust impacts due to all modelled activities associated with the Augusta Mine, Brunswick Processing Plant and the haul routes between them are confined to areas immediately surrounding the mine and plant sites. Costerfield to the north of the sites is predicted to be only slightly impacted by deposited dust generated by mining activities (less than 1 g/m^2/month).



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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LEGEND

- ▭ Approximate Costerfield Town Boundary
- ▭ Model Domain

Worst Case Deposited Dust (g/m²/month)

(Averaging Period: 1 month)

- ☐ <0.5
- 🟩 0.5 - 1
- 🟨 1 - 2
- 🟨 2 - 5
- 🟧 5 - 10
- 🟥 >10

DRAFT

NOTES

1. Aerial imagery sourced from Esri Basemaps.

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0 630 1,260 1,890 2,520 3,150
METRES

REFERENCE SCALE: 1:36,705 (at A3)

PROJECTION: GDA 1994 MGA Zone 55

CLIENT
DEPARTMENT OF STATE DEVELOPMENT, BUSINESS AND INNOVATION (DSDBI)

PROJECT
DUST DEPOSITION MODELLING ASSESSMENT

TITLE
ISOPLETH PLOT OF DEPOSITED DUST (MONTHLY AVERAGE)

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-11-21
PREPARED	JPH
DESIGN	-
REVIEW	JS
APPROVED	AB

PROJECT No.	CONTROL	Rev.	FIGURE
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6.4 Model Validation

Deposited dust monitoring at eight locations in the vicinity of the mine has been conducted by the mine) since March 2006 using dust deposit gauges (DDG). The quality of the data is unknown due to the reported visible ingress of organic matter such as leaves, insects and bird droppings leading to numerous high results.

Figure 16 presents the DDG data for the period March 2006 to March 2014. Note that the mine has been operating in its current configuration since September 2012. The DDG locations are presented in Figure 17.

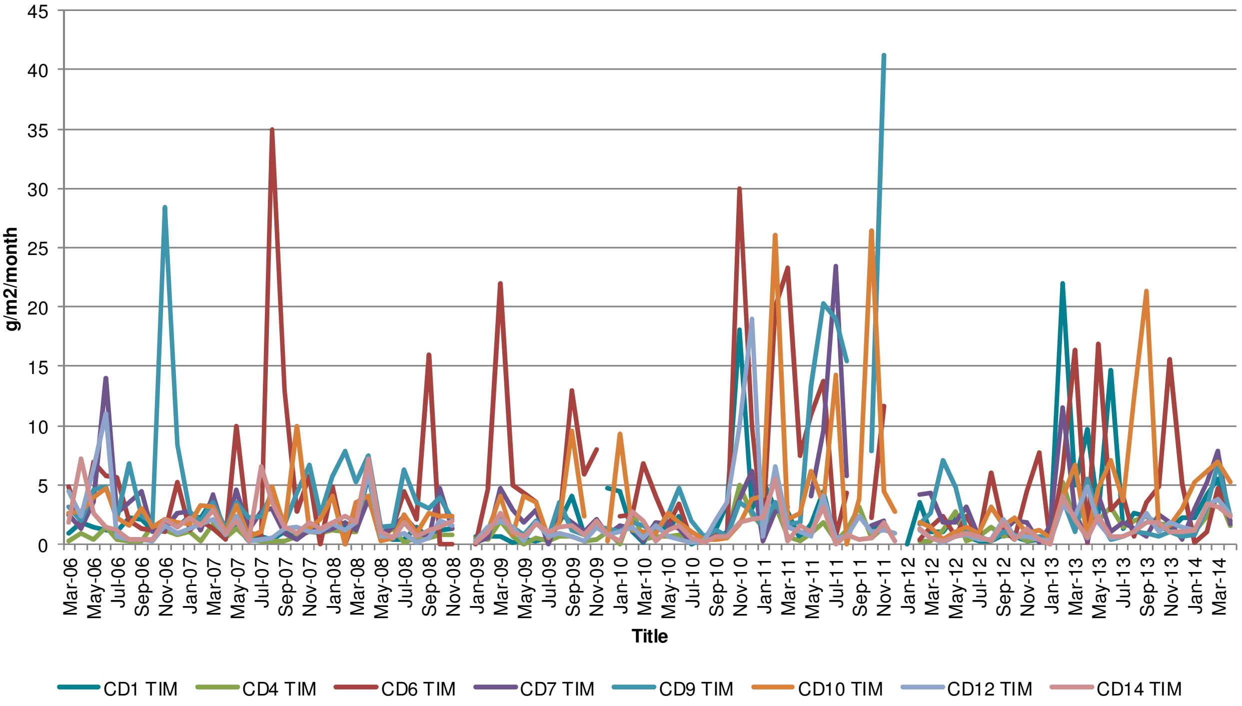

Figure 16: Mandalay Dust Deposit Gauge Data (March 2006 - March 2014)

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

LEGEND

▲ Dust Deposit Gauge Location

□ Approximate Costerfield Town Boundary

NOTES

1. Aerial imagery sourced from Esri Basemaps.
2. Dust Deposit Gauge Locations sourced from Mandalay Resources map. Date and accuracy is unknown.

REFERENCE

1. Aerial imagery copyright ESRI.

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REFERENCE SCALE: 1:18,000 (at A4)
PROJECTION: GDA 1994 MGA Zone 55

CLIENT
DEPARTMENT OF STATE DEVELOPMENT, BUSINESS AND INNOVATION (DSDBI)

PROJECT
DUST DEPOSITION MODELLING ASSESSMENT

TITLE
DUST DEPOSIT GAUGE LOCATIONS

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-11-21
PREPARED	JPH
DESIGN	-
REVIEW	JS
APPROVED	AB

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The maximum monthly and annual average dust deposition rates predicted by the model at the DDG locations are provided in Table 10 along with the corresponding DDG results.

Table 10: Deposited Dust Results: Predicted and Observed[1]

Dust Deposit Gauge Location	Maximum Deposition Rate			Average Deposition Rate	
	Predicted	Observed		Predicted	Observed
	(g/m^2/month)	Insoluble Solids (g/m^2/month)	Ash Content [2] (%)	(g/m^2/month)	Insoluble Solids (g/m^2/month)
CD1	3.4	22	66	2.2	3.4
CD4	1.5	5.2	100	0.83	1.7
CD6	0.60	17	33	0.26	4.1
CD7	1.9	12	100	1.3	2.5
CD9	0.87	6.8	50	0.73	2.0
CD10	0.38	21	50	0.23	4.0
CD12	0.83	4.8	38	0.64	1.5
CD14	0.88	4.1	93	0.59	1.4

Notes:

1	September 2012 – May 2014
2	Non-combustible fraction of insoluble solids

Of note is that the maximum deposited dust reported at CD6, CD9, CD10 and CD12 contained 50% or less ash content (non-combustible material) suggesting 50% or greater organic material, which would not be attributable to mining activity.

A true comparison between the predicted and observed results cannot be made because the observed data includes background deposited dust from wind erosion of exposed areas and wheel generated dust from several unsealed roads in the area not attributable to the mine operations. However Figure 18, which presents the predicted and observed maximum deposition rates, describes a good linear correlation between the data sets (R^2=0.92) if data from CD6 and CD10 are considered outliers and excluded. A slope of 6.6, however, suggests that the model does not predict the scale of the observed maximums well.

Figure 19 presents the predicted and observed average deposition rates and also describes a good linear correlation between the data sets (R^2=0.95) if data from CD6 and CD10 are excluded. A slope of 1.2, suggests that the model predicts the observed average deposition rates well, the intercept of 0.83 inferring the average background deposition rate.

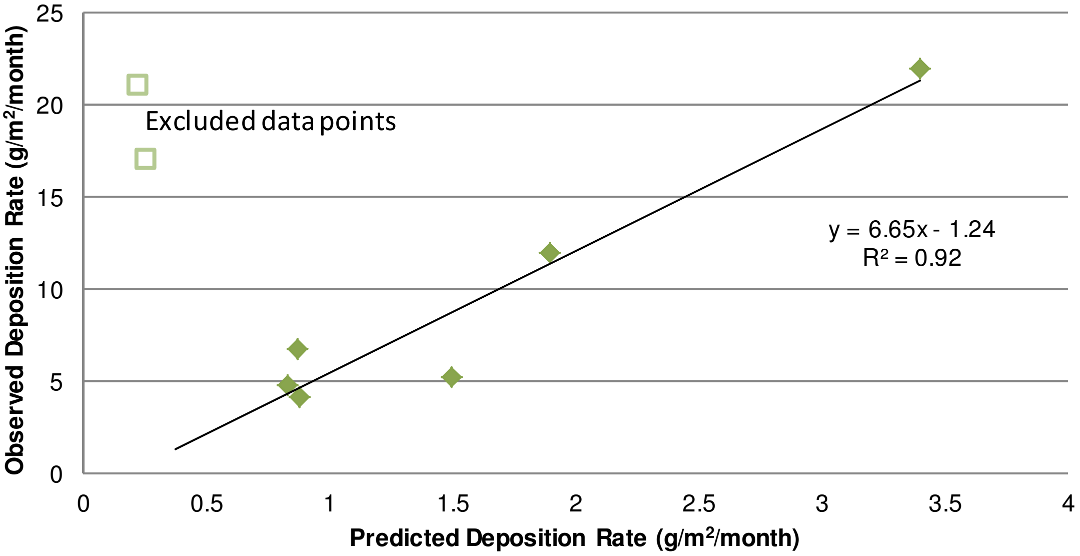

Figure 18: Maximum Dust Deposition Rate Comparison

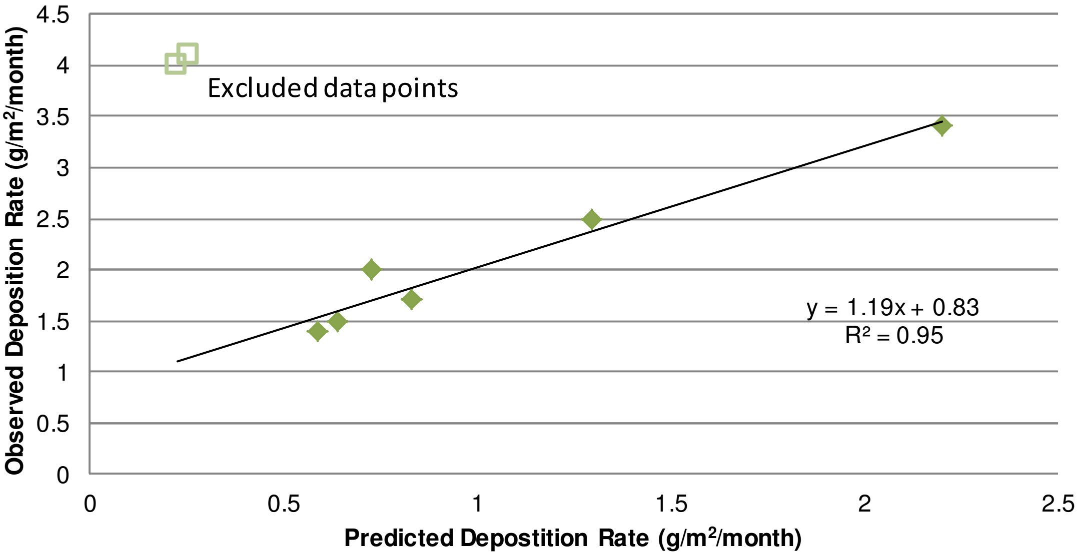

Figure 19: Average Dust Deposition Rate Comparison

7.0 CONCLUSION

The modelling results indicate that deposited dust attributable to the mine activities (including the August mine and the Brunswick processing plant) is for the most part confined to the sites and the land immediately surrounding them and does not impact the town of Costerfield.

The model study incorporates worst case elements in that no wet deposition has been included and wetting of exposed areas and roads due to rainfall has not been accounted for in developing the emissions inventory.

Historical dust deposition data has a number of high results, in some instances due to deposited matter other than dust generated by mining activities, which the model does not predict; however a good correlation between the average deposition rates is apparent.

8.0 LIMITATIONS

Your attention is drawn to the document - "Limitations", which is included as Appendix B to this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

9.0 ABBRIEVIATIONS

BOM	Bureau of Meteorology
DSDBI	Department of State Development, Business and Innovation (DSDBI)
Golder	Golder Associates Pty Ltd
GLC	Ground level concentrations
hr	Hour
Mandalay	Mandalay Resources
Mining PEM	Protocol for Environmental Management - Mining and Extractive Industries
NPI	National Pollutant Inventory
Run of Mine	ROM
SEPP(AQM)	State Environment Protection Policy (Air Quality Management)
TAPM	The Air Pollution Model
TSP	Total suspended particulate matter
USEPA	United States Environmental Protection Agency

9.1 Units

%	Percentage
℃	Degrees Celsius
g/cm^3	Grams per cubic centimetre

g/min	Grams per minute
ha	Hectares
kg/h	Kilograms per hour
km	Kilometre
km/h	Kilometres per hour
m	Metres
mm	Millimetres
m^2	Square metres
m/s	Metres per second
µm	Micron (micrometre)

10.0 REFERENCES

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Report Signature Page

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APPENDIX A

Meteorological Modelling

METEOROLOGICAL MODELLING

1.0 TAPM MODEL SET UP

Prognostic models, such as TAPM, solve the equations of atmospheric dynamics to produce physically realistic three-dimensional meteorological fields, such as wind, temperature, humidity, surface fluxes and boundary-layer structure. They are the models used in weather forecasting and climate research, and as a basis for dispersion modelling. Data from local climate stations are optional and local flows arise through the dynamic forcing simulated by the computational model. Larger-scale fields (up to global scale) are required for their initialization and ongoing boundary updates.

In accordance with EPA Victoria draft Publication No. 1550 *Construction of Input Meteorological Data Files for EPA Victoria's Regulatory Air Pollution Model (AERMOD)*, TAPM (Version 4.0) was used to generate synthetic meteorological data sets, which were pre-processed to create the surface and profile meteorology data sets used by AERMOD. TAPM is a PC-based model developed by CSIRO Marine and Atmospheric Research which is widely used throughout Australia for this purpose and is recognised by state regulatory authorities.

TAPM was run for the year 2009, assimilating climate data from the Bureau of Meteorology Bendigo Station (Table 1), with Bureau of Meteorology Mangalore Station used to validate the model output

Table 1: Meteorological Station Parameters

Station Name	**Bendigo (Station ID 081123)**
Location (UTM Coordinates [m]) Zone 55	261415, 5930780
Start and end dates	1 January 2009 to 31 December 2009
Data frequency	Hourly

TAPM was initially configured with a nested model grid coverage, designed to capture broad scale synoptic flows, regional and broader scale sea breezes and land breezes, regional and broader wind channelling around terrain features and the influence of land use.

The following TAPM setup was used:

- Outer grid resolution 10 km with nested grids of 3 km, 1 km and 300 m
- 41-by-41 horizontal grid points centred at the location of the required data point
- 25 vertical levels
- Nine-second terrain height database
- TAPM default databases for land use and sea surface temperature.

The parameters used for the model runs are shown in Table 2, and apply to the meteorological component of TAPM. The pollution dispersion components of TAPM have not been used. All other input parameters took default values. Graphical representations of the four grids are presented in Figure 1.

Table 2: TAPM Configuration Parameters

Parameter	Value
Start and end dates	1 January – 31 December, 2009
Grid Centre (Lat/Long, WGS84)	-36° 53'S , 144°47.5'E
Grid Centre (UTM Coordinates [m])	(303250, 5915350) UTM zone 55
No. of grids	4
No. of horizontal grid points	41 x 41
Horizontal grid spacing	10 km, 3 km, 1 km, 300 m
No. of vertical levels	25 (up to 8,000 m)
Monthly deep-soil moisture content (12 values)	0.15 m^3/m^3 (model default)
Topography	TAPM datasets
Vegetation and land use	TAPM datasets (manually adjusted with reference to aerial imagery)
Surface vegetation and precipitation processes	Included
Snow processes and non-hydrostatic processes	Excluded
Location of extracted profiles (UTM Coordinates [m])	(304398, 5817093) UTM zone 55

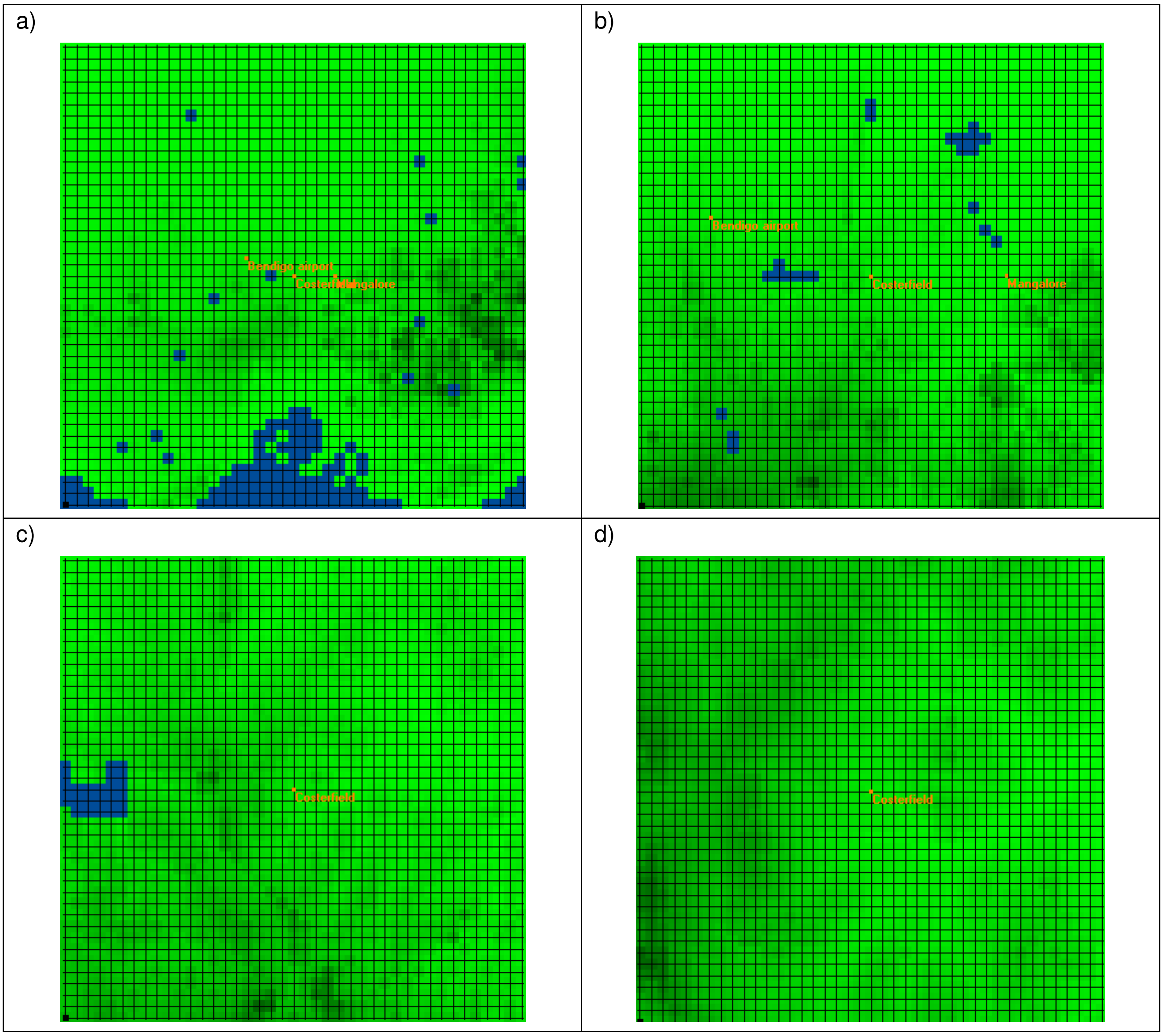


Figure 1: TAPM Grids (a) 10 km Resolution, (b) 3 km Resolution, (c) 1 km Resolution, (d) 300 m Resolution.

2.0 SITE TAPM SOLUTIONS

A synthetic meteorological datasets for the Costerfield Mine was extracted from the TAPM output. The annual wind rose for the TAPM model solution is presented in Figure 2.

The data indicates the following phenomena:

- Annual average wind speed is 3.5 m/s
- Overall, easterly winds are least likely to occur.

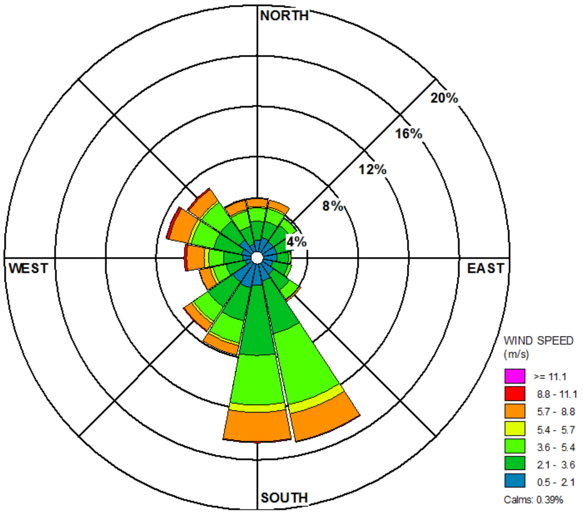


Figure 2: Wind Rose – Costerfield Mine TAPM 2009

3.0 TAPM SOLUTION VALIDATION

The distribution of wind speeds and directions as predicted by TAPM can be validated against a local observed source of meteorology, if available. In this regard, the observed winds at the Mangalore BOM station were used for validation (Table 3). Table 4 presents a comparison of simple summary statistics of the two data sets.

Table 3: TAPM Validation Parameters

Meteorological station used to validate model	Location of meteorological station (UTM Coordinates [m])	Location of extracted profile for validation against observations (UTM Coordinates [m])	Data Periods
Mangalore (Station ID 088109)	(338739, 5915649) UTM zone 55	(339250, 5915350) UTM zone 55	01 Jan 2009 – 31 Dec 2009

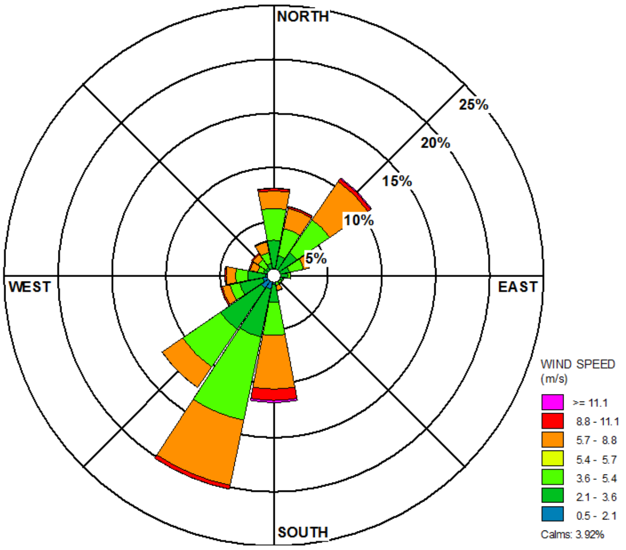
Table 4: Model Performance Statistics

Parameter	Statistic	Observed	Predicted
Wind Speed	Scalar mean	4.3	3.6
	Standard deviation	2.4	1.8
Wind Direction	Scalar mean	182	172
	Standard deviation	98	93

The annual and seasonal wind roses for the observed data and predicted data from the TAPM simulated meteorological file are presented in Figure 3 and Figure 4 respectively. The observed data wind roses generally depict a narrower range of wind directions than the predicted data and where as the obsereved data suggests a south-south-west predominance, the predicted data suggests a south to south-south-east predominance. However, while there are clear differences between the two datasets, the following phenomena are indicated by both data sets:

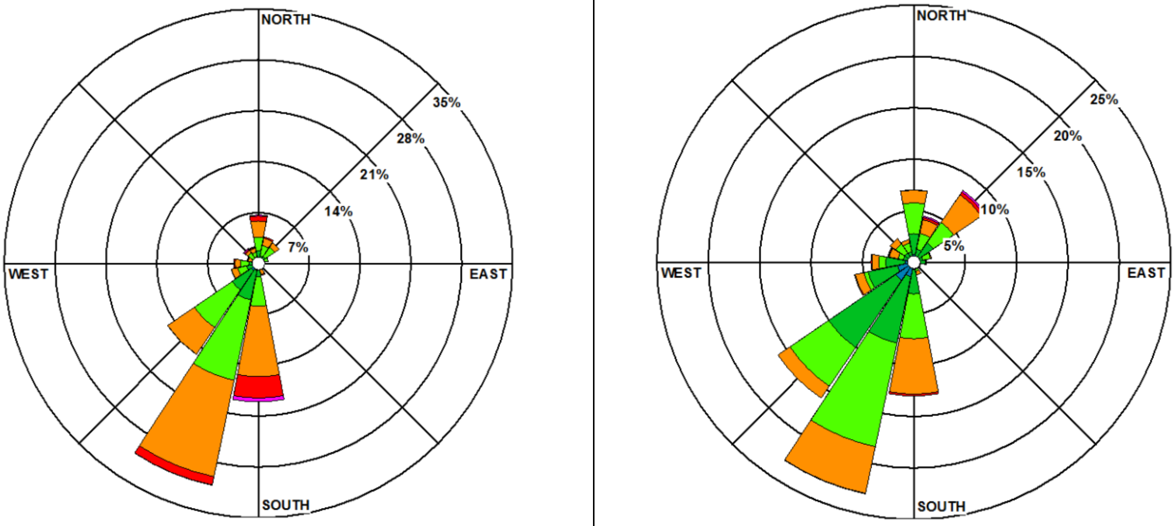
- Annually the wind direction is generally from the southern sectors
- Summer, autumn and spring winds are generally from the southern sectors
- Winter winds are generally from the northern sectors.

Annual



Summer (Dec – Feb)

Autumn (Mar – Apr)



Winter (May – Jul)

Spring (Aug – Nov)

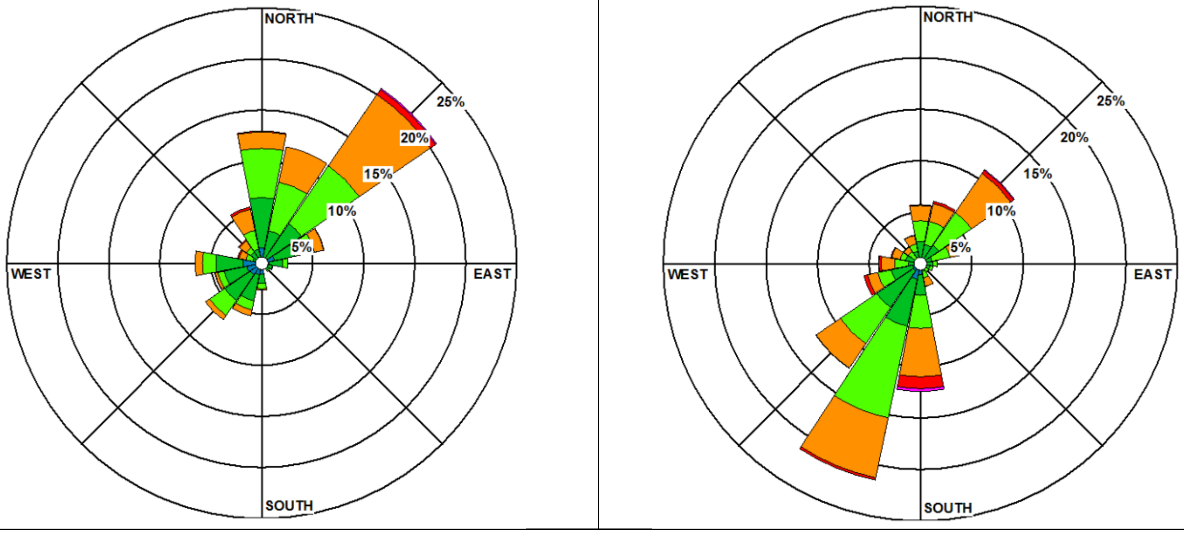


Figure 3: Wind Roses – Mangalore BOM 2009

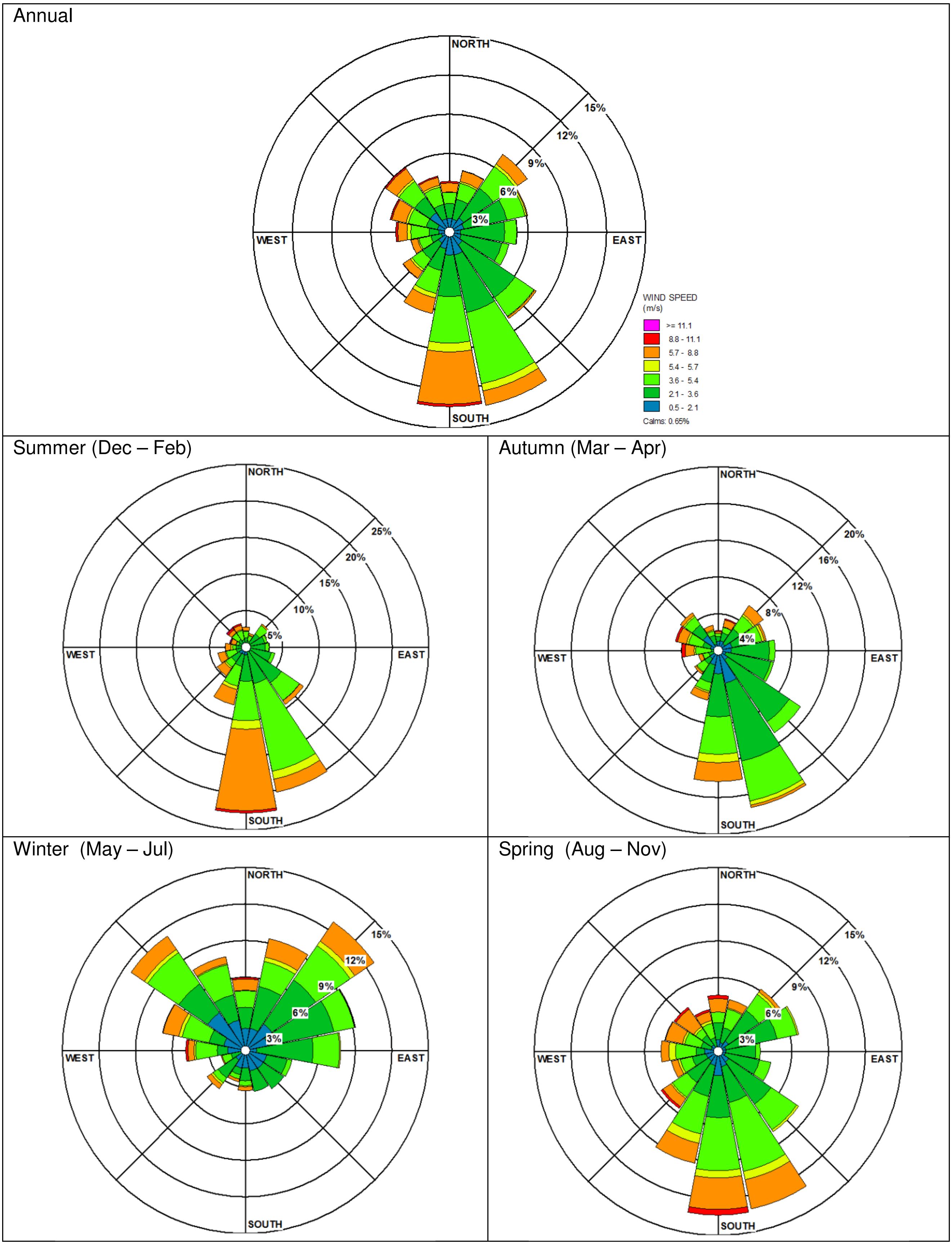


Figure 4: Wind Roses – Mangalore TAPM 2009

4.0 SITE METEOROLOGICAL FILES

The surface and upper air data generated by TAPM was used to develop surface and upper air files for input into AERMOD. The files were developed in accordance with EPA Victoria draft Publication No. 1550 *Construction of Input Meteorological Data Files for EPA Victoria's Regulatory Air Pollution Model (AERMOD).* Assumptions used in preparing the file are presented in Table 5.

Additionally, surface wind speed values less than 0.5 m/s for hourly events were treated as missing data within the file. The minimum wind speed is justified as low wind speed evaluation studies have reported that:

"modelling with wind speeds less than 0.5 m/s is not recommended as:

- *Steady state modelling assumptions are not valid*
- u_* *predictions are especially uncertain*
- *Meander concentration component too high in AERMOD*
- *Representativeness of wind questionable because winds are random*
- *Product of wind speed times sigma-y expected to be constant for low winds, so no higher concentrations expected for winds <0.5 m/s"* (Paine, 2003).

Table 5: Meteorological File Assumptions

Parameter	Value
Surface Roughness	0.4 (Low intensity residential)
Albedo	0.16 (Low intensity residential)
Bowen Ratio	0.80 (Low intensity residential)
Cloud Cover Source	BOM data (Melbourne)

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APPENDIX B

Limitations

LIMITATIONS

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1.0 INTRODUCTION

As part of the ongoing works to assess antimony levels within the environs of Costerfield, egg and sheep samples were collected and submitted for laboratory analysis in October 2014.

Sheep sampling was coordinated and undertaken by the former Department of Environment and Primary Industries (DEPI)[1] and analysis of sheep samples was completed by the National Measurement Institute (NMI). Egg samples were collected by Golder Associates (Golder) and analysis of egg samples was completed by NMI.

The following tables are referred to throughout and attached to this appendix:

- Table D4.1: Summary of Analytical Results – Sheep Tissue
- Table D4.2: Summary of Analytical Results – Eggs.

The laboratory reports from the National Measurement Institute are also attached to this Appendix.

2.0 SAMPLE ANALYSIS

2.1 Eggs

Golder collected 20 egg samples (4 eggs at each of 5 separate properties). The properties were selected to provide a broad geographical spread, both to the north and the south of the current mining operations.

Egg samples (comprising homogenised egg white and egg yolk) were submitted for analysis for a range of heavy metals including antinomy, arsenic, copper, iron, lead, manganese, mercury, zinc, cadmium and nickel.

2.2 Sheep

The selection and sampling of sheep was coordinated and undertaken by DEPI. A total of ten sheep from three properties, located north and south of Costerfield, were selected by DEPI and tissue subsamples were collected from muscle, heart, liver, kidney and lungs of each individual animal. The details of the sheep selected for sampling are provided in Table 1 below.

Table 1: Sheep Selected for Analysis[a]

Sample Number	Description of Animals	Body condition score (C/S)[b]	Comments
1 - 3	Sample 1: 2 year old ewe Samples 2 and 3: 12 month old hoggets	Ewe - moderate (C/S-2) Hoggets - Good (C/S 3)	Ewe was selected due to injury and was found to have only one functional kidney. No abnormalities detected in other animals
4 - 7	7 month old merino cross wether lambs	All in good condition (C/S-3)	No abnormalities detected
8 - 10	7 month old Dorper cross lambs	All in Good condition (C/S-3)	Lamb #8 had a minor developmental abnormality of the urethra which caused urine to issue from above the testicular pouch. It was selected because of this as it would have been unsuitable for sale. No abnormalities detected in other animals.

[a] Table adapted from personal correspondence (DEPI, 2015).
[b] Body condition score (1-5) used to assess the amount of tissue and fat covering the backbone and the short ribs of each sheep

Sheep samples were submitted for a range of heavy metals including antinomy, arsenic, copper, iron, lead, manganese, mercury, zinc, cadmium and nickel.

---

[1] Now Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR)

3.0 RESULTS

A summary of the individual sample results are provided in Tables D4.1 and D4.2 as attached. The laboratory reports are also included as an attachment at the end of this Appendix. A review of the results for sheep and egg testing is provided below.

3.1 Eggs

A summary of the analytical results (NMI 2014a) including mean and range is provided in Table 2 for eggs. The following observations were made:

- Concentrations of antimony, arsenic, cadmium, mercury and nickel in the egg samples were all below the limits of reporting (LOR).
- Concentrations of copper, iron, manganese and zinc were reported at detectable concentrations in all samples.
- Concentrations of lead were detected in 70% of samples.
- No apparent trends were observed for the analytical results of analysis for metals, however eggs from property ID 15 had consistently lower lead concentrations in comparison to lead results from other properties.

There are no available standards for concentrations of heavy metals in eggs.

Table 2: Egg Sampling Results (NMI 2014a)

Analyte	% <LOR[a]	Mean[b] (Range) mg/kg
Antimony	100	NA[c] (<0.01)
Arsenic	100	NA (<0.01)
Cadmium	100	NA (<0.01)
Copper	0	0.58 (0.45 - 0.76)
Iron	0	22.9 (18 - 29)
Lead	30	0.04 (<0.01 - 0.1)
Manganese	0	0.41 (0.19 - 0.69)
Mercury	100	NA (<0.01)
Nickel	100	NA (<0.01)
Zinc	0	13.6 (11 - 18)

[a] % <LOR refers to the number of results (%) reported as less than the limit of reporting (<LOR; <0.01).
[b] Where number of results <LOR is greater than 50% no mean is calculated as the answer would not be statistically significant.
[c] Where the number of results <LOR is less than 50%, <LOR values were assumed to be LOD/2 (0.01/2 = 0.005). NA = not applicable

3.2 Sheep

A summary of the results of the tissue sample from sheep (NMI 2014b, NMI 2015a, NMI 2015b), including mean and range, is provided in Table 3. Table 3 also provides a comparison of results against available Food Standards Australia and New Zealand (FSANZ) Maximum Level (ML)[2] guidelines, where one exists for that analyte.

All analytical results of sheep samples submitted for analysis were reported at less than the FSANZ Maximum Levels (tissue specific) (refer to Table 3).

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[2] ML refers to the maximum level of a specified contaminant or natural toxicant which is permitted to be present in a nominated food; expressed as mg toxicant per kg specified food item.

Table 3: Summary Sheep Subsample Results (NMI 2014b, NMI 2015a, NMI 2015b)

Analyte	Tissue	% <LOR[a]	Mean[b] (Range) mg/kg	FSANZ ML[d]	Samples > ML
Antimony	Muscle	90	NA[c] (<0.01 - 0.017)	-	NA
	Heart	100	NA (<0.01)	-	NA
	Lung	90	NA (<0.01 - 0.011)	-	NA
	Liver	60	NA (<0.01 - 0.035)	-	NA
	Kidney	80	NA (<0.01 - 0.034)	-	NA
Arsenic	Muscle	100	NA (<0.01)	-	NA
	Heart	100	NA (<0.01)	-	NA
	Lung	100	NA (<0.01)	-	NA
	Liver	100	NA (<0.01)	-	NA
	Kidney	100	NA (<0.01)	-	NA
Cadmium	Muscle	100	NA (<0.01)	0.05	None
	Heart	90	NA (<0.01 - 0.046)	-	None
	Lung	90	NA (<0.01 - 0.04)	-	None
	Liver	10	0.16 (<0.01 - 0.3)	1.25	None
	Kidney	10	0.14[e] (<0.01 - 0.5)	2.5	None
Copper	Muscle	0	0.79 (0.53 - 1)	-	NA
	Heart	0	2.73 (2.3 - 3.6)	-	NA
	Lung	0	11.7 (1.6 - 100)	-	NA
	Liver	0	120.6 (2.7 - 200)	-	NA
	Kidney	0	2.57 (2.1 - 2.8)	-	NA
Iron	Muscle	0	20.4 (17 - 24)	-	NA
	Heart	0	46.1 (38 - 54)	-	NA
	Lung	0	145.5 (77 - 220)	-	NA
	Liver	0	134.8 (42 - 240)	-	NA
	Kidney	0	142.8 (42 - 770)	-	NA
Lead	Muscle	100	NA (<0.01)	0.1	None
	Heart	90	NA (<0.01 - 0.027)	0.5[f]	None
	Lung	90	NA (<0.01 - 0.027)	-	None
	Liver	10	0.021 (<0.01 - 0.04)	0.5	None
	Kidney	10	0.015[g] (<0.01 - 0.02)	0.5	None
Manganese	Muscle	0	0.0909 (0.044 - 0.14)	-	NA
	Heart	0	0.297 (0.13 - 1.3)	-	NA
	Lung	0	0.42 (0.11 - 3)	-	NA
	Liver	0	2.5 (0.3 - 3.4)	-	NA
	Kidney	0	0.837 (0.14 - 1.2)	-	NA
Mercury	Muscle	100	NA (<0.01)	-	NA
	Heart	100	NA (<0.01)	-	NA
	Lung	100	NA (<0.01)	-	NA
	Liver	100	NA (<0.01)	-	NA
	Kidney	100	NA (<0.01)	-	NA
Nickel	Muscle	90	NA (<0.01 - 0.15)	-	NA
	Heart	90	NA (<0.01 - 0.021)	-	NA
	Lung	100	NA (<0.01)	-	NA
	Liver	60	NA (<0.01 - 0.016)	-	NA

Analyte	Tissue	% <LOR[a]	Mean[b] (Range) mg/kg	FSANZ ML[d]	Samples > ML
	Kidney	0	0.0201 (0.013 - 0.035)	-	NA
Zinc	Muscle	0	35.4 (20 - 49)	-	NA
	Heart	0	15.9 (13 - 20)	-	NA
	Lung	0	18.9 (13 - 39)	-	NA
	Liver	0	38.3 (15 - 52)	-	NA
	Kidney	0	21.4 (17 - 25)	-	NA

LOR = limit of reporting: FSANZ = Food Standards Australia and New Zealand; ML = Maximum Level; NA = not applicable

[a] % <LOR refers to the number of results (%) reported as less than the limit of reporting (<LOR; <0.01).

[b] Where number of results <LOR is greater than 50% no mean is calculated as the answer would not be statistically significant.

[c] Where the number of results <LOR is less than 50%, <LOR values were assumed to be LOD/2 (0.01/2 = 0.005).

[d] Food Standards Australia and New Zealand (FSANZ) Maximum Level (ML) guidelines; ML refers to the maximum level of a specified contaminant or natural toxicant which is permitted to be present in a nominated food (expressed as mg toxicant per kg specified food item).

[e] Kidney data point was rejected as the Ewe was selected due to injury and was found to have only one functional kidney; without rejecting this data point the mean would be 0.29 mg cadmium/ kg kidney and the maximum data point would be 1.6 mg/kg.

[f] Lead guideline for edible offal; edible offal assumed to be liver, heart and kidneys for sheep.

[g] Kidney data point was rejected as the Ewe was selected due to injury and was found to have only one functional kidney; without rejecting this data point the mean would be 0.019 mg lead/ kg kidney and the maximum data point would be 0.05 mg/kg.

3.3 Data for use in the Health Risk Assessment

As all the analytical results of sheep samples were reported at less than the FSANZ Maximum Levels (tissue specific) (refer to Table 3), there are no COPC that require further consideration in a HRA. However, as the soil and water data have identified antimony, arsenic and lead for inclusion in the HRA, the food contributions for these COPC have been included in the intake calculations.

For the purposes of the HRA, the environmental media inputs (e.g. soil, water, dust) have considered the average (mean) and an upper estimate (typically 95th percentile) concentration of the key contaminants. Given the limited number of data points, the mean concentration for eggs and all sheep tissue samples has been adopted for the 'average' scenario and the maximum concentrations of the contaminants have been adopted as the upper concentration estimate (Table 4). For these calculations, where a concentration is less than the LOR, the LOR value has been adopted for that individual result. Where both the mean and maximum are less than the LOR, 50% of the LOR will be adopted as the mean concentration and the LOR will be adopted as the upper concentration. Where this has occurred is identified by italics in Table 4.

Table 4: Food Concentrations for Health Risk Assessment

Contaminant	Sheep Tissue Concentration (mg/kg) (49 samples)		Egg Concentration (mg/kg) (20 samples)	
	Mean	Maximum	Mean	Maximum
Antimony	0.022	0.035	*0.005*	*0.01*
Arsenic	*0.005*	*0.01*	*0.005*	*0.01*
Lead	0.02	0.04	0.04	0.1

4.0 REFERENCES

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NMI (2014a). Report of Analysis. National Measurement Institute, Report No. RN1041212, 23, dated 23 October 2014.

NMI (2014b). Report of Analysis. National Measurement Institute, Report No. RN1049127, dated 17 December 2014.

NMI (2015a). Report of Analysis. National Measurement Institute, Report No. RN1054119, dated 5 February 2015.

NMI (2015b). Report of Analysis. National Measurement Institute, Report No. RN1054220, dated 6 February 2015.

WHO (2003). World Health Organisation. ‘Antimony in Drinking Water’, Background document for development of WHO *Guidelines for Drinking-water Quality*.

Table D4.1 Summary of Analytical Results – Sheep Tissue

	Laboratory Report Reference	Sample Number	Tissue	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
V14/027208	RN1049127	Number 1	Heart	<0.01	<0.01	<0.01	0.68	24	<0.01	0.087	<0.01	<0.01	43
V14/027212	RN1049127	Number 2	Heart	0.017	<0.01	<0.01	0.93	23	<0.01	0.075	<0.01	<0.01	35
V14/027216	RN1049127	Number 3	Heart	<0.01	<0.01	<0.01	0.53	19	<0.01	0.044	<0.01	<0.01	20
V14/027220	RN1049127	Number 4	Heart	<0.01	<0.01	<0.01	0.89	19	<0.01	0.094	<0.01	<0.01	49
V14/027224	RN1049127	Number 5	Heart	<0.01	<0.01	<0.01	0.70	18	<0.01	0.094	<0.01	<0.01	44
V14/027228	RN1049127	Number 6	Heart	<0.01	<0.01	<0.01	0.60	17	<0.01	0.059	<0.01	<0.01	33
V14/027232	RN1049127	Number 7	Heart	<0.01	<0.01	<0.01	0.82	23	<0.01	0.11	<0.01	<0.01	30
V14/027236	RN1049127	Number 8	Heart	<0.01	<0.01	<0.01	0.92	23	<0.01	0.14	<0.01	<0.01	40
V14/027240	RN1049127	Number 9	Heart	<0.01	<0.01	<0.01	0.83	18	<0.01	0.096	<0.01	0.15	35
V14/027244	RN1049127	Number 10	Heart	<0.01	<0.01	<0.01	1.6	190	<0.01	0.11	<0.01	<0.01	13
V14/027210	RN1049127	Number 1	Kidney	<0.01	<0.01	<0.01	3.6	50	<0.01	0.27	<0.01	<0.01	19
V14/027214	RN1049127	Number 2	Kidney	0.016	<0.01	0.64	23	240	0.036	2.7	<0.01	0.016	31
V14/027218	RN1049127	Number 3	Kidney	<0.01	<0.01	1.6	2.7	770	0.054	0.86	<0.01	0.013	23
V14/027222	RN1049127	Number 4	Kidney	0.011	<0.01	<0.01	1.8	89	<0.01	0.13	<0.01	<0.01	17
V14/027226	RN1049127	Number 5	Kidney	<0.01	<0.01	<0.01	2.7	38	<0.01	0.18	<0.01	<0.01	15
V14/027230	RN1049127	Number 6	Kidney	0.033	<0.01	0.17	83	86	0.020	2.6	<0.01	<0.01	52
V14/027234	RN1049127	Number 7	Kidney	0.034	<0.01	0.50	2.7	42	0.014	0.86	<0.01	0.027	25
V14/027238	RN1049127	Number 8	Kidney	<0.01	<0.01	<0.01	2.1	140	<0.01	0.11	<0.01	<0.01	18
V14/027242	RN1049127	Number 9	Kidney	<0.01	<0.01	<0.01	2.6	41	<0.01	0.13	<0.01	<0.01	14
V14/027246	RN1049127	Number 10	Kidney	<0.01	<0.01	0.30	190	200	0.018	2.5	<0.01	<0.01	45

	Laboratory Report Reference	Sample Number	Tissue	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
V14/027209	RN1049127	Number 1	Liver	<0.01	<0.01	0.18	2.5	88	0.012	0.78	<0.01	0.024	19
V14/027213	RN1049127	Number 2	Liver	<0.01	<0.01	<0.01	2.0	99	<0.01	0.13	<0.01	<0.01	18
V14/027217	RN1049127	Number 3	Liver	<0.01	<0.01	<0.01	2.6	42	<0.01	0.15	<0.01	<0.01	15
V14/027221	RN1049127	Number 4	Liver	0.012	<0.01	0.10	190	130	0.019	3.2	<0.01	<0.01	37
V14/027225	RN1049127	Number 5	Liver	<0.01	<0.01	0.15	2.8	63	0.019	1.2	<0.01	0.014	21
V14/027229	RN1049127	Number 6	Liver	<0.01	<0.01	<0.01	1.9	150	<0.01	0.12	<0.01	<0.01	18
V14/027233	RN1049127	Number 7	Liver	<0.01	<0.01	<0.01	2.9	51	<0.01	0.21	<0.01	<0.01	16
V14/027237	RN1049127	Number 8	Liver	<0.01	<0.01	0.14	130	130	0.017	2.6	<0.01	0.013	38
V14/027241	RN1049127	Number 9	Liver	<0.01	<0.01	0.18	2.8	79	0.015	0.96	<0.01	0.035	21
V14/027245	RN1049127	Number 10	Liver	<0.01	<0.01	<0.01	1.8	220	<0.01	0.12	<0.01	<0.01	17
V14/027207	RN1049127	Number 1	Lung	<0.01	<0.01	<0.01	2.6	45	<0.01	0.18	<0.01	<0.01	15
V14/027211	RN1049127	Number 2	Lung	<0.01	<0.01	0.033	150	130	0.016	1.9	<0.01	<0.01	40
V14/027215	RN1049127	Number 3	Lung	<0.01	<0.01	0.044	2.5	93	0.017	0.92	<0.01	0.016	23
V14/027219	RN1049127	Number 4	Lung	<0.01	<0.01	<0.01	2.0	190	<0.01	0.11	<0.01	<0.01	16
V14/027223	RN1049127	Number 5	Lung	<0.01	<0.01	<0.01	2.3	46	<0.01	0.15	<0.01	<0.01	13
V14/027227	RN1049127	Number 6	Lung	0.035	<0.01	0.072	200	150	0.026	3.1	<0.01	0.012	42
V14/027231	RN1049127	Number 7	Lung	0.017	<0.01	0.072	2.6	91	0.017	0.80	<0.01	0.013	22
V14/027235	RN1049127	Number 8	Lung	<0.01	<0.01	0.040	100	160	0.027	3.0	<0.01	<0.01	39
V14/027239	RN1049127	Number 9	Lung	<0.01	<0.01	0.046	2.4	54	0.027	1.3	<0.01	0.021	20
V14/027243	RN1049127	Number 10	Lung	<0.01	<0.01	<0.01	2.7	42	<0.01	0.30	<0.01	0.012	15
V15/001991	RN1054119	1	Muscle	<0.01	<0.01	<0.01	2.1	97	<0.01	0.14	<0.01	0.020	17
V15/001992	RN1054119	2	Muscle	<0.01	<0.01	<0.01	1.8	77	<0.01	0.22	<0.01	<0.01	16
V15/001993	RN1054119	3	Muscle	<0.01	<0.01	<0.01	2.4	41	<0.01	0.17	<0.01	<0.01	14

	Laboratory Report Reference	Sample Number	Tissue	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
V15/001994	RN1054119	4	Muscle	<0.01	<0.01	0.072	87	100	0.032	2.7	<0.01	<0.01	42
V15/001995	RN1054119	5	Muscle	<0.01	<0.01	0.062	2.3	48	0.020	0.75	<0.01	0.025	20
V15/001996	RN1054119	6	Muscle	<0.01	<0.01	<0.01	2.0	140	<0.01	0.15	<0.01	<0.01	17
V15/001997	RN1054119	7	Muscle	<0.01	<0.01	<0.01	3.2	53	<0.01	0.23	<0.01	<0.01	18
V15/001998	RN1054119	8	Muscle	<0.01	<0.01	0.051	150	140	0.025	3.4	<0.01	<0.01	41
V15/001999	RN1054119	9	Muscle	<0.01	<0.01	0.058	2.7	57	0.020	1.1	<0.01	0.014	23

Table D4.2: Summary of Analytical Results – Eggs

Laboratory Sample Reference	Laboratory Report Reference	Property ID	Sample Number	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
V14/022489	RN1041212	16	1	<0.01	<0.01	<0.01	0.60	21	0.031	0.51	<0.01	<0.01	13
V14/022490	RN1041212	16	2	<0.01	<0.01	<0.01	0.65	21	0.024	0.53	<0.01	<0.01	14
V14/022491	RN1041212	16	3	<0.01	<0.01	<0.01	0.65	26	0.036	0.54	<0.01	<0.01	18
V14/022492	RN1041212	16	4	<0.01	<0.01	<0.01	0.62	19	0.10	0.61	<0.01	<0.01	13
V14/022493	RN1041212	46	1	<0.01	<0.01	<0.01	0.63	21	0.076	0.23	<0.01	<0.01	14
V14/022494	RN1041212	46	2	<0.01	<0.01	<0.01	0.58	29	0.048	0.22	<0.01	<0.01	14
V14/022495	RN1041212	46	3	<0.01	<0.01	<0.01	0.58	25	0.021	0.19	<0.01	<0.01	11
V14/022496	RN1041212	46	4	<0.01	<0.01	<0.01	0.67	29	<0.01	0.23	<0.01	<0.01	15
V14/022497	RN1041212	15	1	<0.01	<0.01	<0.01	0.57	22	<0.01	0.39	<0.01	<0.01	14
V14/022498	RN1041212	15	2	<0.01	<0.01	<0.01	0.51	18	<0.01	0.26	<0.01	<0.01	11
V14/022499	RN1041212	15	3	<0.01	<0.01	<0.01	0.76	25	<0.01	0.30	<0.01	<0.01	17
V14/022500	RN1041212	15	4	<0.01	<0.01	<0.01	0.46	25	<0.01	0.27	<0.01	<0.01	12
V14/022501	RN1041212	30	1	<0.01	<0.01	<0.01	0.70	23	0.090	0.69	<0.01	<0.01	15
V14/022502	RN1041212	30	2	<0.01	<0.01	<0.01	0.59	23	0.027	0.44	<0.01	<0.01	15
V14/022503	RN1041212	30	3	<0.01	<0.01	<0.01	0.52	19	0.046	0.52	<0.01	<0.01	12
V14/022504	RN1041212	30	4	<0.01	<0.01	<0.01	0.55	18	0.049	0.39	<0.01	<0.01	14
V14/022505	RN1041212	28	1	<0.01	<0.01	<0.01	0.50	23	0.020	0.62	<0.01	<0.01	14
V14/022506	RN1041212	28	2	<0.01	<0.01	<0.01	0.45	21	0.018	0.53	<0.01	<0.01	12
V14/022507	RN1041212	28	3	<0.01	<0.01	<0.01	0.47	24	0.010	0.48	<0.01	<0.01	12
V14/022508	RN1041212	28	4	<0.01	<0.01	<0.01	0.54	26	<0.01	0.32	<0.01	<0.01	12

APPENDIX D4

Data Review - Food

ATTACHMENTS – Laboratory Reports

REPORT OF ANALYSIS

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/141009
		Quote No.	: QT-02039
		Order No.	: V352375
		Date Sampled	:
		Date Received	: 9-OCT-2014
Attention	FREYA AMON	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V14/022489	1	16/Egg 1
V14/022490	2	16/Egg 2
V14/022491	3	16/Egg 3
V14/022492	4	16/Egg 4

Lab Reg No.		**V14/022489**	**V14/022490**	**V14/022491**	**V14/022492**	
Sample Reference	**Units**	**1**	**2**	**3**	**4**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Copper	mg/kg	0.60	0.65	0.65	0.62	VL247
Iron	mg/kg	21	21	26	19	VL247
Lead	mg/kg	0.031	0.024	0.036	0.10	VL247
Manganese	mg/kg	0.51	0.53	0.54	0.61	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Zinc	mg/kg	13	14	18	13	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

23-OCT-2014

REPORT OF ANALYSIS

Report No. RN1041212

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/141009 : QT-02039 : V352375 : : 9-OCT-2014
Attention	FREYA AMON	**Sampled By**	: CLIENT
Project Name :			
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V14/022493	5	46/Egg 1
V14/022494	6	46/Egg 2
V14/022495	7	46/Egg 3
V14/022496	8	46/Egg 4

Lab Reg No.		**V14/022493**	**V14/022494**	**V14/022495**	**V14/022496**	
Sample Reference	**Units**	**5**	**6**	**7**	**8**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Copper	mg/kg	0.63	0.58	0.58	0.67	VL247
Iron	mg/kg	21	29	25	29	VL247
Lead	mg/kg	0.076	0.048	0.021	<0.01	VL247
Manganese	mg/kg	0.23	0.22	0.19	0.23	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Zinc	mg/kg	14	14	11	15	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

23-OCT-2014

REPORT OF ANALYSIS

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/141009
		Quote No.	: QT-02039
		Order No.	: V352375
		Date Sampled	:
		Date Received	: 9-OCT-2014
Attention	FREYA AMON	**Sampled By**	: CLIENT
Project Name :			
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V14/022497	9	15/Egg 1
V14/022498	10	15/Egg 2
V14/022499	11	15/Egg 3
V14/022500	12	15/Egg 4

Lab Reg No.	**Units**	**V14/022497**	**V14/022498**	**V14/022499**	**V14/022500**	**Method**
Sample Reference		**9**	**10**	**11**	**12**	
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Copper	mg/kg	0.57	0.51	0.76	0.46	VL247
Iron	mg/kg	22	18	25	25	VL247
Lead	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Manganese	mg/kg	0.39	0.26	0.30	0.27	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Zinc	mg/kg	14	11	17	12	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

23-OCT-2014

REPORT OF ANALYSIS

Report No. RN1041212

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/141009
		Quote No.	: QT-02039
		Order No.	: V352375
		Date Sampled	:
		Date Received	: 9-OCT-2014
Attention	FREYA AMON	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V14/022501	13	30/Egg 1
V14/022502	14	30/Egg 2
V14/022503	15	30/Egg 3
V14/022504	16	30/Egg 4

Lab Reg No.		**V14/022501**	**V14/022502**	**V14/022503**	**V14/022504**	
Sample Reference	**Units**	**13**	**14**	**15**	**16**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Copper	mg/kg	0.70	0.59	0.52	0.55	VL247
Iron	mg/kg	23	23	19	18	VL247
Lead	mg/kg	0.090	0.027	0.046	0.049	VL247
Manganese	mg/kg	0.69	0.44	0.52	0.39	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Zinc	mg/kg	15	15	12	14	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

23-OCT-2014

REPORT OF ANALYSIS

Report No. RN1041212

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/141009
		Quote No.	: QT-02039
		Order No.	: V352375
		Date Sampled	:
		Date Received	: 9-OCT-2014
Attention	FREYA AMON	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V14/022505	17	28/Egg 1
V14/022506	18	28/Egg 2
V14/022507	19	28/Egg 3
V14/022508	20	28/Egg 4

Lab Reg No.		**V14/022505**	**V14/022506**	**V14/022507**	**V14/022508**	
Sample Reference	**Units**	**17**	**18**	**19**	**20**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Copper	mg/kg	0.50	0.45	0.47	0.54	VL247
Iron	mg/kg	23	21	24	26	VL247
Lead	mg/kg	0.020	0.018	0.010	<0.01	VL247
Manganese	mg/kg	0.62	0.53	0.48	0.32	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Zinc	mg/kg	14	12	12	12	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

23-OCT-2014

Results relate only to the sample(s) tested.
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Australian Government

National Measurement Institute

REPORT OF ANALYSIS

Report No. RN1049127

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/141204
		Quote No.	: QT-02039
		Order No.	:
		Date Sampled	:
		Date Received	: 4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V14/027207	Number 1	Lung Collection Date 14/11/14 Time 14:00 pm
V14/027208	Number 1	Heart Collection Date 14/11/14 Time 14:00 pm
V14/027209	Number 1	Liver Collection Date 14/11/14 Time 14:00 pm
V14/027210	Number 1	Kidney Collection Date 14/11/14 Time 14:00 pm

Lab Reg No.		**V14/027207**	**V14/027208**	**V14/027209**	**V14/027210**	
Sample Reference	**Units**	**Number 1**	**Number 1**	**Number 1**	**Number 1**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	0.016	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	0.64	1.6	VL247
Copper	mg/kg	1.6	3.6	23	2.7	VL247
Iron	mg/kg	190	50	240	770	VL247
Lead	mg/kg	<0.01	<0.01	0.036	0.054	VL247
Manganese	mg/kg	0.11	0.27	2.7	0.86	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	0.016	0.013	VL247
Zinc	mg/kg	13	19	31	23	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

REPORT OF ANALYSIS

Report No. RN1049127

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/141204 : QT-02039 : : : 4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V14/027211	Number 2	Lung Collection Date 14/11/14 Time 14:00
V14/027212	Number 2	Heart Collection Date 14/11/14 Time 14:00 pm
V14/027213	Number 2	Liver Collection Date 14/11/14 Time 14:00 pm
V14/027214	Number 2	Kidney Collection Date 14/11/14 Time 14:00 pm

Lab Reg No.		**V14/027211**	**V14/027212**	**V14/027213**	**V14/027214**	
Sample Reference	**Units**	**Number 2**	**Number 2**	**Number 2**	**Number 2**	**Method**
Trace Elements						
Antimony	mg/kg	0.011	<0.01	0.033	0.034	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	0.17	0.50	VL247
Copper	mg/kg	1.8	2.7	83	2.7	VL247
Iron	mg/kg	89	38	86	42	VL247
Lead	mg/kg	<0.01	<0.01	0.020	0.014	VL247
Manganese	mg/kg	0.13	0.18	2.6	0.86	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	0.027	VL247
Zinc	mg/kg	17	15	52	25	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

REPORT OF ANALYSIS

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/141204
		Quote No.	: QT-02039
		Order No.	:
		Date Sampled	:
		Date Received	: 4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V14/027215	Number 3	Lung Collection Date 14/11/14 Time 14:20 pm
V14/027216	Number 3	Heart Collection Date 14/11/14 Time 14:20 pm
V14/027217	Number 3	Liver Collection Date 14/11/14 Time 14:20 pm
V14/027218	Number 3	Kidney Collection Date 14/11/14 Time 14:20 pm

Lab Reg No.		**V14/027215**	**V14/027216**	**V14/027217**	**V14/027218**	
Sample Reference	**Units**	**Number 3**	**Number 3**	**Number 3**	**Number 3**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	0.30	0.18	VL247
Copper	mg/kg	2.1	2.6	190	2.5	VL247
Iron	mg/kg	140	41	200	88	VL247
Lead	mg/kg	<0.01	<0.01	0.018	0.012	VL247
Manganese	mg/kg	0.11	0.13	2.5	0.78	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	0.024	VL247
Zinc	mg/kg	18	14	45	19	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

REPORT OF ANALYSIS

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/141204 : QT-02039 : : : 4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name :			
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V14/027219	Number 4	Lung Collection Date 21/11/14 Time 10:30
V14/027220	Number 4	Heart Collection Date 21/11/14 Time 10:30
V14/027221	Number 4	Liver Collection Date 21/11/14 Time 10:30
V14/027222	Number 4	Kidney Collection Date 21/11/14 Time 10:30

Lab Reg No.		**V14/027219**	**V14/027220**	**V14/027221**	**V14/027222**	
Sample Reference	**Units**	**Number 4**	**Number 4**	**Number 4**	**Number 4**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	0.012	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	0.10	0.15	VL247
Copper	mg/kg	2.0	2.6	190	2.8	VL247
Iron	mg/kg	99	42	130	63	VL247
Lead	mg/kg	<0.01	<0.01	0.019	0.019	VL247
Manganese	mg/kg	0.13	0.15	3.2	1.2	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	0.014	VL247
Zinc	mg/kg	18	15	37	21	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

REPORT OF ANALYSIS

Report No. RN1049127

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/141204
		Quote No.	: QT-02039
		Order No.	:
		Date Sampled	:
		Date Received	: 4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V14/027223	Number 5	Lung Collection Date 21/11/14 Time 10:45
V14/027224	Number 5	Heart Collection Date 21/11/14 Time 10:45
V14/027225	Number 5	Liver Collection Date 21/11/14 Time 10:45
V14/027226	Number 5	Kidney Collection Date 21/11/14 Time 10:45

Lab Reg No.		**V14/027223**	**V14/027224**	**V14/027225**	**V14/027226**	
Sample Reference	**Units**	**Number 5**	**Number 5**	**Number 5**	**Number 5**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	0.14	0.18	VL247
Copper	mg/kg	1.9	2.9	130	2.8	VL247
Iron	mg/kg	150	51	130	79	VL247
Lead	mg/kg	<0.01	<0.01	0.017	0.015	VL247
Manganese	mg/kg	0.12	0.21	2.6	0.96	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	0.013	0.035	VL247
Zinc	mg/kg	18	16	38	21	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

REPORT OF ANALYSIS

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/141204
		Quote No.	: QT-02039
		Order No.	:
		Date Sampled	:
		Date Received	: 4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V14/027227	Number 6	Lung Collection Date 21/11/14 Time 11:00
V14/027228	Number 6	Heart Collection Date 21/11/14 Time 11:00
V14/027229	Number 6	Liver Collection Date 21/11/14 Time 11:00
V14/027230	Number 6	Kidney Collection Date 21/11/14 Time 11:00

Lab Reg No.		**V14/027227**	**V14/027228**	**V14/027229**	**V14/027230**	
Sample Reference	**Units**	**Number 6**	**Number 6**	**Number 6**	**Number 6**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	0.033	0.044	VL247
Copper	mg/kg	1.8	2.6	150	2.5	VL247
Iron	mg/kg	220	45	130	93	VL247
Lead	mg/kg	<0.01	<0.01	0.016	0.017	VL247
Manganese	mg/kg	0.12	0.18	1.9	0.92	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	0.016	VL247
Zinc	mg/kg	17	15	40	23	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

REPORT OF ANALYSIS

Report No. RN1049127

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/141204 : QT-02039 : : : 4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name :			
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V14/027231	Number 7	Lung Collection Date 21/11/14 Time 11:15
V14/027232	Number 7	Heart Collection Date 21/11/14 Time 11:15
V14/027233	Number 7	Liver Collection Date 21/11/14 Time 11:15
V14/027234	Number 7	Kidney Collection Date 21/11/14 Time 11:15

Lab Reg No.		**V14/027231**	**V14/027232**	**V14/027233**	**V14/027234**	
Sample Reference	**Units**	**Number 7**	**Number 7**	**Number 7**	**Number 7**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	0.035	0.017	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	0.072	0.072	VL247
Copper	mg/kg	2.0	2.3	200	2.6	VL247
Iron	mg/kg	190	46	150	91	VL247
Lead	mg/kg	<0.01	<0.01	0.026	0.017	VL247
Manganese	mg/kg	0.11	0.15	3.1	0.80	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	0.012	0.013	VL247
Zinc	mg/kg	16	13	42	22	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

REPORT OF ANALYSIS

Report No. RN1049127

Client	: GOLDER ASSOCIATES PTY LTD	**Job No.**	:	GOLD15/141204
	BUILDING 7	**Quote No.**	:	QT-02039
	BOTANICCA CORPORATE PARK	**Order No.**	:	
	570-588 SWAN ST	**Date Sampled**	:	
	RICHMOND VIC 3121	**Date Received**	:	4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	:	CLIENT
Project Name :				
Your Client Services Manager	: Tim Stobaus	**Phone**	:	(03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V14/027235	Number 8	Lung Collection Date 1/12/14 Time 15:00
V14/027236	Number 8	Heart Collection Date 1/12/14 Time 15:00
V14/027237	Number 8	Liver Collection Date 1/12/14 Time 15:00
V14/027238	Number 8	Kidney Collection Date 1/12/14 Time 15:00

Lab Reg No.		**V14/027235**	**V14/027236**	**V14/027237**	**V14/027238**	
Sample Reference	**Units**	**Number 8**	**Number 8**	**Number 8**	**Number 8**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	0.040	0.046	<0.01	<0.01	VL247
Copper	mg/kg	100	2.4	2.7	2.1	VL247
Iron	mg/kg	160	54	42	97	VL247
Lead	mg/kg	0.027	0.027	<0.01	<0.01	VL247
Manganese	mg/kg	3.0	1.3	0.30	0.14	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	0.021	0.012	0.020	VL247
Zinc	mg/kg	39	20	15	17	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

REPORT OF ANALYSIS

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/141204
		Quote No.	: QT-02039
		Order No.	:
		Date Sampled	:
		Date Received	: 4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V14/027239	Number 9	Lung Collection Date 1/12/14 Time 15:30
V14/027240	Number 9	Heart Collection Date 1/12/14 Time 15:30
V14/027241	Number 9	Liver Collection Date 1/12/14 Time 15:30
V14/027242	Number 9	Kidney Collection Date 1/12/14 Time 15:30

Lab Reg No.		**V14/027239**	**V14/027240**	**V14/027241**	**V14/027242**	
Sample Reference	**Units**	**Number 9**	**Number 9**	**Number 9**	**Number 9**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	0.072	0.062	VL247
Copper	mg/kg	1.8	2.4	87	2.3	VL247
Iron	mg/kg	77	41	100	48	VL247
Lead	mg/kg	<0.01	<0.01	0.032	0.020	VL247
Manganese	mg/kg	0.22	0.17	2.7	0.75	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	0.025	VL247
Zinc	mg/kg	16	14	42	20	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

REPORT OF ANALYSIS

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/141204 : QT-02039 : : : 4-DEC-2014
Attention	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V14/027243	Number 10	Lung Collection Date 1/12/14 Time 16:00
V14/027244	Number 10	Heart Collection Date 1/12/14 Time 16:00
V14/027245	Number 10	Liver Collection Date 1/12/14 Time 16:00
V14/027246	Number 10	Kidney Collection Date 1/12/14 Time 16:00

Lab Reg No.		**V14/027243**	**V14/027244**	**V14/027245**	**V14/027246**	
Sample Reference	**Units**	**Number 10**	**Number 10**	**Number 10**	**Number 10**	**Method**
Trace Elements						
Antimony	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Cadmium	mg/kg	<0.01	<0.01	0.051	0.058	VL247
Copper	mg/kg	2.0	3.2	150	2.7	VL247
Iron	mg/kg	140	53	140	57	VL247
Lead	mg/kg	<0.01	<0.01	0.025	0.020	VL247
Manganese	mg/kg	0.15	0.23	3.4	1.1	VL247
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	VL247
Nickel	mg/kg	<0.01	<0.01	<0.01	0.014	VL247
Zinc	mg/kg	17	18	41	23	VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

17-DEC-2014

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REPORT OF ANALYSIS

Page: 1 of 1

Report No. RN1054220

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/150130 : QT-02039 : : : 30-JAN-2015
Attention	: NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name :			
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V15/002000	10	Skeletal Muscle of Sheep

Lab Reg No.		**V15/002000**				
Sample Reference	**Units**	**10**				**Method**
Trace Elements						
Antimony	mg/kg	<0.01				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	1.0				VL247
Iron	mg/kg	20				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.11				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	<0.01				VL247
Zinc	mg/kg	25				VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

6-FEB-2015

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Report No. RN1055265

Client	:	GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	:	GOLD15/150130 QT-02039 30-JAN-2015
Attention	:	NICHOLAS FOOT	**Sampled By**	:	CLIENT
Project Name	:				
Your Client Services Manager	:	Tim Stobaus	**Phone**	:	(03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V15/001991	1	Skeletal Muscle of Sheep

Lab Reg No.		**V15/001991**				
Sample Reference	**Units**	**1**				**Method**
Trace Elements						
Antimony	mg/kg	<0.01				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	0.68				VL247
Iron	mg/kg	24				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.087				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	<0.01				VL247
Zinc	mg/kg	43				VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

16-FEB-2015

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Report No. RN1055266

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/150130 : QT-02039 : : : 30-JAN-2015
Attention	: NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V15/001992	2	Skeletal Muscle of Sheep

Lab Reg No.		**V15/001992**				
Sample Reference	**Units**	**2**				**Method**
Trace Elements						
Antimony	mg/kg	0.017				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	0.93				VL247
Iron	mg/kg	23				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.075				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	<0.01				VL247
Zinc	mg/kg	35				VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

16-FEB-2015

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REPORT OF ANALYSIS

Page: 1 of 1

Report No. RN1055267

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/150130 : QT-02039 : : : 30-JAN-2015
Attention	: NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V15/001993	3	Skeletal Muscle of Sheep

Lab Reg No.		**V15/001993**				
Sample Reference	**Units**	**3**				**Method**
Trace Elements						
Antimony	mg/kg	<0.01				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	0.53				VL247
Iron	mg/kg	19				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.044				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	<0.01				VL247
Zinc	mg/kg	20				VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

16-FEB-2015

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REPORT OF ANALYSIS

Page: 1 of 1

Report No. RN1055268

Client : GOLDER ASSOCIATES PTY LTD
BUILDING 7
BOTANICCA CORPORATE PARK
570-588 SWAN ST
RICHMOND VIC 3121

Attention : NICHOLAS FOOT

Project Name :

Your Client Services Manager : Tim Stobaus

Job No. : GOLD15/150130

Quote No. : QT-02039

Order No. :

Date Sampled :

Date Received : 30-JAN-2015

Sampled By : CLIENT

Phone : (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V15/001994	4	Skeletal Muscle of Sheep

Lab Reg No.		**V15/001994**				
Sample Reference	**Units**	**4**				**Method**
Trace Elements						
Antimony	mg/kg	<0.01				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	0.89				VL247
Iron	mg/kg	19				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.094				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	<0.01				VL247
Zinc	mg/kg	49				VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

16-FEB-2015

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REPORT OF ANALYSIS

Page: 1 of 1

Report No. RN1055269

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	: GOLD15/150130
		Quote No.	: QT-02039
		Order No.	:
		Date Sampled	:
		Date Received	: 30-JAN-2015
Attention	: NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V15/001995	5	Skeletal Muscle of Sheep

Lab Reg No.		**V15/001995**				
Sample Reference	**Units**	**5**				**Method**
Trace Elements						
Antimony	mg/kg	<0.01				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	0.70				VL247
Iron	mg/kg	18				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.094				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	<0.01				VL247
Zinc	mg/kg	44				VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

16-FEB-2015

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REPORT OF ANALYSIS

Page: 1 of 1

Report No. RN1055270

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/150130 : QT-02039 : : : 30-JAN-2015
Attention	: NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V15/001996	6	Skeletal Muscle of Sheep

Lab Reg No.		**V15/001996**				
Sample Reference	**Units**	**6**				**Method**
Trace Elements						
Antimony	mg/kg	<0.01				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	0.60				VL247
Iron	mg/kg	17				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.059				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	<0.01				VL247
Zinc	mg/kg	33				VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

16-FEB-2015

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REPORT OF ANALYSIS

Page: 1 of 1
Report No. RN1055271

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.**	:	GOLD15/150130
		Quote No.	:	QT-02039
		Order No.	:	
		Date Sampled	:	
		Date Received	:	30-JAN-2015
Attention	: NICHOLAS FOOT	**Sampled By**	:	CLIENT
Project Name	:			
Your Client Services Manager	: Tim Stobaus	**Phone**	:	(03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V15/001997	7	Skeletal Muscle of Sheep

Lab Reg No.		**V15/001997**				
Sample Reference	**Units**	**7**				**Method**
Trace Elements						
Antimony	mg/kg	<0.01				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	0.82				VL247
Iron	mg/kg	23				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.11				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	<0.01				VL247
Zinc	mg/kg	30				VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

16-FEB-2015

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REPORT OF ANALYSIS

Page: 1 of 1

Report No. RN1055272

Client	: GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/150130 : QT-02039 : : : 30-JAN-2015
Attention	: NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V15/001998	8	Skeletal Muscle of Sheep

Lab Reg No.		**V15/001998**				
Sample Reference	**Units**	**8**				**Method**
Trace Elements						
Antimony	mg/kg	<0.01				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	0.92				VL247
Iron	mg/kg	23				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.14				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	<0.01				VL247
Zinc	mg/kg	40				VL247

Paul Adorno

Paul Adorno, Section Manager
Inorganics - Vic

16-FEB-2015

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National Measurement Institute

REPORT OF ANALYSIS

Page: 1 of 1

Report No. RN1055273

Client :	GOLDER ASSOCIATES PTY LTD BUILDING 7 BOTANICCA CORPORATE PARK 570-588 SWAN ST RICHMOND VIC 3121	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: GOLD15/150130 : QT-02039 : : : 30-JAN-2015
Attention :	NICHOLAS FOOT	**Sampled By**	: CLIENT
Project Name :			
Your Client Services Manager :	Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	**Sample Ref**	**Sample Description**
V15/001999	9	Skeletal Muscle of Sheep

Lab Reg No.		**V15/001999**				
Sample Reference	**Units**	**9**				**Method**
Trace Elements						
Antimony	mg/kg	<0.01				VL247
Arsenic	mg/kg	<0.01				VL247
Cadmium	mg/kg	<0.01				VL247
Copper	mg/kg	0.83				VL247
Iron	mg/kg	18				VL247
Lead	mg/kg	<0.01				VL247
Manganese	mg/kg	0.096				VL247
Mercury	mg/kg	<0.01				VL247
Nickel	mg/kg	0.15				VL247
Zinc	mg/kg	35				VL247

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Paul Adorno, Section Manager
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16-FEB-2015

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1.0 INTRODUCTION

Appendix D5 presents a summary of the surface dust program and the black dust sampling conducted by Golder in the Costerfield region. The data collected in these programs is summarised for completeness, it was not used in the HRA exposure assessment due to the limitations in the results as discussed below. The exposure to dust was included in the HRA using the air quality data (Appendix D3).

This Appendix describes the following for both the surface dust and black dust assessment:

- summary of the sampling approach and methodology
- summary of the results and statistical analysis of the data.

The following tables are referred to throughout and attached to this appendix:

- Table D5.1 – Swab Sample Analytical Results
- Table D5.2 – QAQC Analytical Results.

2.0 SURFACE DUST SAMPLING PROGRAM

Golder collected surface dust swab samples from four properties and a silage bag within Costerfield in May 2015. Samples were collected from residential properties to provide further information on the composition of dust in and around people's houses. Samples were collected from the silage bag to investigate the potential origin of a black dust which had settled on the silage bag. Further information on the sampling undertaken is presented in the following sections.

2.1 Property Sampling

The four properties from which dust samples were collected were Property 12, Property 27, Property 37 and Property 42. The properties were chosen primarily to gain a geographical spread of locations. The samples were collected to assist the understanding of outdoor and indoor dust.

Samples were collected from a range of indoor and outdoor surfaces. Inside surfaces were selected to reflect those with potential impacts from outside dust (e.g. window sills) and those less likely to be impacted by outside dust (e.g. bookshelf located away from any windows or doors). The results of swab sampling undertaken at residential properties are discussed in Section 3.0.

2.2 Black Dust Assessment

A Costerfield resident provided a sample of black dust which had deposited on their silage bags, during the Costerfield Environmental Review Committee (ERC) meeting on 7 May 2015. The Environment Protection Authority (EPA) and Golder carried out testing in separate events to investigate the composition of the dust. Golder collected two swab samples from the surface of the silage bag, one from the east and one from the west of the bag. The results of the silage bag sampling are discussed in Section 4.0, along with data provided by Mandalay Resources and the EPA in relation to the black dust.

2.3 Methodology

Surface dust swab samples were collected in general accordance with *ASTM D6966- 13: Standard Practice for Collection of Settled Dust Samples Using Wipe Sampling Methods for Subsequent Determination of Metals* (ASTM International, 2013).

2.4 Quality Control and Quality Assurance

The QA/QC procedures included the collection of a field blank, rinsates blank and trip blank sample. Analytical results for these samples are presented in Table D5.2, attached to this appendix. Analytical results of these samples were less than the detection limit with the exception of zinc. Blank samples of the surface dust swipes reported concentrations of zinc between 3,400 – 4,000 mg/m^2. For this reason, the results for zinc from the dust samples are not considered representative of surface dust concentrations. Information from the supplier indicated that the surface dust swipes may contain zinc and are therefore, not suitable to assess zinc concentrations. The data quality of remaining analytes was considered appropriate for this investigation.

3.0 PROPERTY RESULTS

The results of the swab sampling are presented in Table D5.1, attached to this appendix. Results are presented in milligrams per square metre (mg/m^2) indicating the mass of measured metals over an area.

Antimony was reported above the laboratory limit of reporting (LOR) for each of the samples collected from outdoor surfaces (such as outside walls, tables or objects). The concentration of antimony in surface dust samples taken from outside locations ranged from 200 to 17,300 mg/m^2. Generally, where samples were collected from two different sides of a house, the sample from the side which was closest to the road appeared to have the highest concentration of antimony. It is noted that the two highest antimony concentrations were reported for two outside samples collected from surfaces which were observed to be weathered and painted. Antimony is used as a fire retardant in paints and therefore, the surface where these samples were collected could have contributed to the reported antimony concentrations at these locations.

For indoor samples, antimony was detected above the LOR for samples collected from windowsills. Whereas, concentrations of antimony in samples collected from surfaces located away from doors or windowsills were below the laboratory LOR. One sample collected from a floor reported antimony above the LOR, although it is noted that this sample was collected near a door. These results indicate that the level of antimony in dust is likely to be greater outside of residences, compared to inside.

The swab sample results were compared to soil results for each of the properties. There was no observable trend between the two data sets.

3.1 Outcomes relevant to the HRA

Generally, samples collected from outside surfaces had higher reported antimony concentrations compared to inside surfaces. This data supports the conceptual site model (CSM) in that it is expect that exposure to dust is higher outside compared to inside houses.

As the surface dust sampling programme was limited, concentrations of antimony reported for air monitoring (refer Appendix D3) have been used in the health risk assessment (HRA) to estimate exposure from dust.

4.0 BLACK DUST ASSESSMENT

4.1 Black dust, Soil and Ore data

Golder was provided with results for a “swale” sample and “silage bag” sample collected for a Costerfield property and reported by Hg Recoveries Pty Ltd (Hg Recoveries) (in an email dated 14 May 2015 (Thornton: Frangos)). However, the data was inadequate for scientific interpretation for the following reasons:

- No units were provided with the data. Units are essential for the correct interpretation of the results.
- Some results were designated with zero values. An analytical result cannot be represented as zero as the analytical reporting/detection limit is normally above zero. It was noted that some values were entered as zero, others were entered as ND and others as “<” which were all presumed to denote non-detectable concentrations.
- The data presented indicates time-series data for collection with approximate 3 – 5 minute intervals from each of the two locations. Collection of data in this manner is not standard scientific practice and the reasoning for this sampling is unknown.

- The location of the sample locations could not be confirmed using the coordinates provided within the report. The coordinates do not match the location of the silage bag and there was no map provided to confirm the sample locations.
- No information was provided on the sample type or collection method (including whether or not quality control and quality assurance (QA/QC) procedures were implemented).

Golder has assumed that the antimony results presented are in mg/kg (based on a comparison to other results, which is discussed further below). The assumed average result for antimony reported by Hg Recoveries is 1,062 mg/kg for the swale sample and 252 mg/kg for the silage bag sample.

The Environment Protection Authority Victoria (EPA) provided Golder with the analytical results of three soil samples (two collected from “next to silage” and one “next to dam/dust monitoring”) and one ”powder” sample “off silage” (a sample of the black dust) (in email dated 20 July 2015 (Childs:Foot)). The results were presented in ALS Report number: 499722, dated 01 June 2015. As a part of this sampling the EPA collected QA/QC samples including a field blank, bottle blank and background sample. A review of the QA/QC procedures has not been undertaken by Golder, as it has been assumed this has been completed by the EPA.

Golder has compared the highest concentration from the two samples collected next to the silage bags (sample IDs 08351/1 and 08351/6) against the powder result (sample ID 08351/5) and relevant Health-based Investigation Levels (HIL) (NEPC 2013) in Table 1 below.

Table 1: Analytical results of dust and soil samples collected by the EPA compared to adopted assessment criteria

Metal*	**Silage Bag Powder Concentration (mg/kg)**	**Highest Concentration in Soil at the Base of the Silage Bag (mg/kg)**	**NEPM HIL ****
Antimony	140	16	200***
Arsenic	< 5	14	100
Chromium (VI)	11	21	100
Cobalt	5	5	100
Copper	20	10	6000
Lead	15	14	300
Manganese	110	440	3800
Mercury (inorganic)	0.27	<0.05	40
Nickel	16	13	400
Selenium	3	<3	200

Notes:

Aluminium, barium, and iron are not considered to be chemicals of interest for the investigation and were generally within background ranges (within or below estimated crustal abundance) (EPA, 2015).

**Health investigation levels (HIL) for soil contaminants Table 1A(1) NEPM (Assessment of Site Contamination) 1999 (NEPC, 2013).

***HIL for antimony derived by Golder as a part of the HRA.

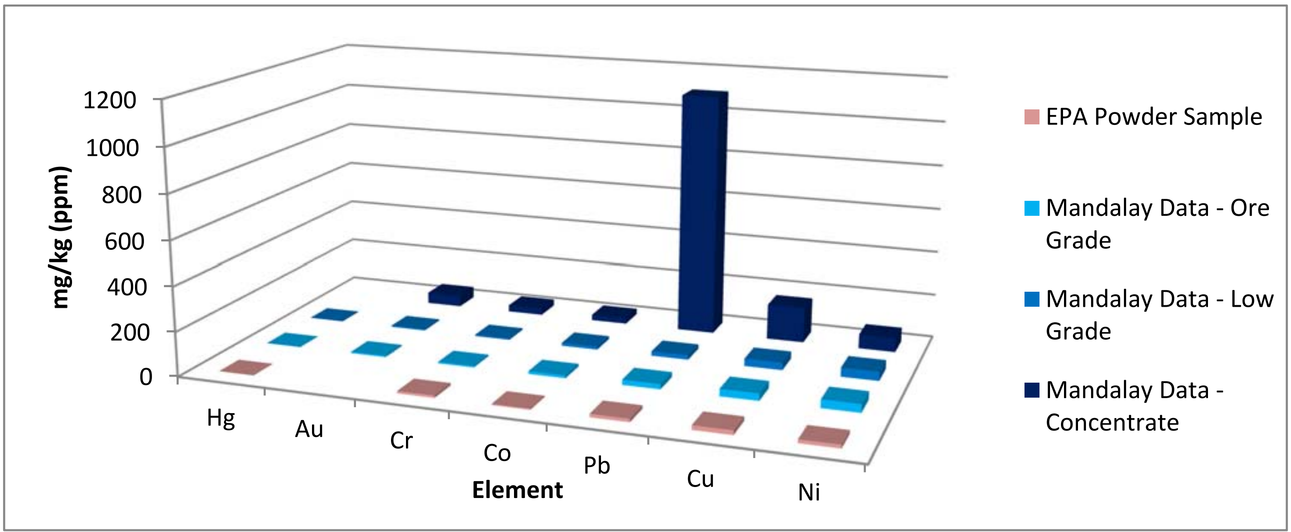
Results of the EPA's sampling reported that the concentration of antimony in the black powder on the silage bag was 140 mg/kg and the highest concentration of antimony is soils at the base of the silage bag was 16 mg/kg. The reported antimony concentrations for the powder sample and soil samples were less than the derived Health Investigation Levels (HILs) (NEPC, 2013). The EPA powder result appears relatively consistent with the 252 mg/kg reported by Hg Recoveries for the black powder (assuming the results obtained by Hg Recoveries were in mg/kg).

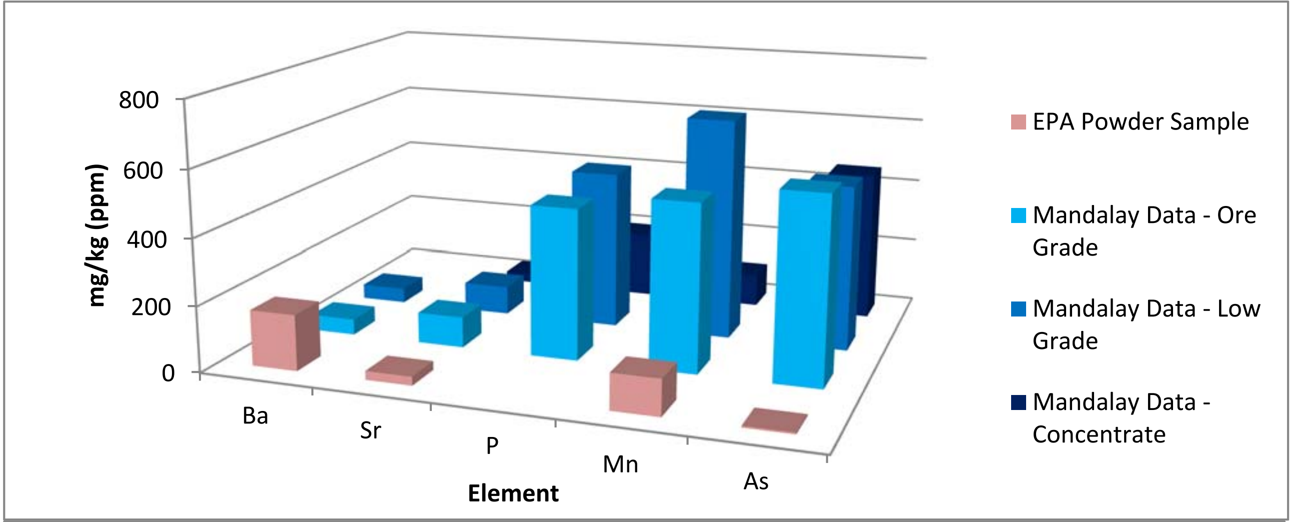
The following is noted regarding localised and regional antimony soil concentrations in the vicinity of the silage bag:

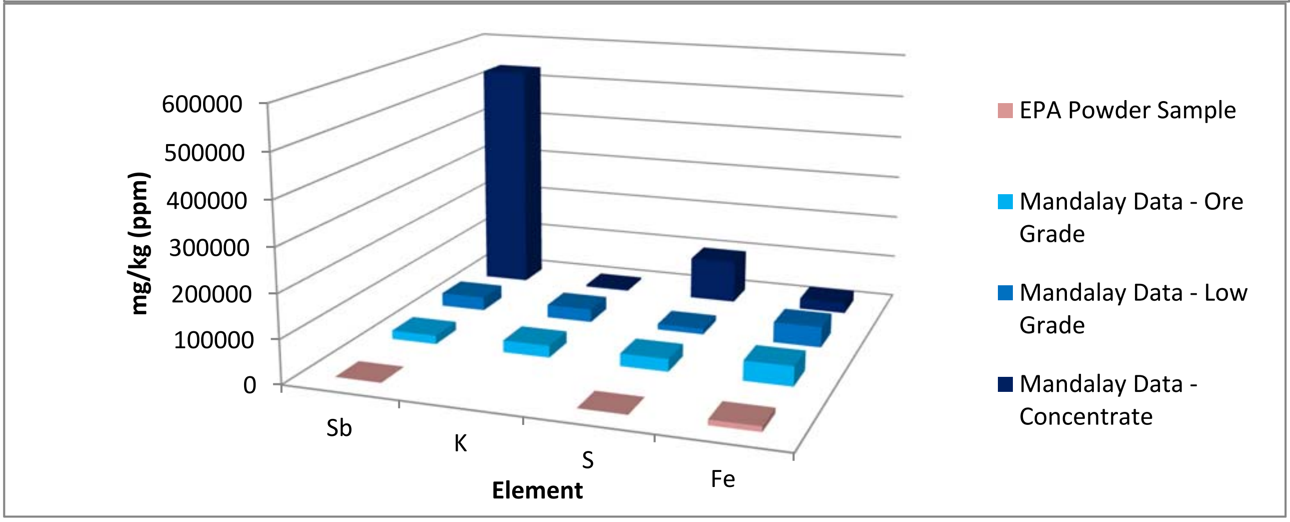
- The *Desktop Review: Antimony in the Costerfield Area* (included in Appendix A of the HRA report) presented a summary of Department of Environment and Primary Industries (DEPI) data for soil and bedrock samples collected from within the Costerfield Dome area. The review found the 95% upper confidence limit (UCL) of the mean antimony concentration for soils at 0 to 0.3 meters below ground level (m bgl) was 47.6 mg/kg.
- Golder's sampling of shallow soil (0-0.3 m bgl) within a 1 km radius of the silage bag reported concentrations of antimony ranging from < 5 mg/kg (detection limit) to 210 mg/kg. The maximum antimony concentration reported for soil samples collected from the property where the silage bag was located (Property 50) was 52 mg/kg.
- Mandalay Resources (Mandalay) collected soil samples in June 2015 from across the property (results provided to Golder in an email dated 16 June 2015 (Bruans:Amon)). The sampling found the concentration of antimony was <33 mg/kg, with the exception of two soil samples collected from approximately 800 m north-east of the silage bag. These samples had antimony concentrations of 67.2 mg/kg and 223 mg/kg. Mandalay indicated these results correlate with the Brunswick lode, which is an area of mineralisation characterised by high antimony anomalism.
- The highest concentration of antimony for the two soil samples collected from the base of the silage bag was 16 mg/kg.

Based on this, the 140 mg/kg of antimony reported for the powder sample collected by the EPA appears consistent with regional antimony soil concentrations. Although it is noted that soil within the immediate vicinity of the silage bag appeared to have lower antimony concentrations than that reported for the powder result and for the general Costerfield area.

The results of the EPA powder sample have been compared to Mandalay data for "Ore Grade" and "Low Grade" material (provided in an email dated 27 August 2014 (Thornton:Frangos)) and "Concentrate" material (provided in an email dated 7 July 2015 (Place:Frangos)). The comparison is presented in Graph Series 1. The antimony concentration report in the powder sample is approximately 3800 times less than the reported antimony concentration in the Concentrate and 140 to 225 times less than the reported concentration in Ore Grade and Low Grade material. The concentration of arsenic in the powder sample was approximately 90 times less than in the Concentrate sample and the concentration of sulphur was approximately 30,000 times less. A similar trend was observed between the powder sample and the Ore Grade/Low Grade material for arsenic (approximately 100 to 115 times less) and sulphur (approximately 4,000 to 10,000 times less).







Graph Series 1: Comparison of EPA powder sample results to Mandalay data for Ore Grade, Low Grade and Concentrate material

4.2 Surface dust samples

As discussed above, Golder undertook surface dust (swab) sampling on 25 May 2015. Two samples were collected from the surface of the silage bag, one on the eastern side and one on the southern side.

The results of the swab sampling are presented in Table D5.1, attached to this appendix. The maximum reported antimony concentration for the surface dust samples collected from the silage bag was 600 mg/m^2. No surface dust criteria were available for comparison of this result.

The results of surface dust samples were reported in mg/m^2 and therefore cannot be compared to concentrations of antimony in soil samples (reported in mg/kg). However, a comparison can be made to other surface dust samples and dust deposition data. As discussed in Section 3.0, the concentration of antimony in surface dust samples taken from outside locations ranged from 200 to 17,300 mg/m^2. Based on this, the maximum concentration reported for the silage bag surface dust samples (600 mg/m^2) appears consistent with the range seen for surface dust samples collected from outside surfaces in Costerfield.

Mandalay's dust gauge CD06 is located between the location of the processing plant and the silage bag. Monthly dust monitoring results from this gauge, from October 2014 until June 2015, indicated a monthly antimony deposition range of less than the detection limit (0.0005 mg/m^2 per month) to 2.4 mg/m^2 per month, with an average of 1 mg/m^2 per month. The deposition results during this period (October to June 2015) did not indicated a dust deposition event which could have resulted in the concentration observed on the silage bag, assuming dust was moving from the processing plant towards the silage bag.

4.3 Summary

The key findings of the black dust review can be summarised as follows:

- The EPA sampled the black powder from the silage bag and reported that concentrations of the metals analysed were below NEPM HILs. The 140 mg/kg of antimony reported for the powder sample appears consistent with regional antimony soil concentrations. Although it is noted that soil within the immediate vicinity of the silage bag appeared to have lower antimony concentrations than that reported for the powder result and for the general Costerfield area.
- The EPA's powder result was compared to the Ore data provided by Mandalay. The powder antimony concentration is notably less than the reported concentration of antimony in Ore Grade and Low Grade material.
- The maximum concentration reported for the silage bag surface dust samples (600 mg/m^2) appears consistent with the range seen for surface dust samples collected from outside surface for various properties within the Costerfield area.
- Deposition data does not indicate a significant deposition event which may have led to a short term deposition of the powder.

Based on the data available, the powder sample from the silage bag does not appear to correspond with ore or concentrate material. The exact source of the black dusts on the silage bag is not known. However, it could be a consequence of local or regional influences. For example vehicle emissions or regional soil and dust.

5.0 REFERENCES

ASTM International (2013). *D6966- 13: Standard Practice for Collection of Settled Dust Samples Using Wipe Sampling Methods for Subsequent Determination of Metals.*

NEPC (2013). *National Environment Protection (Assessment of Site Contamination) Measure*. National Environment Protection Council Service Corporation. Adelaide, SA.

APPENDIX D5

Data Review - Surface Dust

Attachments

1. Table D5.1 – Swab Sample Analytical Results
2. Table D5.2 – QAQC Analytical Results

Golder Associates

Table D5.1 - Surface Dust Swab Samples Analytical Results

Golder Reference: 1413212
Costerfield
Health Risk Assessment

				Metals									
				Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Zinc
				mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
LOR				200	200	40	200	2000	200	200	4	80	200
Location Code	**Field ID**	**Location**	**Sampled Date**										
13	13/SD1_20150525	Inside, sunroom windowsill, painted wood	25/05/2015	700	<200	<40	400	46,000	<200	<200	<4	100	4,900
13	13/SD2_20150525	Inside, under kitchen bench, tiles	25/05/2015	<200	<200	<40	<200	3,000	<200	<200	<4	<80	3,200
13	13/SD3_20150525	Inside, top of side table in kitchen, varnished wood	25/05/2015	<200	<200	<40	<200	4,000	<200	400	<4	<80	3,600
13	13/SD4_20150525	Outside, table, wooded/laminated?	25/05/2015	200	<200	<40	<200	3,000	<200	<200	<4	<80	3,700
13	13/SD5_20150525	Outside, widowsil/on top of steps to the side, tiles	25/05/2015	300	<200	<40	<200	3,000	<200	200	<4	<80	3,500
13	13/SD6_20150525	Silage Bag eastern side	25/05/2015	600	<200	<40	<200	57,000	<200	300	<4	<80	3,800
13	13/SD7_20150525	Silage Bag western side	25/05/2015	<200	<200	<40	<200	40,000	<200	200	<4	<80	3,700
27	27/SD1_20150525	Inside, kitchen windowsill, painted wood	25/05/2015	200	<200	<40	<200	<2,000	<200	<200	<4	<80	3,400
27	27/SD2_20150525	Inside, under desk, sealed tile	25/05/2015	<200	<200	<40	<200	3,000	<200	<200	<4	<80	3,900
27	27/SD3_20150525	Inside, bookshelf, varnished wood	25/05/2015	<200	<200	<40	300	3,000	<200	<200	<4	<80	4,400
27	27/SD4_20150525	Outside, northern wall of house, painted wood	25/05/2015	200	<200	<40	<200	3,000	300	<200	<4	<80	3,900
27	27/SD5_20150525	Outside, southern protected windowsil, painted wood	25/05/2015	5,400	<200	<40	400	131,000	1,300	2,200	<4	<80	5,100
37	37/SD1_20150525	Inside, kitchen windowsil, wood	25/05/2015	400	<200	<40	<200	8,000	<200	<200	<4	<80	4,500
37	37/SD2_20150525	Inside, floor, lino	25/05/2015	300	<200	<40	<200	4,000	<200	<200	<4	<80	3,900
37	37/SD3_20150525	Inside, TV table, wood	25/05/2015	<200	<200	<40	<200	3,000	<200	<200	<4	<80	3,800
37	37/SD4_20150525	Outside, table, painted wood	25/05/2015	700	<200	<40	<200	149,000	<200	700	<4	<80	5,100
37	37/SD5_20150525	Outside, shed wall, painted wood	25/05/2015	17,300	400	<40	400	233,000	300	1,100	<4	150	6,200
42	42/SD1_20150525	Inside, kitchen windowsil, painted wood	25/05/2015	400	<200	<40	<200	6,000	<200	<200	<4	<80	4,100
42	42/SD2_20150525	Inside, under kitchen bench, varnished wood	25/05/2015	<200	<200	<40	<200	<2,000	<200	<200	<4	<80	3,800
42	42/SD3_20150525	Inside, clock on bedside table, wood	25/05/2015	<200	<200	<40	200	2,000	<200	<200	<4	<80	3,900
42	42/SD4_20150525	Outside, wall outside back door, painted wood	25/05/2015	1,000	<200	<40	<200	19,000	<200	200	<4	<80	4,100
42	42/SD5_20150525	Outside, top of heater, painted metal	25/05/2015	1,800	<200	<40	<200	44,000	<200	400	<4	<80	3,900

Table D5.2 – QAQC Analytical Results

				Heavy Metals									
				Antimony	**Arsenic**	**Cadmium**	**Copper**	**Iron**	**Lead**	**Manganese**	**Mercury**	**Nickel**	**Zinc**
				mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2	mg/m2
LOR				200	200	40	200	2000	200	200	4	80	200
Location_Code	**Field_ID**	**Sample Type**	**Sampled_Date_Time**										
NA	13/SDFB_20150525	Field Blank	25/05/2015	<200	<200	<40	<200	<2,000	<200	<200	<4	<80	3,800
NA	13/SDRB_20150525	Rinse Blank	25/05/2015	<200	<200	<40	<200	<2,000	<200	<200	<4	<80	4,000
NA	37/SDTB_20150525	Trip Blank	25/05/2015	<200	<200	<40	<200	<2,000	<200	<200	<4	<80	3,400

1.0 INTRODUCTION

Appendix D6 presents the results of further assessment work conducted by Golder relating to lead and arsenic reported in soil from Costerfield. The object for this further work was to:

- Assess the potential source of lead in Costerfield using lead isotope analysis.
- Assess the bioaccessibility (BAC) of lead and arsenic in soil at Costerfield.
- Assess the potential for derivation of bioavailability (BA) factors for lead and arsenic in Costerfield for use in the HRA.

This appendix is structured as follows:

- Section 2.0 – Additional soil sampling
- Section 3.0 – Bioaccessibility assessment
- Section 4.0 – Lead isotopes assessment.

The following tables are referred to throughout and attached to this appendix:

- Table D6.1: Soil Analytical Results – lead, arsenic, antimony
- Table D6.2: Soil QA/QC Duplicate results
- Table D6.3: Soil QA/QC Rinsate blank results.

The laboratory reports for the bioaccessibility analysis are also attached.

2.0 ADDITIONAL SOIL SAMPLING

To allow for the isotope and bioaccessibility assessment, additional soil sampling was undertaken by Golder on 8 December 2015. Thirty seven primary shallow soil samples (0 to 0.05 m below ground level (m bgl)) were collected from five different properties. As the additional analysis required the presence of lead and arsenic in the soil samples, the five properties were chosen based on having historically relatively high reported lead and/or arsenic concentration in soil.

The soil samples were collected in general accordance with the methodology outlined in Section 2.0 of Appendix D1 – Soil Data Summary.

2.1 Results

The samples were analysed for lead, arsenic and antimony, with the results presented in attached Table D6.1, and have been included in the data review in Appendix D1. The results of the analysis were used to determine which of the 37 samples would be used in the isotope and bioaccessibility assessment (discussed further in Section 3.0 and Section 4.0).

2.2 QAQC

The data quality objectives and indicators for soil sampling are discussed in Section 4.1 of Appendix D1 – Soil Data Summary.

The QAQC samples collected for the additional soil sampling included:

- Two primary duplicate samples
- Two secondary duplicate samples
- One rinsate sample, collected from the shovel.

The analytical results for the duplicate samples are included in Table D6.2 and for the rinsate sample in Table D6.3.

The Primary (intra-laboratory) and Secondary (inter-laboratory) Duplicates are duplicate samples of the primary sample collected during sampling. The Primary Duplicates are labelled differently to the Primary Sample and both are submitted to the primary laboratory for analysis. The Secondary Duplicate is sent to the quality control laboratory (secondary or 'check' laboratory) for analysis to compare the results obtained between the two laboratories.

The Primary and Secondary Duplicate results are compared with primary sample results using Relative Percentage Difference (RPDs). RPDs are calculated according to the following formula where A is the concentration of the primary laboratory result per analyte, B is the corresponding duplicate result and ABS is the absolute number:

$$\%RPD = \mathrm{ABS}\left\{\left[\frac{A-B}{A+B}\right]*200\right\}$$

RPD values can range from 0% (indicating perfect correlation between results) to 200% (indicating complete divergence in results). A summary of the QA/QC completeness for additional soil samples is presented in Table 1 and Table 2, below.

Table 1: Summary of Data Quality Indicators (DQI)

DQO	Field & Laboratory DQI Considerations
Representativeness	Soil was sampled in general accordance with NEPM (2013) guidelines. Samples were analysed using the same laboratory procedures and within appropriate holding times. Appropriate collection, handling, storage and preservation used.
Comparability	Standard procedures were used for the collection of samples, use of qualified samplers, same types of instruments used, same types of samples collected, same analytical methods used, same sample limits of reporting (LORs), same laboratories, same units, same laboratory methods and appropriate sample integrity. The laboratories used were NATA registered and the methods used were to be NATA endorsed for the majority of the analyses undertaken.
Precision	Assessed through the collection of field duplicates, analysis of primary and secondary laboratory field duplicates and analysis of laboratory duplicates. Details are provided in Table 2.
Accuracy	This was assessed through compliance with standard procedures and analysis of rinsates, method blanks, matrix spikes, surrogate spikes, reference materials, laboratory control samples and laboratory prepared spiked control samples. Different matrix effects can affect the recoveries of some analytes and therefore recoveries that fall outside this range may still be acceptable. Accuracy is assessed by measuring the extent to which an analytical result reflects the known concentration as measured by the recovery obtained from internal laboratory spikes. Details are provided in Table 2.
Completeness	Locations sampled were selected to meet the objective of the project. Field and laboratory documentation was collected and assessed to be correct. Appropriate standard procedures were used and complied with. Samples were analysed for analytes in accordance with the proposal and variations to meet the objectives of the assessment. Laboratory methods and LORs were appropriate. Sample documentation including CoCs is complete and sample holding times in compliance. Acceptable data are obtained when samples are collected and analysed in accordance with the quality control procedures and the DQIs.

Table 2: Summary of Soil QA/QC Completeness

QC Sample Type	No. Results (individual analytes) NOT Meeting DQI	Total No. Results (individual analytes)	Percentage Results Meeting DQI
Sample Receipt Notifications-Primary Lab	0	1	100%
Holding Time Exceedances-Primary Lab	0	37	100%
Field Primary Duplicates-Primary Lab	0	8	100%
Field Rinsate-Primary Lab	0	3	100%
Internal Primary Lab Duplicates	0	15	100%
Internal Primary Lab Method Blanks	0	9	100%
Internal Primary Lab Control Spikes	0	9	100%
Internal Primary Lab Matrix Spikes	0	4	100%
Internal Primary Lab Surrogate Spikes	-	-	-
Sample Receipt Notifications-Secondary Lab	0	1	100%
Holding Time Exceedances-Secondary Lab	0	3	100%
Field Secondary Duplicates-Secondary Lab	2	8	75%
Internal Secondary Lab Duplicates	0	3	100%
Internal Secondary Lab Method Blanks	0	3	100%
Internal Secondary Lab Control Spikes	0	3	100%
Internal Secondary Lab Matrix Spikes	0	3	100%
Internal Secondary Lab Surrogate Spikes	-	-	-
Overall Soil Completeness	**2**	**110**	**98%**

2.2.1 Discussion of Soil QA/QC Completeness

- Two primary and two secondary duplicates were analysed during the assessment with a total of 37 primary soil samples analysed. This equates to a frequency of 10% for the collection of field duplicates of which 5% were intra-laboratory duplicates and 5% were inter-laboratory duplicates. This complies with the minimum collection frequency of 5%. Soil primary and secondary analytical results are presented in Table D6.2, attached.
  - Of the eight primary duplicate analytes, no analytes returned an RPD above 50%
  - Of the eight secondary duplicates, two analytes returned an RPD above 50%. RPDs greater than 50% were reported for antimony. In both cases the secondary duplicate reported a higher antimony concentration than the primary duplicate. The primary purposes of the additional soil sampling works was to assess lead and arsenic bioaccessibility. The RPDs for lead and arsenic were less than 50%. Therefore, the RPDs greater than 50% are considered to not change the outcomes of the assessment.
- One rinsate samples was collected from the shovel used to collect the samples. The analytical results for the rinsate sample were below the limit of reporting (LOR).

- A review of the Primary and Secondary Laboratory internal QA/QC procedures, including laboratory duplicates, matrix spikes, method blanks and laboratory control samples, indicates that the conformance level was greater than the 95%, providing confidence in the accuracy and precision of the results.

The achieved QA/QC completeness of 98% is above the overall completeness objective of 95%. Based on this, it is considered that the overall data quality generated during the additional assessment of soil is sufficient for the purposes of the HRA.

3.0 BIOACCESSIBILITY ASSESSMENT

3.1 Introduction

Bioaccessibility testing of lead and arsenic in soils from Costerfield was undertaken using the Solubility Bioaccessibility Research Consortium Assay (“SBRC”), available through the Centre for Environmental Risk Assessment and Remediation (CERAR), at the University of South Australia. The bioaccessibility testing was undertaken to assess the potential for derivation of bioavailability (BA) factors for lead and arsenic in Costerfield for use in the HRA. The following sections present the methodology and results of the bioaccessibility testing.

3.2 Background

3.2.1 Lead

In 2013, the soil lead health investigation level (HIL) in the NEPM (NEPC 2013) was derived using a human health risk assessment model with a number of input assumptions. There are two key assumptions around the absorption of lead into the body following incidental ingestion of soil. These assumptions are:

- The bioaccessibility (BAC) of the lead in the soil (i.e. once ingested, the proportion of lead dissolved from the soil).
- The absorption (Abs) of the dissolved lead (i.e. how much of the soluble lead is then taken up into the bloodstream as opposed to passing through the gut).

When soil containing lead is ingested (or inhaled and enters the stomach), initial digestion occurs in the gastric (stomach) system. From the stomach, the digested material passes to the intestinal system for absorption. Only the soluble portion of the lead will be available for absorption. However, the pH of the intestinal system is higher (less acidic) than the gastric. A proportion of the lead in solution, entering the intestinal system may precipitate out as the pH rises and thus escape absorption. The soluble proportion of the lead, compared against the quantity of lead in the soil, represents a measure of the BAC. However, the soluble proportion may be based on that resulting from the gastric-phase digestion or that resulting from the intestinal-phase depending upon the assessment method.

The combination of the bioaccessible fraction and the absorbed fraction, compared against the quantity of lead in the soil, represents a measure of the bioavailability (BA) of the lead in the soil.

As toxicological studies and data are typically based on the effects of particular pure chemical forms of lead (i.e. lead acetate), the soil BA value may then be adjusted to derive a measure of BA relative to (for example) lead acetate. This relative bioavailability (RelBA) is then appropriate for comparison against toxicological data and use in calculation of potential health risks. Figure 1 below presents an outline of the oral intake and absorption pathway for soil and respective bioavailability/bioaccessibility concepts.

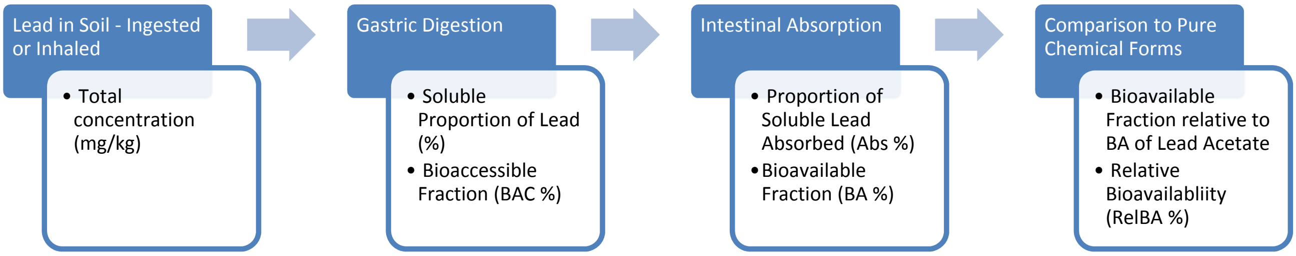


Figure 1: Outline of Oral Intake and Bioavailability Concepts

The soil lead HIL used in the NEPM adopts an oral RelBA of 50% (i.e. the oral bioavailability of lead acetate in children which is a highly soluble form of lead) under the assumption that 100% of the lead in soil is bioaccessible (i.e. 100% BAC, all the lead in soil dissolves in the human gut), and 50% of the soluble lead is then absorbed (50% Abs).

The NEPM (NEPC, 2013) and CRC CARE (2009) provide for further adjustment of lead screening levels based on bioaccessibility. *In vitro* bioaccessibility testing is now routinely undertaken for lead.

3.2.2 Arsenic

The arsenic HIL in the NEPM (NEPC 2013) was derived adopting an arsenic bioavailability within the range of 70 – 100%. However, the NEPM (NEPC, 2013) states that available data from Bendigo in Victoria suggests that the bioavailability of arsenic in soil derived from mine tailings in this region commonly ranges from 10 – 20% and is generally less than 30%. This indicated adopting a bioavailability of 70 – 100% is likely overestimating bioavailability. Like lead, the NEPM (NEPC, 2013) allows for adjustment of the arsenic screening levels based on bioaccessibility. *In vitro* bioaccessibility testing is also routinely undertaken for arsenic.

3.3 Methodology

3.3.1 Sample Selection

The analytical results for lead and arsenic (see Section 2.1) were reviewed to select the 10 samples tested for bioaccessibility. The samples were chosen to spatially cover the 5 properties sampled, with a range of relative concentration characteristics. The following samples were selected:

- 1_BH09/4001_20151208 (1_BH09)
- 1_BH10/4001_20151208 (1_BH10)
- 1_BH18/4001_20151208 (1_BH18)
- 7_BH01/4001_20151208 (7_BH01)
- 7_BH07/4001_20151208 (7_BH07)
- 20_BH10/4001_20151208 (20_BH10)
- 20_BH11/4001_20151208 (20_BH11)
- 30_BH10/4001_20151208 (30_BH10)
- 30_BH11/4001_20151208 (30_BH11)
- 32_BH09/4001_20151208 (32_BH09)

3.3.2 Bioaccessibility testing

The bioaccessibility of lead and arsenic were estimated using in vitro assay that simulates the process that occurs in the human body that leads to the release of contaminates from the soil matrix. The bioaccessibility testing was undertaken using the Solubility Bioaccessibility Research Consortium Assay (“SBRC”), available through the Centre for Environmental Risk Assessment and Remediation (CERAR), at the University of South Australia. 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).

3.4 Results

The results of the bioaccessibility testing are presented in the following two laboratory reports, attached to this appendix:

- University of South Australia, 2016a. *Determination of arsenic and lead Bioaccessibility in Impacted Soil*, date of issue: 12 January 2016
- University of South Australia, 2016b. *Determination of arsenic and lead Bioaccessibility in Impacted Soil (Costerfield – 1413212)*, date of issue: 20 January 2016.

3.5 Discussion

The samples were collected to provide a snapshot of bioaccessibility within the Costerfield Dome. A statistical summary of the results is provided in Table 3.

Most samples had low bioaccessibility. Seven out of ten lead soil samples had lead bioaccessibility results of less than 30%. Six out of ten arsenic samples were at or less than 10% bioaccessible.

Table 3: Bioaccessibility results

Sample	Lead	Arsenic	Ratio lead / arsenic	Comment
30_BH10/4001_20151208 (30_BH10)	96.5%	9.3%	10.4	Most of the ratio’s of lead to arsenic fall in the range of 2 – 4
1_BH18/4001_20151208 (1_BH18)	29.2%	7.5%	3.9	
7_BH07/4001_20151208 (7_BH07)	27.2%	7.7%	3.5	
1_BH09/4001_20151208 (1_BH09)	29.3%	10.0%	2.9	
32_BH09/4001_20151208 (32_BH09)	49.6%	18.2%	2.7	
20_BH11/4001_20151208 (20_BH11)	55.2%	23.3%	2.4	
30_BH11/4001_20151208 (30_BH11)	14.8%	7.7%	1.9	
7_BH01/4001_20151208 (7_BH01)	12.60%	6.70%	1.9	
20_BH10/4001_20151208 (20_BH10)	17.40%	32.00%	0.5	
1_BH10/4001_20151208 (1_BH10)	3.10%	22.10%	0.1	
Values used in the HRA 95th upper confidence limit [a]	**49%**	**23%**		

[a] US EPA PROUCL v5.0.

4.0 LEAD ISOTOPES

4.1 Introduction

Lead isotope testing was conducted by The University of Melbourne, School of Earth Sciences to assist in identifying the potential sources of lead in the soil samples collected at Costerfield. Analyses were conducted on four soil samples collected as part of the additional soil sampling program outlined in Section 2.0 and one ore sample provided by Mandalay Resources. Samples for isotope ratio measurement were selected based upon the total lead results to assess whether the various concentrations of lead could be attributed to different sources. The following sections provide some background information on lead isotope testing, the analytical methodology and discussion of the results.

4.2 Background to Lead Isotope Testing

Lead is a ubiquitous environmental toxicant that is found in urban and rural environments. Lead isotope testing can be used to assist in understanding possible sources for lead contamination.

The use of lead isotopes to determine possible sources has been widely reported and has been used since 1972 to assist in understanding contributing factors to human exposure Jaeger 1998, Gulson et al 2004.

Each geologic source of lead possesses what is called an independent isotopic ratio (IR). Thus, environmental samples including soil, water, ore, and dust can be measured and compared to reference IR for geologic sources. With such data, certain sources can be ruled out or better implicated as contributing factors to elevated lead levels (in this case soil).

Lead is composed of 4 stable isotopes of atomic masses: 204, 206, 207, and 208 (Dickin, 1995; Cheng & Hu, 2010; Sangster *et al*., 2000; Lepitre *et al*., 2003; Grezzi *et al.,* 2011; Albarède *et al.,* 2012). The isotopes are referred to in the following manner:

- ^{204}Pb (relative abundance of 1.36%). This isotope is considered to be a measure of the original lead present when the solar system condensed. That is, it is not produced naturally by a radioactive decay process and is stable within its geologic origin. For this reason it can be used as a stable reference isotope against which the accumulation of the other radiogenic isotopes over time can be quantified (Dickin, 1995; Lepitre *et al*., 2003; Cheng & Hu, 2010).
- ^{206}Pb (25.42%), ^{206}Pb is the decay product of ^{238}U,
- ^{207}Pb (21.11%), ^{207}Pb is the decay product of ^{235}U
- ^{208}Pb (52.10%), ^{208}Pb is the decay product of ^{232}Th

The isotopic composition of lead in any ore sample is the result of the interplay of three factors (Sangster *et al*., 2000; Lepitre *et al*., 2003; Albarède *et al.,* 2012; Gulson, 1979):

1) the initial isotopic composition of the system, for example a given crustal volume.
2) the ratios of the radioactive (Uranium (U) or Thorium (Th)) ‘parent’ to the ‘daughter’ (Pb) isotopes under which the system evolved i.e. ^{238}U/^{206}Pb, ^{235}U/^{207}Pb, and ^{232}Th/^{208}Pb
3) the amount of time this reservoir evolved prior to the separation of lead into the ore deposit.

Once most[1] ores are formed the isotopic composition of their contained lead does not evolve any further, as it does not contain significant amounts of parent isotopes Uranium or Thorium. The lead signature ‘frozen in’ the ore in this way will reflect the time at which the lead was incorporated into the ore as lead sulphides do not readily incorporate decaying ‘parent’ Uranium and Thorium into their crystal lattice; thus older lead deposits will generally contain less radiogenic lead-isotope signatures than younger ones within the same plumbo-tectonic terrain. Therefore, because of this property lead isotopic signatures enable ‘fingerprinting’ of

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[1] The exception being Uranium and REE deposits

anthropogenic lead contamination in the environment i.e. in soils (Gulson, 1979; Townsend & Seen, 2012; Balcaen *et al*., 2010). Another additional strength of using lead isotopic 'fingerprinting' is that radiogenic isotope ratios are not fractionated by low temperature processes and thus isotopic signatures are not affected by environmental weathering processes (such as wind or water weathering). Lead isotope ratios only reflect variability of the appropriate geological reservoirs and so, from the observed ratios of ^{208}Pb, ^{207}Pb, ^{206}Pb relative to ^{204}Pb it is possible to identify a source of lead by matching its measured lead isotopic composition measured with those of its potential sources.

The objective of the lead isotope testing was to provide a preliminary assessment of whether the Costerfield ore was the source of the lead (Pb) in Costerfield.

4.3 Methodology and Analytical Technique

Lead isotopic analyses were conducted on four soil samples (1_BH18/4001_20151208; 30_BH10/4001_20151208; 30_BH11/4001_20151208; 7_BH07/4001_20151208) and one ore sample (1413212 ore) from the Augusta Deposit of the Mandalay Resources, Costerfield mine.

All samples were sent to the University of Melbourne, School of Earth Sciences to be analysed in U-Th-Pb (uranium-thorium-lead) geochemistry laboratory by Professor Jon Woodhead and Dr Roland Maas. Samples were sieved to <1.4mm, removing much of the plant material in the soils however significant root like fragments remained. Fractions of the sieved soil (0.67-0.91g) and ore (0.43 g) were leached with warm concentrate aqua regia (3:1 HCl-HNO_3, 3ml). Mixtures were then transferred to acid-cleaned centrifuge tubes. Rock fragments settled at the bottom of the tube and clear acid was pipetted into a clean beaker and dried. The residue was heated with 2 ml of concentrated HNO_3 to destroy organics (this was only partially successful). Dried residues were picked up in 0.6M HBr and 1/3 of each liquid was loaded onto 0.15 ml beds of AG1-X8 (100-200 mesh) anion exchange resin to extract the lead using the HBr-HCl method. Two passes were done to remove matrix constituents.

Samples were measured using faraday detectors on a Nu Instruments Multi Collector-Inductively Coupled Plasma-Mass Spectrometry (MC-ICP-MS) Instrument.

A Broken Hill reference ore sample was also run through the MC-ICP-MS on the same day as the Costerfield ore and soil samples. The Broken Hill ore lead isotope signature is used as a reference point in interpreting isotopic analysis results.

4.4 QA/QC

Standards were run in between samples as a check on data quality. The reference material used was the National Bureau of Standards (NBS) SRM 981 Standard Isotope Reference Material. A Thallium (Tl) tracer was used to correct for instrumental mass bias.

4.5 Results

Lead isotopes are related to the geologic origins from which they are sourced and are reported as ratios; ^{206}Pb/^{204}Pb, ^{207}Pb/^{204}Pb and ^{208}Pb/^{204}Pb.

As a consequence the lead isotope ratios of geologic distinct samples can be used as references ('signatures') to compare isotope ratios from environmental samples (in this case soil).

There are two geologic terranes that are used in this report as references:

- Lachlan Fold Belt - The Augusta deposit (Costerfield Ore) lies in the Lachlan Fold Belt and therefore is expected to have a ^{206}Pb/^{204}Pb at around 18 and higher (Carr, 1995).
- Broken Hill - Lead products of Australian origin for example lead in fuel, paint, piping, shot or other industrial materials (including lead nitrate used in mine processing), is likely to come from Broken Hill, and thus an anthropogenic contribution to lead in soils would produce a Broken Hill type signature (^{206}Pb/^{204}Pb > 15.999). It is important to note that lead products produced overseas will have a different

isotope ratio signature. Most overseas ^{206}Pb/^{204}Pb signatures are higher than Broken Hill, in order of 17-18 (Kamenov & Gulson 2014)).

In order to interpret lead isotope results, they are plotted on the two curves, ^{206}Pb/^{204}Pb vs ^{207}Pb/^{204}Pb and ^{206}Pb/^{204}Pb vs ^{208}Pb/^{204}Pb. Therefore, if the lead in soil samples taken from Costerfield have their sole contribution of lead from the Costerfield ore, the samples will plot above the Costerfield ore (^{206}Pb/^{204}Pb > 18.218).

If there is a significant but not sole contribution from the ore to the soil, the samples should plot proximal to the Costerfield ore.

If the lead is of anthropogenic Australian origin, the samples will plot proximal to the Broken Hill lead signature (^{206}Pb/^{204}Pb > 15.999).

^{206}Pb/^{204}Pb vs ^{207}Pb/^{204}Pb and ^{206}Pb/^{204}Pb vs ^{208}Pb/^{204}Pb plots are used to interpret the relationship between the samples and their potential sources. Both graphs are used to express relationships robustly as in some instances a single plot may not indicate a relationship when one exists.

The Costerfield ore deposit signature, as defined by the sample provided is (Table 4):

- ^{206}Pb/^{204}Pb = 18.218
- ^{207}Pb/^{204}Pb =15.654
- ^{208}Pb/^{204}Pb = 38.399

This signature falls onto the growth curve[2] developed by Dr Graham Carr (CSIRO) for deposits in the Lachlan Fold Belt (Carr, 1995) and is consistent with the previously determined ages of the deposit (veins deposited in Silurian Costerfield Siltstones).

The lead isotope signatures of the soil samples in addition to the two reference samples (Broken Hill ore and Costerfield Ore/Lachlan Fold Belt reference) are presented in Table 4. The signatures of the soil samples are more primitive (less radiogenic, lower ^{206}Pb/^{204}Pb ratio) than the Costerfield ore sample.

This means that the Costerfield ore is unlikely to be the sole source of lead in the soil samples. It is likely that there is a mixture of anthropogenic sources. It is not possible to distinguish these sources based on the results provided in Table 4 and graphically presented in Figure 2 and 3.

Table 4: Lead Isotope signatures for Costerfield ore and soil samples.

Sample Type		Lab Sample ID	Golder Sample ID	^{206}Pb/^{204}Pb	^{207}Pb/^{204}Pb	^{208}Pb/^{204}Pb
Reference Samples	Broken Hill Reference	Broken Hill Ore	-	15.999	15.382	35.645
	Lachlan Fold Belt Reference (Costerfield Ore)	1413212 ore	Ore_20151208	18.218	15.654	38.399
Field Samples		7-BH07	7_BH07/4001_20151208	17.903	15.581	37.904
		30-BH10	30_BH10/4001_20151208	17.599	15.534	37.484
		30-BH11	30_BH11/4001_20151208	17.848	15.564	37.775
		1-BH18	1_BH18/4001_20151208	17.801	15.561	37.785

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[2] A graph that shows changing isotopic levels due to radioactive decay.

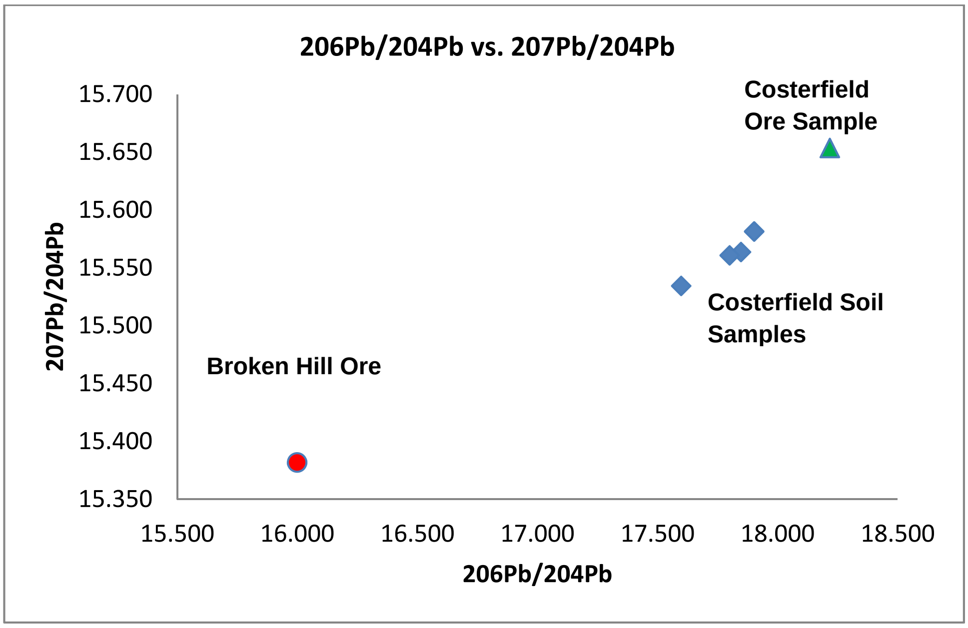

Figure 2: ^{206}Pb/^{204}Pb versus ^{207}Pb/^{204}Pb of Broken Hill galena, Costerfield soil samples and Costerfield ore sample.

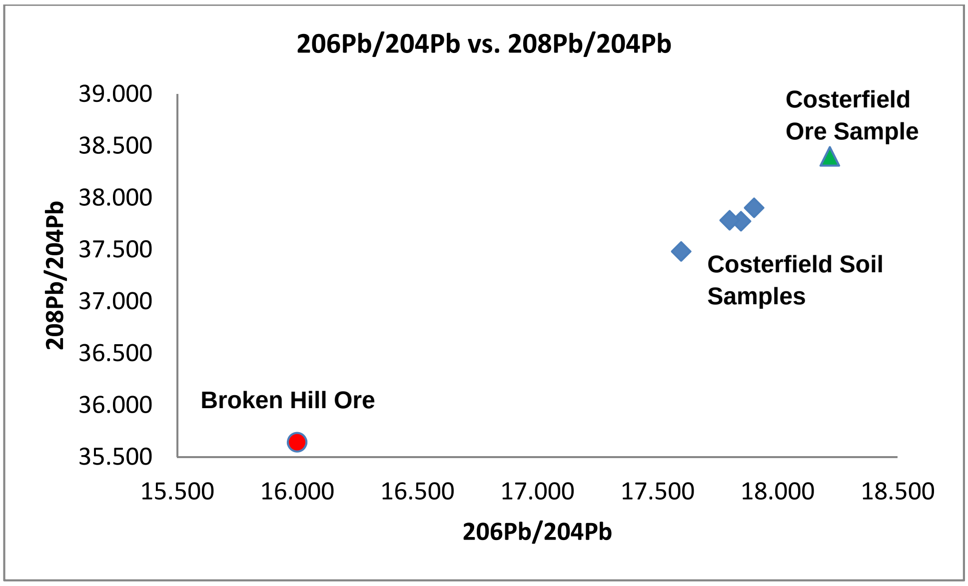

Figure 3: ^{206}Pb/^{204}Pb versus ^{208}Pb/^{204}Pb of Broken Hill galena, Costerfield soil samples and Costerfield ore sample.

4.6 Discussion and Conclusions

If the lead in the Costerfield soil were derived entirely from only anthropogenic, or naturally occurring ore, we would expect the isotopic composition to fall in the region of the Broken Hill or Costerfield ores, respectively. The lead signatures derived are intermediate between these extremes indicating a mixture of sources rather than a unique single source.

As the soil signatures are less radiogenic than the Costerfield ore (Augusta deposit) some of the lead contributing to the soil lead concentrations originate from a geological source outside of Victoria The results suggest that the lead in soil is most likely a mixture of anthropogenic sources and unlikely to be solely from the Costerfield ore. It is possible that the lead isotope signatures of the soil samples contain Broken Hill like ore signature (i.e. anthropogenic lead). This is significant as lead in products manufactured in Australia typically contain lead sourced from Broken Hill ore.

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APPENDIX D6

Further Lead and Arsenic Assessment

Attachments

1. Table D6.1: Soil Analytical Results – Lead, Arsenic, Antimony
2. Table D6.2: Soil QA/QC Duplicate results
3. Table D6.3: Soil QA/QC Rinsate blank results.
4. Laboratory Reports

Table D6.1: Analytical Results for Additional Soil Sampling

					Heavy Metals			Sample Quality Parameters
					Antimony	Arsenic	Lead	Moisture
					mg/kg	mg/kg	mg/kg	%
EQL					5	5	5	1
NEPM 2013 HIL- Residential A Soil					200	100	300	
Field_ID	**Location_Code**	**Sample_Depth_Range**	**Sampled_Date_Time**	**Lab_Report_Number**				
1_BH09/4001_20151208	1_BH09	0-0.1	8/12/2015	EM1518174	114	40	418	10.8
1_BH10/4001_20151208	1_BH10	0-0.1	8/12/2015	EM1518174	6540	278	306	8.8
1_BH11/4001_20151208	1_BH11	0-0.1	8/12/2015	EM1518174	3110	60	102	6.2
1_BH12/4001_20151208	1_BH12	0-0.1	8/12/2015	EM1518174	7460	31	12	6.2
1_BH13/4001_20151208	1_BH13	0-0.1	8/12/2015	EM1518174	1420	124	717	10
1_BH14/4001_20151208	1_BH14	0-0.1	8/12/2015	EM1518174	59	28	63	3.3
1_BH15/4001_20151208	1_BH15	0-0.1	8/12/2015	EM1518174	17	17	22	5.4
1_BH16/4001_20151208	1_BH16	0-0.1	8/12/2015	EM1518174	103	26	28	3.9
1_BH17/4001_20151208	1_BH17	0-0.1	8/12/2015	EM1518174	729	76	51	5.6
1_BH18/4001_20151208	1_BH18	0-0.1	8/12/2015	EM1518174	538	60	69	7.5
20_BH09/4001_20151208	20_BH09	0-0.1	8/12/2015	EM1518174	1140	113	156	3.9
20_BH10/4001_20151208	20_BH10	0-0.1	8/12/2015	EM1518174	1350	417	292	2.6
20_BH11/4001_20151208	20_BH11	0-0.1	8/12/2015	EM1518174	716	117	291	3.9
20_BH12/4001_20151208	20_BH12	0-0.1	8/12/2015	EM1518174	860	194	405	3.2
20_BH13/4001_20151208	20_BH13	0-0.1	8/12/2015	EM1518174	365	31	901	3.7
30_BH09/4001_20151208	30_BH09	0-0.1	8/12/2015	EM1518174	238	16	491	11.6
30_BH10/4001_20151208	30_BH10	0-0.1	8/12/2015	EM1518174	292	77	3920	5
30_BH11/4001_20151208	30_BH11	0-0.1	8/12/2015	EM1518174	149	32	435	7.7
30_BH12/4001_20151208	30_BH12	0-0.1	8/12/2015	EM1518174	137	18	378	15.9
30_BH13/4001_20151208	30_BH13	0-0.1	8/12/2015	EM1518174	218	19	77	8.1
30_BH14/4001_20151208	30_BH14	0-0.1	8/12/2015	EM1518174	161	36	156	7.1
30_BH15/4001_20151208	30_BH15	0-0.1	8/12/2015	EM1518174	98	17	48	8.6
30_BH16/4001_20151208	30_BH16	0-0.1	8/12/2015	EM1518174	92	17	58	5.9
30_BH17/4001_20151208	30_BH17	0-0.1	8/12/2015	EM1518174	94	11	94	9.2
30_BH18/4001_20151208	30_BH18	0-0.1	8/12/2015	EM1518174	142	14	36	9.8
32_BH09/4001_20151208	32_BH09	0-0.1	8/12/2015	EM1518174	79	26	139	3.7
32_BH10/4001_20151208	32_BH10	0-0.1	8/12/2015	EM1518174	24	14	58	<1
7_BH01/4001_20151208	7_BH01	0-0.1	8/12/2015	EM1518174	1890	82	160	3.9
7_BH02/4001_20151208	7_BH02	0-0.1	8/12/2015	EM1518174	41	26	49	4.6
7_BH03/4001_20151208	7_BH03	0-0.1	8/12/2015	EM1518174	909	265	61	5
7_BH04/4001_20151208	7_BH04	0-0.1	8/12/2015	EM1518174	23	<5	9	2.9
7_BH05/4001_20151208	7_BH05	0-0.1	8/12/2015	EM1518174	339	34	40	10.7
7_BH06/4001_20151208	7_BH06	0-0.1	8/12/2015	EM1518174	1250	81	266	10.2
7_BH07/4001_20151208	7_BH07	0-0.1	8/12/2015	EM1518174	1690	155	710	3.7
7_BH08/4001_20151208	7_BH08	0-0.1	8/12/2015	EM1518174	337	58	66	5.4
7_BH09/4001_20151208	7_BH09	0-0.1	8/12/2015	EM1518174	1050	76	188	3.6
7_BH10/4001_20151208	7_BH10	0-0.1	8/12/2015	EM1518174	1490	62	203	5.9

Statistical Summary

	Antimony	Arsenic	Lead	Moisture
Number of Results	37	37	37	37
Number of Detects	37	36	37	36
Minimum Concentration	17	<5	9	<1
Minimum Detect	17	11	9	2.6
Maximum Concentration	7460	417	3920	15.9
Maximum Detect	7460	417	3920	15.9
Average Concentration	953	74	310	6.3
Median Concentration	337	36	139	5.6
Standard Deviation	1621	88	648	3.2
Number of Guideline Exceedances	22	8	10	0
Number of Guideline Exceedances(Detects Only)	22	8	10	0

Table D6.2: Soil Duplicate Sample Results

			Lab Report Number	EM1518174	EM1518174		EM1518174	EM1518174		EM1518174	Interlab_D		EM1518174	Interlab_D	
			Field ID	1_BH11/4001_20151208	1_BH11/4801_20151208	**RPD**	7_BH05/4001_20151208	7_BH05/4801_20151208	**RPD**	7_BH05/4001_20151208	7_BH05/4901_20151208	**RPD**	1_BH11/4001_20151208	1_BH11/4901_20151208	**RPD**
			Sampled Date/Time	8/12/2015 15:00	8/12/2015 15:00		8/12/2015 15:00	8/12/2015 15:00		8/12/2015 15:00	8/12/2015 15:00		8/12/2015 15:00	8/12/2015 15:00	
Chem_Group	**ChemName**	**Units**	**EQL**												
Heavy Metals	Antimony	mg/kg	5 : 10 (Interlab)	3110	3360	8	339	371	9	**339**	**750**	**75**	**3110**	**8600**	**94**
	Arsenic	mg/kg	5 : 2 (Interlab)	60	63	5	34	34	0	34	34	0	60	89	39
	Lead	mg/kg	5	102	96	6	40	40	0	40	39	3	102	90	13
Sample Quality Parameters	Moisture	%	1 : 0.1 (Interlab)	6.2	8.6	32	10.7	9.9	8	10.7	9.9	8	6.2	7.9	24

*RPDs have only been considered where a concentration is greater than 1 times the EQL.

**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (1-10 x EQL); 50 (10-30 x EQL); 50 (> 30 x EQL))

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the row header relate to those used in the primary laboratory

Table D6.3: Rinsate Sample Results

Lab Report Number	EM1518174
Field ID	Rinsate-20151208
Sampled Date	8/12/2015 15:00
Sample Type	Rinsate

Chem Group	**Chem Name**	**Units**	**EQL**	
Heavy Metals	Antimony	mg/L	0.001	<0.001
	Arsenic	mg/L	0.001	<0.001
	Lead	mg/L	0.001	<0.001

University of South Australia

Determination of As and Pb Bioaccessibility in Impacted Soil

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Date of issue: 12 January 2016

Important Notice

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INTRODUCTION

This report was prepared for Golder Associates Pty Ltd to assess arsenic and lead bioaccessibility in impacted soil. The bioaccessibility testing was conducted by the Centre for Environmental Risk Assessment and Remediation (CERAR), an established research centre based at the Mawson Lakes Campus of the University of South Australia.

OBJECTIVES

The objective of this assessment was to:

- Assess the concentration of arsenic and lead in the < 2 mm and < 250 μm soil particle size fractions;
- Assess arsenic and 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 arsenic and lead in soil. The report was to include:
    - Assessment of arsenic and lead concentration in the < 2 mm and < 250 μm soil particle size fractions;
    - Assessment of arsenic and 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 Golder Associates Pty Ltd for an assessment of arsenic and 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 arsenic and lead concentration for each sample is shown in Tables 1 and 2 while arsenic and lead bioaccessibility results are shown in Tables 3 and 6 (arsenic bioaccessibility) and Tables 4, 5 and 7 (lead bioaccessibility).

- Total arsenic concentration in the < 2 mm soil particle size fraction ranged from 29.5 (30_BH11/4001_20151208) to 140 mg kg^{-1} (7_BH7/4001_20151208) (Table 1). A similar concentration range (26 to 137 mg kg^{-1}) was measured in the < 250 µm soil particle size fraction.

- Total lead concentration in the < 2 mm soil particle size fraction ranged from 433 (1_BH09/4001_20151208) to 4560 mg kg^{-1} (30_BH10/4001_20151208) (Table 2). A similar concentration range (379 to 4540 mg kg^{-1}) was measured in the < 250 µm soil particle size fraction.

- Arsenic bioaccessibility determined using gastric phase extraction (SBRC-G) was ≤ 10% for all soils (Tables 3 and 6).

- Lead bioaccessibility determined using gastric phase extraction (SBRC-G) ranged from 45.4 (7_BH07/4001_20151208) to 76.3% (30_BH10/4001_20151208) (Table 4).

- When assays parameters were modified to reflect intestinal phase conditions (SBRC-I), lead bioaccessibility was reduced considerably (1.5% [30_BH11/4001_20151208] to 10.0% [30_BH10/4001_20151208]), presumably as a result of re-adsorption of lead onto soil particles and / or precipitation at the neutral intestinal phase pH (Table 5).

- 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 7). Lead relative bioaccessibility was variable ranging from 14.8% (30_BH11/4001_20151208) to 96.5% (30_BH10/4001_20151208).
- Bioaccessibility values determined for QC1 (arsenic and lead contaminated reference soil) was within the acceptable range for this reference material.

Table 1. Total As 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	
		As (mg kg^{-1})	Mean As (mg kg^{-1})		As (mg kg^{-1})	Mean As (mg kg^{-1})
1_BH09/4001_20151208	1_BH09-2A	35		1_BH09-250A	30	
	1_BH09-2B	38	36.5	1_BH09-250B	30	30
7_BH07/4001_20151208	1_BH07-2A	133		1_BH07-250A	134	
	1_BH07-2B	146	140	1_BH07-250B	139	137
30_BH10/4001_20151208	30_BH10-2A	64		30_BH10-250A	53	
	30_BH10-2B	110	87	30_BH10-250B	55	54
30_BH11/4001_20151208	30_BH11-2A	28		30_BH11-250A	26	
	30_BH11-2B	31	29.5	30_BH11-250B	26	26

Table 2. 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})
1_BH09/4001_20151208	1_BH09-2A	442		1_BH09-250A	372	
	1_BH09-2B	424	433	1_BH09-250B	386	379
7_BH07/4001_20151208	1_BH07-2A	669		1_BH07-250A	731	
	1_BH07-2B	751	710	1_BH07-250B	722	727
30_BH10/4001_20151208	30_BH10-2A	4900		30_BH10-250A	4530	
	30_BH10-2B	4220	4560	30_BH10-250B	4550	4540
30_BH11/4001_20151208	30_BH11-2A	477		30_BH11-250A	451	
	30_BH11-2B	466	472	30_BH11-250B	464	458

Table 3. Arsenic bioaccessibility in contaminated soils determined using gastric phase extraction (SBRC-G).

Soil	**Sample #**	**ICP-MS As (mg l^{-1})**	**Soil:Solution Ratio**	**Gastric Phase As Bioaccessibility (mg kg^{-1})**	**Mean Gastric Phase As Bioaccessibility (mg kg^{-1})**
1_BH09/4001_20151208	1_BH09-G1	0.03	100	3.0	
	1_BH09-G2	0.03	100	3.0	3.0
7_BH07/4001_20151208	1_BH07-G1	0.10	100	10.0	
	1_BH07-G2	0.11	100	11.0	10.5
30_BH10/4001_20151208	30_BH10-G1	0.05	100	5.0	
	30_BH10-G2	0.05	100	5.0	5.0
30_BH11/4001_20151208	30_BH11-G1	0.02	100	2.0	
	30_BH11-G2	0.02	100	2.0	2.0
QC1[†]	QC1-G1	4.92	100	492	
	QC1-G2	4.98	100	498	495
QC2[‡]	QC2-G1	<0.01	-	<0.01	
	QC2-G2	<0.01	-	<0.01	<0.01

[†] QC1 comprised of an arsenic-contaminated (604 mg As kg^{-1}) reference soil.

[‡] QC2 comprised of SBRC gastric phase solution without soil addition (assay blank).

Table 4. Lead bioaccessibility in contaminated soils determined using gastric phase extraction (SBRC-G).

Soil	Sample #	ICP-MS Pb (mg l^{-1})	Soil:Solution Ratio	Gastric Phase Pb Bioaccessibility (mg kg^{-1})	Mean Gastric Phase Pb Bioaccessibility (mg kg^{-1})
1_BH09/4001_20151208	1_BH09-G1	2.36	100	236	
	1_BH09-G2	2.41	100	241	239
7_BH07/4001_20151208	1_BH07-G1	3.30	100	330	
	1_BH07-G2	3.30	100	330	330
30_BH10/4001_20151208	30_BH10-G1	34.2	100	3420	
	30_BH10-G2	35.1	100	3510	3465
30_BH11/4001_20151208	30_BH11-G1	2.91	100	291	
	30_BH11-G2	2.91	100	291	291
QC1[†]	QC1-G1	4.40	100	440	
	QC1-G2	4.34	100	434	437
QC2[‡]	QC2-G1	<0.01	-	<0.01	
	QC2-G2	<0.01	-	<0.01	<0.01

[†] QC1 comprised of a lead-contaminated (681 mg Pb kg^{-1}) reference soil.

[‡] QC2 comprised of SBRC gastric phase solution without soil addition (assay blank)

Table 5. Lead bioaccessibility in contaminated soils determined using gastro-intestinal phase extraction (SBRC-I).

Soil	Sample #	ICP-MS Pb ($mg\ l^{-1}$)	Soil:Solution Ratio	Intestinal Phase Pb Bioaccessibility ($mg\ kg^{-1}$)	Mean Intestinal Phase Pb Bioaccessibility ($mg\ kg^{-1}$)
1_BH09/4001_20151208	1_BH09-I1	0.13	100	13.0	
	1_BH09-I2	0.10	100	10.0	11.5
7_BH07/4001_20151208	1_BH07-I1	0.21	100	21.0	
	1_BH07-I2	0.20	100	20.0	20.5
30_BH10/4001_20151208	30_BH10-I1	4.21	100	421	
	30_BH10-I2	4.84	100	484	453
30_BH11/4001_20151208	30_BH11-I1	0.08	100	8.0	
	30_BH11-I2	0.06	100	6.0	7.0
QC1†	QC1-I1	0.04	100	4.0	
	QC1-I2	0.04	100	4.0	4.0
QC2‡	QC2-I1	<0.01	-	<0.01	
	QC2-I2	<0.01	-	<0.01	<0.01

†QC1 comprised of a lead-contaminated (681 mg Pb kg^{-1}) reference soil.

‡QC2 comprised of SBRC gastric phase solution without soil addition (assay blank)

Table 6. Total arsenic concentration and bioaccessible arsenic in contaminated soils (< 250 µm soil particle size fraction).

Soil	**Total As (mg kg^{-1})**	**In vitro Phase**	**As Bioacc. (mg kg^{-1})**	**As Bioacc.[‡] (%)**
1_BH09/4001_20151208	30	SBRC-G	3.0	10.0
7_BH07/4001_20151208	137	SBRC-G	10.5	7.7
30_BH10/4001_20151208	54	SBRC-G	5.0	9.3
30_BH11/4001_20151208	26	SBRC-G	2.0	7.7
QC1[Ω]	604	SBRC-G	495	82.0

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

[Ω] Arsenic bioaccessibility for the QC1 soil was within an acceptable range for this reference material (85.2 ± 5.2% [75.3-93.6%] for SBRC-G.

Table 7. Total lead concentration and bioaccessible lead in contaminated soils (< 250 µm soil particle size fraction).

Soil	**Total Pb (mg kg^{-1})**	**In vitro Phase**	**Pb Bioacc. (mg kg^{-1})**	**Pb Bioacc.[‡] (%)**
1_BH09/4001_20151208	379	SBRC-G	239	63.1
		SBRC-I	11.5	3.0
		Rel-SBRC-I*	111	29.3
7_BH07/4001_20151208	727	SBRC-G	330	45.4
		SBRC-I	20.5	2.8
		Rel-SBRC-I	198	27.2
30_BH10/4001_20151208	4540	SBRC-G	3465	76.3
		SBRC-I	453	10.0
		Rel-SBRC-I	4379	96.5
30_BH11/4001_20151208	458	SBRC-G	291	63.5
		SBRC-I	7.0	1.5
		Rel-SBRC-I	67.7	14.8
QC1[Ω]	681	SBRC-G	437	64.2
		SBRC-I	4.0	0.6
		Rel-SBRC-I	38.7	5.7

[‡] 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.

[Ω] Lead bioaccessibility for the QC1 soil was within an acceptable range for this reference material (68.5 ± 4.9% [60.1-77.8%] for SBRC-G.

REFERENCES

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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 Golder Associates Pty Ltd 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 arsenic and lead bioaccessibility.

Assessment of total As and Pb concentration in the < 2 mm and < 250 µm soil particle size fractions

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

Assessment of As and Pb 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* arsenic and 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

ALS Environmental Laboratories conducted the analysis for total and bioaccessible lead concentrations for all samples. ALS Environmental Laboratories are 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 – Arsenic and lead-contaminated (604 mg As kg^{-1} and 681 mg Pb kg^{-1}) reference soil with bioaccessibility values of 85.2 ± 5.2% [75.3-93.6%] and 68.5 ± 4.9% [60.1-77.8%] respectively for SBRC-G.
b. QC2 – SBRC solution without soil addition (assay blank).

APPENDIX 2 – CHAIN OF CUSTODY FORMS

Golder Associates

CHAIN OF COUSTODY

NO. ____

GOLDER ASSOCIATES PTY LTD
570 - 588 Swan Street
RICHMOND VIC 3121

Tel: (03) 8862 3500
Fax: (03) 8862 3501

Page 1 of 1

Golder Job Number: 1413212
Job Location: Costerfield
Laboratory Issued To: University of South Australia
Order No.: V356810
Sampled By (Golder): Freya Amon, Maddie Thomas
Golder Job Contact: Maddie Thomas
Golder Contact Email: mthomas@golder.com.au cbingham@golder.com.au

# OBSERV - ATIONS	SAMPLE DATE	SAMPLE NUMBER TAAXXX/MQNN	SAMPLE TYPE	SAMPLE DEPTH (m)	No. OF CONTAIN-ERS	Hold	Solubility Bioaccessibility Research Consortium Assay - Lead and Arsenic
	8/12/2015	1_BH09/4001_20151208	Soil	0.0 - 0.1	1		X
	8/12/2015	1_BH10/4001_20151208	Soil	0.0 - 0.1	1	X	
	8/12/2015	1_BH18/4001_20151208	Soil	0.0 - 0.1	1	X	
	8/12/2015	7_BH01/4001_20151208	Soil	0.0 - 0.1	1	X	
	8/12/2015	7_BH07/4001_20151208	Soil	0.0 - 0.1	1		X
	8/12/2015	20_BH10/4001_20151208	Soil	0.0 - 0.1	1	X	
	8/12/2015	20_BH11/4001_20151208	Soil	0.0 - 0.1	1	X	
	8/12/2015	30_BH10/4001_20151208	Soil	0.0 - 0.1	1		X
	8/12/2015	30_BH11/4001_20151208	Soil	0.0 - 0.1	1		X
	8/12/2015	32_BH09/4001_20151208	Soil	0.0 - 0.1	1	X	

Special Instructions:

TURN AROUND TIME REQUIRED

☐ 1 Working Day ☐ 2 Working Days ☐ 3 Working Days ☐ 5 Working Days (standard) ☐ Other As discussed

SAMPLE RECEIPT

Relinquished by: M Thomas Date: 14/12/2015
Organisation: Golder Associates Time: 1100
Recieved by: ALBERT JUHASZ Date: 15/12/15
Organisation: UniSA Time: 10.30

DELIVERED BY:
COURIER/LAB ☒
GOLDER ☐

ANALYTICAL SCHEDULE

Relinquished by: M Thomas Date: 14/12/2015
Organisation: Golder Associates Time: 1100
Received by: Date:
Organisation: Time:

RECEIVED BY:
FAX ☐
HAND ☒

SAMPLE STATUS
☒ Security Sealed
☒ Chilled
☐ Frozen
☐ Ambient

RECEIVING LABORATORY TO CONFIRM RECEIPT OF ANALYTICAL SCHEDULE BY RETURN EMAIL OR FAX TO: (03) 8862 3501

Observations to Assist Analysis and OH&S
C - Expected to be Highly Contaminated
N - NAPL Sample
HS - Expected High Salinity
HOC - Expected High Total Organic Carbon
S - Sheen
O - Odourous

Checked By: ____ Date: ____

Forms F012-b RL8 Aug08

CHAIN OF CUSTODY

ALS

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176
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Email Reports to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au
Email Invoice to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☒ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: [✓ 1] 2 3 4 5 6 7
OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No NA
Free ice / frozen ice bricks present upon receipt? Yes No NA
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY: *Albert Juhasz*
DATE/TIME: 17/12/15

RECEIVED BY:
DATE/TIME:

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY: [illegible] (ALS)
DATE/TIME: 18/12, [illegible]

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	Total As	Total Pb							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1.	1_BH09-2A	17/12/2015	S		1	1	1							
2	1_BH09-2B	17/12/2015	S		1	1	1							Soils have been oven dried and sieved
3	1_BH09-250A	17/12/2015	S		1	1	1							
4	1_BH09-250B	17/12/2015	S		1	1	1							
5	7_BH07-2A	17/12/2015	S		1	1	1							
6	7_BH07-2B	17/12/2015	S		1	1	1							
7	7_BH07-250A	17/12/2015	S		1	1	1							
8	7_BH07-250B	17/12/2015	S		1	1	1							
9	30_BH10-2A	17/12/2015	S		1	1	1							
10	30_BH10-2B	17/12/2015	S		1	1	1							
11	30_BH10-250A	17/12/2015	S		1	1	1							
12	30_BH10-250B	17/12/2015	S		1	1	1							
				TOTAL	12	12	12							

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division
Melbourne
Work Order Reference
EM1518647

Telephone : + 61-3-8549 9600

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney:** 277 Woodpark Rd, Smithfield NSW 2176
Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304
Ph:02 4968 9433 E:samples.newcastle@alsenviro.com

☐ **Brisbane:** 32 Shand St, Stafford QLD 4053
Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818
Ph:07 4796 0600 E: townsville.environmental@alsenviro.com

☐ **Melbourne:** 2-4 Westall Rd, Springvale VIC 3171
Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095
Ph: 08 8359 0890 E:adelaide@alsenviro.com

☐ **Perth:** 10 Hod Way, Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston:** 27 Wellington St, Launceston TAS 7250
Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	CERAR University of South Australia
OFFICE:	Mawson Lakes Campus X1-17
PROJECT:	Gold As / Pb BioAcc
ORDER NUMBER:	
PROJECT MANAGER:	Albert Juhasz
CONTACT PH:	08 8302 5045
SAMPLER:	Albert Juhasz
SAMPLER MOBILE:	0418 818 121
COC emailed to ALS?	(NO)
EDD FORMAT (or default):	
Email Reports to (will default to PM if no other addresses are listed):	Albert.Juhasz@unisa.edu.au
Email Invoice to (will default to PM if no other addresses are listed):	Albert.Juhasz@unisa.edu.au

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)
☒ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 [✓ 2] 3 4 5 6 7
OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt:
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Albert Juhasz			
DATE/TIME: 17/12/15	DATE/TIME:	DATE/TIME:	DATE/TIME: 18/12 9-30

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	Total As	Total Pb							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
13	30_BH11-2A	17/12/2015	S		1	1	1							Soils have been oven dried and sieved
14	30_BH11-2B	17/12/2015	S		1	1	1							
15	30_BH11-250A	17/12/2015	S		1	1	1							
16	30_BH11-250B	17/12/2015	S		1	1	1							
					TOTAL 4	4	4							

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

, OF CUSTODY

.LS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176
Ph 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304
Ph:02 4968 9433 E:samples.newcastle@alsenviro.com

☐ Brisbane: 32 Shand St, Stafford QLD 4053
Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818
Ph:07 4796 0600 E: townsville.environmental@alsenviro.com

☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171
Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095
Ph: 08 8359 0890 E:adelaide@alsenviro.com

☐ Perth: 10 Hod Way, Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250
Ph. 03 6331 2158 E: launceston@alsenviro.com

CERAR University of South Australia
.ᴇ: Mawson Lakes Campus X1-17
PROJECT: Gold As / Pb BioAcc
ORDER NUMBER:
PROJECT MANAGER: Albert Juhasz
CONTACT PH: 08 8302 5045
SAMPLER: Albert Juhasz
SAMPLER MOBILE: 0418 818 121
COC emailed to ALS? (NO)
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Email Reports to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au
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TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☒ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 [✓ 3] 4 5 6 7
OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt:
Other comment:

RELINQUISHED BY: *Albert Juhasz*
DATE/TIME: 17/12/15

RECEIVED BY:
DATE/TIME:

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY:
DATE/TIME: 18/12 9-30

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required)								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	Dissolved As	Dissolved Pb							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
17	1_BH09-G1	17/12/2015	W		1	1	1							Samples have been filtered and are ICP ready
18	1_BH09-G2	17/12/2015	W		1	1	1							
19	1_BH09-I1	17/12/2015	W		1	1	1							
20	1_BH09-I2	17/12/2015	W		1	1	1							
21	7_BH07-G1	17/12/2015	W		1	1	1							
22	7_BH07-G2	17/12/2015	W		1	1	1							
23	7_BH07-I1	17/12/2015	W		1	1	1							
24	7_BH07-I2	17/12/2015	W		1	1	1							
25	30_BH10-G1	17/12/2015	W		1	1	1							
26	30_BH10-G2	17/12/2015	W		1	1	1							
27	30_BH10-I1	17/12/2015	W		1	1	1							
28	30_BH10-I2	17/12/2015	W		1	1	1							
				TOTAL	12	12	12							

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
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CHAIN OF CUSTODY

ALS Laboratory: please tick →

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Ph:07 4796 0600 E: townsville.environmental@alsenviro.com

☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171
Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095
Ph: 08 8359 0890 E:adelaide@alsenviro.com

☐ Perth: 10 Hod Way, Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250
Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: CERAR University of South Australia
OFFICE: Mawson Lakes Campus X1-17
PROJECT: Gold As / Pb BioAcc
ORDER NUMBER:
PROJECT MANAGER: Albert Juhasz **CONTACT PH:** 08 8302 5045
SAMPLER: Albert Juhasz **SAMPLER MOBILE:** 0418 818 121
COC emailed to ALS? (NO) **EDD FORMAT (or default):**
Email Reports to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au
Email Invoice to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au

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☒ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 [✓ 4] 5 6 7
OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt:
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Albert Juhasz			
DATE/TIME: 17/12/15	DATE/TIME:	DATE/TIME:	DATE/TIME: 18/12 9:30

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	Dissolved As	Dissolved Pb							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
29	30_BH11-G1	17/12/2015	W		1	1	1							Samples have been filtered and are ICP ready
30	30_BH11-G2	17/12/2015	W		1	1	1							
31	30_BH11-I1	17/12/2015	W		1	1	1							
32	30_BH11-I2	17/12/2015	W		1	1	1							
33	QC1-G1	17/12/2015	W		1	1	1							
34	QC1-G2	17/12/2015	W		1	1	1							
35	QC1-I1	17/12/2015	W		1	1	1							
36	QC1-I2	17/12/2015	W		1	1	1							
37	QC2-G1	17/12/2015	W		1	1	1							
38	QC2-G2	17/12/2015	W		1	1	1							
39	QC2-I1	17/12/2015	W		1	1	1							
40	QC2-I2	17/12/2015	W		1	1	1							
				TOTAL	12	12	12							

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

APPENDIX 3 – ANALYTICAL RESULTS AND QA/QC

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order : **EM1518647**
Client : **UNISA - CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION**
Contact : MR ALBERT JUHASZ
Address : UNIVERSITY OF SOUTH AUSTRALIA CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION
BUILDING X MAWSON LAKES CAMPUS
MAWSON LAKES SOUTH AUSTRALIA 5095
E-mail : albert.juhasz@unisa.edu.au
Telephone : +61 08 8302 6273
Facsimile : ----
Project : Gold As / Pb BioAcc
Order number : ----
C-O-C number : ----
Sampler : ALBERT JUHASZ
Site : ----

Quote number : ----

Page : 1 of 11
Laboratory : Environmental Division Melbourne
Contact :
Address : 4 Westall Rd Springvale VIC Australia 3171

E-mail :
Telephone : +61-3-8549 9600
Facsimile : +61-3-8549 9601
QC Level : NEPM 2013 B3 & ALS QC Standard
Date Samples Received : 18-Dec-2015 09:30
Date Analysis Commenced : 21-Dec-2015
Issue Date : 29-Dec-2015 14:22

No. of samples received : 40
No. of samples analysed : 40

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA

WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Eric Chau	Metals Team Leader	Melbourne Inorganics, Springvale, VIC

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key :
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**1_BH09-2A**	**1_BH09-2B**	**1_BH09-250A**	**1_BH09-250B**	**7_BH07-2A**
			Client sampling date / time	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1518647-001**	**EM1518647-002**	**EM1518647-003**	**EM1518647-004**	**EM1518647-005**
				Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**35**	**38**	**30**	**30**	**133**
Lead	7439-92-1	5	mg/kg	**442**	**424**	**372**	**386**	**669**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**7_BH07-2B**	**7_BH07-250A**	**7_BH07-250B**	**30_BH10-2A**	**30_BH10-2B**
			Client sampling date / time	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1518647-006**	**EM1518647-007**	**EM1518647-008**	**EM1518647-009**	**EM1518647-010**
				Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**146**	**134**	**139**	**64**	**110**
Lead	7439-92-1	5	mg/kg	**751**	**731**	**722**	**4900**	**4220**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)	*Client sample ID*			**30_BH10-250A**	**30_BH10-250B**	**30_BH11-2A**	**30_BH11-2B**	**30_BH11-250A**
	Client sampling date / time			[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1518647-011**	**EM1518647-012**	**EM1518647-013**	**EM1518647-014**	**EM1518647-015**
				Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**53**	**55**	**28**	**31**	**26**
Lead	7439-92-1	5	mg/kg	**4530**	**4550**	**477**	**466**	**451**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**30_BH11-250B**	----	----	----	----
			Client sampling date / time	[17-Dec-2015]	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EM1518647-016**	-------	-------	-------	-------
				Result	Result	Result	Result	Result
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**26**	----	----	----	----
Lead	7439-92-1	5	mg/kg	**464**	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**1_BH09-G1**	**1_BH09-G2**	**1_BH09-I1**	**1_BH09-I2**	**7_BH07-G1**
			Client sampling date / time	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1518647-017**	**EM1518647-018**	**EM1518647-019**	**EM1518647-020**	**EM1518647-021**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	**0.03**	**0.03**	**0.04**	**0.04**	**0.10**
Lead	7439-92-1	0.01	mg/L	**2.36**	**2.41**	**0.13**	**0.10**	**3.30**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	**7_BH07-G2**	**7_BH07-I1**	**7_BH07-I2**	**30_BH10-G1**	**30_BH10-G2**
			Client sampling date / time	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1518647-022**	**EM1518647-023**	**EM1518647-024**	**EM1518647-025**	**EM1518647-026**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	**0.11**	**0.11**	**0.12**	**0.05**	**0.05**
Lead	7439-92-1	0.01	mg/L	**3.30**	**0.21**	**0.20**	**34.2**	**35.1**

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	**30_BH10-I1**	**30_BH10-I2**	**30_BH11-G1**	**30_BH11-G2**	**30_BH11-I1**
			Client sampling date / time	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1518647-027**	**EM1518647-028**	**EM1518647-029**	**EM1518647-030**	**EM1518647-031**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	**0.06**	**0.06**	**0.02**	**0.02**	**0.02**
Lead	7439-92-1	0.01	mg/L	**4.21**	**4.84**	**2.91**	**2.91**	**0.08**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**30_BH11-I2**	**QC1-G1**	**QC1-G2**	**QC1-I1**	**QC1-I2**
			Client sampling date / time	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1518647-032**	**EM1518647-033**	**EM1518647-034**	**EM1518647-035**	**EM1518647-036**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	**0.03**	**4.92**	**4.98**	**3.48**	**3.43**
Lead	7439-92-1	0.01	mg/L	**0.06**	**4.40**	**4.34**	**0.04**	**0.04**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**QC2-G1**	**QC2-G2**	**QC2-I1**	**QC2-I2**	----
			Client sampling date / time	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	[17-Dec-2015]	----
Compound	*CAS Number*	*LOR*	*Unit*	**EM1518647-037**	**EM1518647-038**	**EM1518647-039**	**EM1518647-040**	-------
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Lead	7439-92-1	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1518647**	Page	: 1 of 4
Client	: **UNISA - CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION**	Laboratory	: Environmental Division Melbourne
Contact	: MR ALBERT JUHASZ	Contact	:
Address	: UNIVERSITY OF SOUTH AUSTRALIA CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION BUILDING X MAWSON LAKES CAMPUS MAWSON LAKES SOUTH AUSTRALIA 5095	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: albert.juhasz@unisa.edu.au	E-mail	:
Telephone	: +61 08 8302 6273	Telephone	: +61-3-8549 9600
Facsimile	: ----	Facsimile	: +61-3-8549 9601
Project	: Gold As / Pb BioAcc	QC Level	: NEPM 2013 B3 & ALS QC Standard
Order number	: ----	Date Samples Received	: 18-Dec-2015
C-O-C number	: ----	Date Analysis Commenced	: 21-Dec-2015
Sampler	: ALBERT JUHASZ	Issue Date	: 29-Dec-2015
Site	: ----	No. of samples received	: 40
Quote number	: ----	No. of samples analysed	: 40

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA

WORLD RECOGNISED
ACCREDITATION

NATA Accredited
Laboratory 825

Accredited for
compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out ir compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics, Springvale, VIC
Eric Chau	Metals Team Leader	Melbourne Inorganics, Springvale, VIC

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to hig

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG005T: Total Metals by ICP-AES (QC Lot: 316867)									
EM1518530-003	Anonymous	EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	6	16	96.9	No Limit
EM1518530-001	Anonymous	EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	378	380	0.388	0% - 20%
EG005T: Total Metals by ICP-AES (QC Lot: 316869)									
EM1518647-011	30_BH10-250A	EG005T: Arsenic	7440-38-2	5	mg/kg	53	52	0.00	0% - 50%
		EG005T: Lead	7439-92-1	5	mg/kg	4530	4340	4.37	0% - 20%
EM1518655-014	Anonymous	EG005T: Arsenic	7440-38-2	5	mg/kg	<5	<5	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	18	20	12.2	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG005T: Total Metals by ICP-AES (QCLot: 316867)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	21.7 mg/kg	99.3	79	113
EG005T: Lead	7439-92-1	5	mg/kg	<5	40 mg/kg	95.5	85	107
EG005T: Total Metals by ICP-AES (QCLot: 316869)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	21.7 mg/kg	99.5	79	113
EG005T: Lead	7439-92-1	5	mg/kg	<5	40 mg/kg	98.2	85	107

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG005F: Dissolved Metals by ICP-AES (QCLot: 321369)								
EG005F: Arsenic	7440-38-2	0.01	mg/L	<0.01	1 mg/L	106	82	114
EG005F: Lead	7439-92-1	0.01	mg/L	<0.01	1 mg/L	100	84	116
EG005F: Dissolved Metals by ICP-AES (QCLot: 321370)								
EG005F: Arsenic	7440-38-2	0.01	mg/L	<0.01	1 mg/L	107	82	114
EG005F: Lead	7439-92-1	0.01	mg/L	<0.01	1 mg/L	100	84	116

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	*SpikeRecovery(%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG005T: Total Metals by ICP-AES (QCLot: 316867)							
EM1518530-002	Anonymous	EG005T: Arsenic	7440-38-2	50 mg/kg	105	78	124
		EG005T: Lead	7439-92-1	50 mg/kg	101	76	124
EG005T: Total Metals by ICP-AES (QCLot: 316869)							
EM1518647-012	30_BH10-250B	EG005T: Arsenic	7440-38-2	50 mg/kg	98.1	78	124
		EG005T: Lead	7439-92-1	50 mg/kg	# Not Determined	76	124

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1518647**	Page	: 1 of 5
Client	: **UNISA - CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION**	Laboratory	: Environmental Division Melbourne
Contact	: MR ALBERT JUHASZ	Telephone	: +61-3-8549 9600
Project	: Gold As / Pb BioAcc	Date Samples Received	: 18-Dec-2015
Site	: ----	Issue Date	: 29-Dec-2015
Sampler	: ALBERT JUHASZ	No. of samples received	: 40
Order number	: ----	No. of samples analysed	: 40

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EG005T: Total Metals by ICP-AES	EM1518647--012	30_BH10-250B	**Lead**	7439-92-1	Not Determined	—	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type Method	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
Dissolved Metals by ICP-AES	0	24	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)					
Dissolved Metals by ICP-AES	2	24	8.33	10.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
Dissolved Metals by ICP-AES	0	24	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method *Container / Client Sample ID(s)*		*Sample Date*	*Extraction / Preparation*			*Analysis*		
			Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EG005T: Total Metals by ICP-AES								
Plastic Tube (EG005T)								
1_BH09-2A, 1_BH09-250A, 7_BH07-2A, 7_BH07-250A, 30_BH10-2A, 30_BH10-250A, 30_BH11-2A, 30_BH11-250A,	1_BH09-2B, 1_BH09-250B, 7_BH07-2B, 7_BH07-250B, 30_BH10-2B, 30_BH10-250B, 30_BH11-2B, 30_BH11-250B	**17-Dec-2015**	**21-Dec-2015**	14-Jun-2016	✓	**22-Dec-2015**	14-Jun-2016	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EG005F: Dissolved Metals by ICP-AES							
Plastic Tube (EG005F)							
1_BH09-G1, 1_BH09-G2, 1_BH09-I1, 1_BH09-I2, 7_BH07-G1, 7_BH07-G2, 7_BH07-I1, 7_BH07-I2, 30_BH10-G1, 30_BH10-G2, 30_BH10-I1, 30_BH10-I2, 30_BH11-G1, 30_BH11-G2, 30_BH11-I1, 30_BH11-I2, QC1-G1, QC1-G2, QC1-I1, QC1-I2, QC2-G1, QC2-G2, QC2-I1, QC2-I2	**17-Dec-2015**	----	----	----	**29-Dec-2015**	14-Jun-2016	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		*Count*		*Rate (%)*			*Quality Control Specification*
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Total Metals by ICP-AES	EG005T	4	36	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Total Metals by ICP-AES	EG005T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Total Metals by ICP-AES	EG005T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Total Metals by ICP-AES	EG005T	2	36	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		*Count*		*Rate (%)*			*Quality Control Specification*
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Dissolved Metals by ICP-AES	EG005F	0	24	**0.00**	**10.00**	×	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Dissolved Metals by ICP-AES	EG005F	2	24	**8.33**	**10.00**	×	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Dissolved Metals by ICP-AES	EG005F	2	24	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Dissolved Metals by ICP-AES	EG005F	0	24	**0.00**	**5.00**	×	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Total Metals by ICP-AES	EG005T	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-AES	EG005F	WATER	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. The ICPAES technique ionises the 0.45um filtered samples, emitting a characteristic spectrum which is compared against matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)

University of South Australia

Determination of As and Pb Bioaccessibility in Impacted Soil (Costerfield – 1413212)

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Date of issue:	20 January 2016

Important Notice

Table of Contents

INTRODUCTION

This report was prepared for Golder Associates Pty Ltd to assess arsenic and lead bioaccessibility in impacted soil. The bioaccessibility testing was conducted by the Centre for Environmental Risk Assessment and Remediation (CERAR), an established research centre based at the Mawson Lakes Campus of the University of South Australia.

OBJECTIVES

The objective of this assessment was to:

- Assess the concentration of arsenic and lead in the < 2 mm and < 250 μm soil particle size fractions;
- Assess arsenic and 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 arsenic and lead in soil. The report was to include:
    - Assessment of arsenic and lead concentration in the < 2 mm and < 250 μm soil particle size fractions;
    - Assessment of arsenic and 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 Golder Associates Pty Ltd for an assessment of arsenic and 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 arsenic and lead concentration for each sample is shown in Tables 1 and 2 while arsenic and lead bioaccessibility results are shown in Tables 3 and 6 (arsenic bioaccessibility) and Tables 4, 5 and 7 (lead bioaccessibility).

- Total arsenic concentration in the < 2 mm soil particle size fraction ranged from 27 (32_BH09/4001_20151208) to 389 mg kg^{-1} (20_BH10/4001_20151208) (Table 1). A similar concentration range (22 to 381 mg kg^{-1}) was measured in the < 250 µm soil particle size fraction.
- Total lead concentration in the < 2 mm soil particle size fraction ranged from 64 (1_BH18/4001_20151208) to 448 mg kg^{-1} (1_BH10/4001_20151208) (Table 2). A similar concentration range (66 to 462 mg kg^{-1}) was measured in the < 250 µm soil particle size fraction.
- Arsenic bioaccessibility determined using gastric phase extraction (SBRC-G) ranged from 6.7 (7_BH01/4001_20151208) to 32.0% (20_BH10/4001_20151208) (Tables 3 and 6).
- Lead bioaccessibility determined using gastric phase extraction (SBRC-G) ranged from 12.1 (1_BH10/4001_20151208) to 61.0% (20_BH11/4001_20151208) (Table 4).
- When assays parameters were modified to reflect intestinal phase conditions (SBRC-I), lead bioaccessibility was reduced considerably (0.3% [1_BH10/4001_20151208] to 5.7%

[20_BH11/4001_20151208]), presumably as a result of re-adsorption of lead onto soil particles and / or precipitation at the neutral intestinal phase pH (Table 5).

- 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 7). Lead relative bioaccessibility was variable ranging from 3.1% (1_BH10/4001_20151208) to 55.2% (20_BH11/4001_20151208).

- An elevated arsenic bioaccessibility value was determined for QC1, however, lead bioaccessibility was within the acceptable range for this reference material and extraction phase.

Table 1. Total arsenic 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	
		As (mg kg^{-1})	Mean As (mg kg^{-1})		As (mg kg^{-1})	Mean As (mg kg^{-1})
1_BH10/4001_20151208	1_BH10-2A	275		1_BH10-250A	293	
	1_BH10-2B	283	279	1_BH10-250B	323	308
1_BH18/4001_20151208	1_BH18-2A	56		1_BH18-250A	52	
	1_BH18-2B	54	55	1_BH18-250B	53	53
7_BH01/4001_20151208	7_BH01-2A	86		7_BH01-250A	81	
	7_BH01-2B	97	92	7_BH01-250B	83	82
20_BH10/4001_20151208	20_BH10-2A	386		20_BH10-250A	377	
	20_BH10-2B	392	389	20_BH10-250B	385	381
20_BH11/4001_20151208	20_BH11-2A	127		20_BH11-250A	89	
	20_BH11-2B	112	120	20_BH11-250B	90	90
32_BH09/4001_20151208	32_BH09-2A	26		32_BH09-250A	21	
	32_BH09-2B	27	27	32_BH09-250B	22	22

Table 2. Total lead 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})
1_BH10/4001_20151208	1_BH10-2A	520		1_BH10-250A	476	
	1_BH10-2B	376	448	1_BH10-250B	448	462
1_BH18/4001_20151208	1_BH18-2A	65		1_BH18-250A	65	
	1_BH18-2B	63	64	1_BH18-250B	66	66
7_BH01/4001_20151208	7_BH01-2A	162		7_BH01-250A	166	
	7_BH01-2B	177	170	7_BH01-250B	170	168
20_BH10/4001_20151208	20_BH10-2A	310		20_BH10-250A	327	
	20_BH10-2B	315	313	20_BH10-250B	339	333
20_BH11/4001_20151208	20_BH11-2A	381		20_BH11-250A	317	
	20_BH11-2B	370	376	20_BH11-250B	315	315
32_BH09/4001_20151208	32_BH09-2A	146		32_BH09-250A	124	
	32_BH09-2B	139	143	32_BH09-250B	129	127

Table 3. Arsenic bioaccessibility in contaminated soils determined using gastric phase extraction (SBRC-G).

Soil	Sample #	ICP-MS As (mg l^{-1})	Soil:Solution Ratio	Gastric Phase As Bioaccessibility (mg kg^{-1})	Mean Gastric Phase As Bioaccessibility (mg kg^{-1})
1_BH10/4001_20151208	1_BH10-G1	0.68	100	68	
	1_BH10-G2	0.68	100	68	68
1_BH18/4001_20151208	1_BH18-G1	0.04	100	4.0	
	1_BH18-G2	0.04	100	4.0	4.0
7_BH01/4001_20151208	7_BH01-G1	0.06	100	6.0	
	7_BH01-G2	0.05	100	5.0	5.5
20_BH10/4001_20151208	20_BH10-G1	1.20	100	120	
	20_BH10-G2	1.23	100	123	122
20_BH11/4001_20151208	20_BH11-G1	0.21	100	21	
	20_BH11-G2	0.20	100	20	21
32_BH09/4001_20151208	32_BH09-G1	0.04	100	4.0	
	32_BH09-G2	0.04	100	4.0	4.0
QC1[†]	QC1-G1	6.57	100	657	
	QC1-G2	6.84	100	684	671
QC2[‡]	QC2-G1	0.03	-	0.03	
	QC2-G2	0.03	-	0.03	0.03

[†] QC1 comprised of an arsenic-contaminated (604 mg As kg^{-1}) reference soil.

[‡] QC2 comprised of SBRC gastric phase solution without soil addition (assay blank).

Table 4. Lead bioaccessibility in contaminated soils determined using gastric phase extraction (SBRC-G).

Soil	Sample #	ICP-MS Pb ($mg\ l^{-1}$)	Soil:Solution Ratio	Gastric Phase Pb Bioaccessibility ($mg\ kg^{-1}$)	Mean Gastric Phase Pb Bioaccessibility ($mg\ kg^{-1}$)
1_BH10/4001_20151208	1_BH10-G1	0.59	100	59	
	1_BH10-G2	0.52	100	52	56
1_BH18/4001_20151208	1_BH18-G1	0.23	100	23	
	1_BH18-G2	0.23	100	23	23
7_BH01/4001_20151208	7_BH01-G1	0.53	100	53	
	7_BH01-G2	0.54	100	54	54
20_BH10/4001_20151208	20_BH10-G1	1.63	100	163	
	20_BH10-G2	1.61	100	161	162
20_BH11/4001_20151208	20_BH11-G1	1.93	100	193	
	20_BH11-G2	1.90	100	190	192
32_BH09/4001_20151208	32_BH09-G1	0.71	100	71	
	32_BH09-G2	0.74	100	74	73
QC1†	QC1-G1	4.49	100	449	
	QC1-G2	4.61	100	461	455
QC2‡	QC2-G1	0.01	-	0.01	
	QC2-G2	<0.01	-	<0.01	0.01

†QC1 comprised of a lead-contaminated (681 mg Pb kg^{-1}) reference soil.

‡QC2 comprised of SBRC gastric phase solution without soil addition (assay blank)

Table 5. Lead bioaccessibility in contaminated soils determined using gastro-intestinal phase extraction (SBRC-I).

Soil	Sample #	ICP-MS Pb (mg l^{-1})	Soil:Solution Ratio	Intestinal Phase Pb Bioaccessibility (mg kg^{-1})	Mean Intestinal Phase Pb Bioaccessibility (mg kg^{-1})
1_BH10/4001_20151208	1_BH10-G1	0.02	100	2.0	1.5
	1_BH10-G2	0.01	100	1.0	
1_BH18/4001_20151208	1_BH18-G1	0.02	100	2.0	2.0
	1_BH18-G2	0.02	100	2.0	
7_BH01/4001_20151208	7_BH01-G1	0.03	100	3.0	2.5
	7_BH01-G2	0.02	100	2.0	
20_BH10/4001_20151208	20_BH10-G1	0.06	100	6.0	6.0
	20_BH10-G2	0.06	100	6.0	
20_BH11/4001_20151208	20_BH11-G1	0.18	100	18	18
	20_BH11-G2	0.17	100	17	
32_BH09/4001_20151208	32_BH09-G1	0.07	100	7.0	6.5
	32_BH09-G2	0.06	100	6.0	
QC1†	QC1-G1	0.12	100	12	12
	QC1-G2	0.11	100	11	
QC2‡	QC2-G1	<0.01	-	<0.01	<0.01
	QC2-G2	<0.01	-	<0.01	

†QC1 comprised of a lead-contaminated (681 mg Pb kg^{-1}) reference soil.

‡QC2 comprised of SBRC gastric phase solution without soil addition (assay blank)

Table 6. Total arsenic concentration and bioaccessible arsenic in contaminated soils (< 250 µm soil particle size fraction).

Soil	**Total As (mg kg^{-1})**	**In vitro Phase**	**As Bioacc. (mg kg^{-1})**	**As Bioacc.**[‡] **(%)**
1_BH10/4001_20151208	308	SBRC-G	68	22.1
1_BH18/4001_20151208	53	SBRC-G	4.0	7.5
7_BH01/4001_20151208	82	SBRC-G	5.5	6.7
20_BH10/4001_20151208	381	SBRC-G	122	32.0
20_BH11/4001_20151208	90	SBRC-G	21	23.3
32_BH09/4001_20151208	22	SBRC-G	4.0	18.2
QC1[Ω]	604	SBRC-G	671	~100

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

[Ω] Arsenic bioaccessibility for the QC1 soil was outside the range for this reference material (85.2 ± 5.2% [75.3-93.6%] for SBRC-G.

Table 7. Total lead concentration and bioaccessible lead in contaminated soils (< 250 μm soil particle size fraction).

Soil	Total Pb (mg kg^{-1})	In vitro Phase	Pb Bioacc. (mg kg^{-1})	Pb Bioacc.[‡] (%)
1_BH10/4001_20151208	462	SBRC-G	56	12.1
		SBRC-I	1.5	0.3
		Rel-SBRC-I[*]	14	3.1
1_BH18/4001_20151208	66	SBRC-G	23	34.8
		SBRC-I	2.0	3.0
		Rel-SBRC-I	19	29.2
7_BH01/4001_20151208	168	SBRC-G	54	32.1
		SBRC-I	2.5	1.5
		Rel-SBRC-I	21	12.6
20_BH10/4001_20151208	333	SBRC-G	162	48.6
		SBRC-I	6.0	1.8
		Rel-SBRC-I	58	17.4
20_BH11/4001_20151208	315	SBRC-G	192	61.0
		SBRC-I	18	5.7
		Rel-SBRC-I	174	55.2
32_BH09/4001_20151208	127	SBRC-G	73	57.5
		SBRC-I	6.5	5.1
		Rel-SBRC-I	63	49.6
QC1[Ω]	681	SBRC-G	455	66.8
		SBRC-I	12	1.8
		Rel-SBRC-I	116	17.0

[‡] 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.

[Ω] Lead bioaccessibility for the QC1 soil was within an acceptable range for this reference material (68.5 ± 4.9% [60.1-77.8%] for SBRC-G.

REFERENCES

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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 Golder Associates Pty Ltd 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 arsenic and lead bioaccessibility.

Assessment of total As and Pb concentration in the < 2 mm and < 250 µm soil particle size fractions

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

Assessment of As and Pb 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* arsenic and 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

ALS Environmental Laboratories conducted the analysis for total and bioaccessible lead concentrations for all samples. ALS Environmental Laboratories are 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 – Arsenic and lead-contaminated (604 mg As kg^{-1} and 681 mg Pb kg^{-1}) reference soil with bioaccessibility values of 85.2 ± 5.2% [75.3-93.6%] and 68.5 ± 4.9% [60.1-77.8%] respectively for SBRC-G.
b. QC2 – SBRC solution without soil addition (assay blank).

APPENDIX 2 – CHAIN OF CUSTODY FORMS

Golder Associates

CHAIN OF CUSTODY

NO. ____

GOLDER ASSOCIATES PTY LTD
570 - 588 Swan Street
RICHMOND VIC 3121

Tel: (03) 8862 3500
Fax: (03) 8862 3501

Page 1 of 1

Golder Job Number: 1413212
Job Location: Costerfield
Laboratory Issued To: University of South Australia
Order No.: V356810
Sampled By (Golder): Freya Amon, Maddie Thomas
Golder Job Contact: Maddie Thomas
Golder Contact Email: mthomas@golder.com.au cbingham@golder.com.au

# OBSERV - ATIONS	SAMPLE DATE	SAMPLE NUMBER TAAXXX/MQNN	SAMPLE TYPE	SAMPLE DEPTH (m)	No. OF CONTAIN-ERS	Hold	Solubility Bioaccessibility Research Consortium Assay - Lead and Arsenic
	8/12/2015	1_BH09/4001_20151208	Soil	0.0 - 0.1	1		x
	8/12/2015	1_BH10/4001_20151208	Soil	0.0 - 0.1	1	x	
	8/12/2015	1_BH18/4001_20151208	Soil	0.0 - 0.1	1	x	
	8/12/2015	7_BH01/4001_20151208	Soil	0.0 - 0.1	1	x	
	8/12/2015	7_BH07/4001_20151208	Soil	0.0 - 0.1	1		x
	8/12/2015	20_BH10/4001_20151208	Soil	0.0 - 0.1	1	x	
	8/12/2015	20_BH11/4001_20151208	Soil	0.0 - 0.1	1	x	
	8/12/2015	30_BH10/4001_20151208	Soil	0.0 - 0.1	1		x
	8/12/2015	30_BH11/4001_20151208	Soil	0.0 - 0.1	1		x
	8/12/2015	32_BH09/4001_20151208	Soil	0.0 - 0.1	1	x	

Special Instructions:

TURN AROUND TIME REQUIRED

☐ 1 Working Day ☐ 2 Working Days ☐ 3 Working Days ☐ 5 Working Days (standard) ☐ Other As discussed

SAMPLE RECEIPT

Relinquished by: M Thomas Date: 14/12/2015
Organisation: Golder Associates Time: 1100
Recieved by: ALBERT JUHASZ Date: 15/12/15
Organisation: UniSA Time: 10.30

DELIVERED BY:
COURIER/LAB ☒
GOLDER ☐

ANALYTICAL SCHEDULE

Relinquished by: M Thomas Date: 14/12/2015
Organisation: Golder Associates Time: 1100
Received by: Date:
Organisation: Time:

RECEIVED BY:
FAX ☐
HAND ☒

SAMPLE STATUS
☒ Security Sealed
☒ Chilled
☐ Frozen
☐ Ambient

RECEIVING LABORATORY TO CONFIRM RECEIPT OF ANALYTICAL SCHEDULE BY RETURN EMAIL OR FAX TO: (03) 8862 3501

Observations to Assist Analysis and OH&S

C - Expected to be Highly Contaminated	HS - Expected High Salinity	S - Sheen
N - NAPL Sample	HOC - Expected High Total Organic Carbon	O - Odourous

Checked By: ____ Date: ____

Forms F012-b RL8 Aug08

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☐ **Launceston:** 27 Wellington St, Launceston TAS 7250 Ph. 03 6331 2158 E: launceston@alsenviro.com

CLIENT: CERAR University of South Australia
OFFICE: Mawson Lakes Campus X1-17
PROJECT: Gold As / Pb BioAcc 2
ORDER NUMBER:
PROJECT MANAGER: Albert Juhasz **CONTACT PH:** 08 8302 5045
SAMPLER: Albert Juhasz **SAMPLER MOBILE:** 0418 818 121
COC emailed to ALS? (NO) **EDD FORMAT (or default):**
Email Reports to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au
Email Invoice to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au
COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
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☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: [✓ 1] 2 3 4 5 6 7
OF: 1 2 3 4 [✓ 5] 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt:
Other comment:

RELINQUISHED BY: *Albert Juhasz*
DATE/TIME: 14/1/16

RECEIVED BY:
DATE/TIME:

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY:
DATE/TIME: 15/01, 10.25

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).		Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	Total As	Total Pb	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	7_BH01-2A	14/01/2016	S		1	1	1	
2	7_BH01-2B	14/01/2016	S		1	1	1	Soils have been oven dried and sieved
3	7_BH01-250A	14/01/2016	S		1	1	1	
4	7_BH01-250B	14/01/2016	S		1	1	1	
5	32_BH09-2A	14/01/2016	S		1	1	1	
6	32_BH09-2B	14/01/2016	S		1	1	1	
7	32_BH09-250A	14/01/2016	S		1	1	1	
8	32_BH09-250B	14/01/2016	S		1	1	1	
9	1_BH10-2A	14/01/2016	S		1	1	1	
10	1_BH10-2B	14/01/2016	S		1	1	1	
11	1_BH10-250A	14/01/2016	S		1	1	1	
12	1_BH10-250B	14/01/2016	S		1	1	1	
				TOTAL	12	12	12	

SCANNED

Environmental Division
Melbourne
Work Order Reference
EM1600340

Telephone : + 61-3-8549 9600

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

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COC: 1 [✓ 2] 3 4 5 6 7
OF: 1 2 3 4 [✓ 5] 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt:
Other comment:

RELINQUISHED BY: *Albert Juhasz*
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DATE/TIME:

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DATE/TIME:

RECEIVED BY: Mana Cau
DATE/TIME: 15/01 10-25

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required)								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	Total As	Total Pb							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
13	20_BH10-2A	14/01/2016	S		1	1	1							
14	20_BH10-2B	14/01/2016	S		1	1	1							Soils have been oven dried and sieved
15	20_BH10-250A	14/01/2016	S		1	1	1							
16	20_BH10-250B	14/01/2016	S		1	1	1							
17	20_BH11-2A	14/01/2016	S		1	1	1							
18	20_BH11-2B	14/01/2016	S		1	1	1							
19	20_BH11-250A	14/01/2016	S		1	1	1							
20	20_BH11-250B	14/01/2016	S		1	1	1							
21	1_BH18-2A	14/01/2016	S		1	1	1							
22	1_BH18-2B	14/01/2016	S		1	1	1							
23	1_BH18-250A	14/01/2016	S		1	1	1							
24	1_BH18-250B	14/01/2016	S		1	1	1							
				TOTAL	12	12	12							

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
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Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

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CLIENT: CERAR University of South Australia
OFFICE: Mawson Lakes Campus X1-17
PROJECT: Gold As / Pb BioAcc 2
ORDER NUMBER:
PROJECT MANAGER: Albert Juhasz **CONTACT PH:** 08 8302 5045
SAMPLER: Albert Juhasz **SAMPLER MOBILE:** 0418 818 121
COC emailed to ALS? (NO) **EDD FORMAT (or default):**
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☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 [✓ 3] 4 5 6 7
OF: 1 2 3 4 [✓ 5] 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt:
Other comment:

RELINQUISHED BY: *Albert Juhasz* DATE/TIME: 14/1/16	**RECEIVED BY:** DATE/TIME:	**RELINQUISHED BY:** DATE/TIME:	**RECEIVED BY:** DATE/TIME: 15/01 10:45

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	Dissolved As	Dissolved Pb							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
25	7_BH01-G1	14/01/2016	W		1	1	1							
26	7_BH01-G2	14/01/2016	W		1	1	1							Samples have been filtered (0.45 um)
27	7_BH01-I1	14/01/2016	W		1	-	1							and are ICP ready
28	7_BH01-I2	14/01/2016	W		1	-	1							
29	32_BH09-G1	14/01/2016	W		1	1	1							
30	32_BH09-G2	14/01/2016	W		1	1	1							
31	32_BH09-I1	14/01/2016	W		1	-	1							
32	32_BH09-I2	14/01/2016	W		1	-	1							
33	1_BH10-G1	14/01/2016	W		1	1	1							
34	1_BH10-G2	14/01/2016	W		1	1	1							
35	1_BH10-I1	14/01/2016	W		1	-	1							
36	1_BH10-I2	14/01/2016	W		1	-	1							
				TOTAL	12	6	12							

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag

ALS

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176
Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304
Ph:02 4968 9433 E:samples.newcastle@alsenviro.com

☐ Brisbane: 32 Shand St, Stafford QLD 4053
Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818
Ph:07 4796 0600 E: townsville.environmental@alsenviro.com

☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171
Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095
Ph: 08 8359 0890 E:adelaide@alsenviro.com

☐ Perth: 10 Hod Way, Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250
Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: CERAR University of South Australia
OFFICE: Mawson Lakes Campus X1-17
PROJECT: Gold As / Pb BioAcc 2
ORDER NUMBER:
PROJECT MANAGER: Albert Juhasz **CONTACT PH:** 08 8302 5045
SAMPLER: Albert Juhasz **SAMPLER MOBILE:** 0418 818 121
COC emailed to ALS? (NO) **EDD FORMAT (or default):**
Email Reports to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au
Email Invoice to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au

TURNAROUND REQUIREMENTS : ☒ Standard TAT (List due date):
(Standard TAT may be longer for some tests e.g., Ultra Trace Organics) ☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 [✓ 4] 5 6 7
OF: 1 2 3 4 [✓ 5] 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt:
Other comment:

RELINQUISHED BY: *Albert Juhasz*
DATE/TIME: 14/1/16

RECEIVED BY:
DATE/TIME:

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY: Mana (AL
DATE/TIME: ~~10~~ 15/01 10:45

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	Dissolved As	Dissolved Pb							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
37	20_BH10-G1	14/01/2016	W		1	1	1							
38	20_BH10-G2	14/01/2016	W		1	1	1							Samples have been filtered (0.45 um)
39	20_BH10-I1	14/01/2016	W		1	-	1							and are ICP ready
40	20_BH10-I2	14/01/2016	W		1	-	1							
41	20_BH11-G1	14/01/2016	W		1	1	1							
42	20_BH11-G2	14/01/2016	W		1	1	1							
43	20_BH11-I1	14/01/2016	W		1	-	1							
44	20_BH11-I2	14/01/2016	W		1	-	1							
45	1_BH18-G1	14/01/2016	W		1	1	1							
46	1_BH18-G2	14/01/2016	W		1	1	1							
47	1_BH18-I1	14/01/2016	W		1	-	1							
48	1_BH18-I2	14/01/2016	W		1	-	1							
				TOTAL	12	6	12							

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176
Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304
Ph:02 4968 9433 E:samples.newcastle@alsenviro.com

☐ **Brisbane**: 32 Shand St, Stafford QLD 4053
Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818
Ph:07 4796 0600 E: townsville.environmental@alsenviro.com

☐ **Melbourne**: 2-4 Westall Rd, Springvale VIC 3171
Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095
Ph: 08 8359 0890 E:adelaide@alsenviro.com

☐ **Perth**: 10 Hod Way, Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston:** 27 Wellington St, Launceston TAS 7250
Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: CERAR University of South Australia
OFFICE: Mawson Lakes Campus X1-17
PROJECT: Gold As / Pb BioAcc 2
ORDER NUMBER:
PROJECT MANAGER: Albert Juhasz **CONTACT PH:** 08 8302 5045
SAMPLER: Albert Juhasz **SAMPLER MOBILE:** 0418 818 121
COC emailed to ALS? (NO) **EDD FORMAT (or default):**
Email Reports to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au
Email Invoice to (will default to PM if no other addresses are listed): Albert.Juhasz@unisa.edu.au

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☒ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 [✓ 5] 6 7
OF: 1 2 3 4 [✓ 5] 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt:
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Albert Juhasz			Karra Au
DATE/TIME: 14/1/16	DATE/TIME:	DATE/TIME:	DATE/TIME: 15/01 10-45

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	Dissolved As	Dissolved Pb							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
49	QC1-G1	14/01/2016	W		1	1	1							
50	QC1-G2	14/01/2016	W		1	1	1							Samples have been filtered (0.45 um)
51	QC1-I1	14/01/2016	W		1	-	1							and are ICP ready
52	QC1-I2	14/01/2016	W		1	-	1							
53	QC2-G1	14/01/2016	W		1	1	1							
54	QC2-G2	14/01/2016	W		1	1	1							
55	QC2-I1	14/01/2016	W		1	-	1							
56	QC2-I2	14/01/2016	W		1	-	1							
					TOTAL 8	4	8							

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

APPENDIX 3 – ANALYTICAL RESULTS AND QA/QC

CERTIFICATE OF ANALYSIS

Work Order	: **EM1600340**	Page	: 1 of 14
Client	: **UNISA - CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION**	Laboratory	: Environmental Division Melbourne
Contact	: MR ALBERT JUHASZ	Contact	:
Address	: UNIVERSITY OF SOUTH AUSTRALIA CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION BUILDING X MAWSON LAKES CAMPUS MAWSON LAKES SOUTH AUSTRALIA 5095	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: albert.juhasz@unisa.edu.au	E-mail	:
Telephone	: +61 08 8302 6273	Telephone	: +61-3-8549 9600
Facsimile	: ----	Facsimile	: +61-3-8549 9601
Project	: Gold As / Pb BioAcc 2	QC Level	: NEPM 2013 B3 & ALS QC Standard
Order number	: ----	Date Samples Received	: 15-Jan-2016 10:45
C-O-C number	: ----	Date Analysis Commenced	: 18-Jan-2016
Sampler	: ALBERT JUHASZ	Issue Date	: 20-Jan-2016 11:44
Site	: ----		
		No. of samples received	: 56
Quote number	: ----	No. of samples analysed	: 56

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

WORLD RECOGNISED ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Herman Lin	Laboratory Manager	Melbourne Inorganics, Springvale, VIC

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**7_BH01-2A**	**7_BH01-2B**	**7_BH01-250A**	**7_BH01-250B**	**32_BH09-2A**
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-001**	**EM1600340-002**	**EM1600340-003**	**EM1600340-004**	**EM1600340-005**
				Result	Result	Result	Result	Result
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	<1.0	<1.0	<1.0	<1.0	**1.4**
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**86**	**97**	**81**	**83**	**26**
Lead	7439-92-1	5	mg/kg	**162**	**177**	**166**	**170**	**146**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**32_BH09-2B**	**32_BH09-250A**	**32_BH09-250B**	**1_BH10-2A**	**1_BH10-2B**
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-006**	**EM1600340-007**	**EM1600340-008**	**EM1600340-009**	**EM1600340-010**
				Result	Result	Result	Result	Result
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**1.2**	<1.0	**1.2**	<1.0	<1.0
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**27**	**21**	**22**	**275**	**283**
Lead	7439-92-1	5	mg/kg	**139**	**124**	**129**	**520**	**376**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**1_BH10-250A**	**1_BH10-250B**	**20_BH10-2A**	**20_BH10-2B**	**20_BH10-250A**
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-011**	**EM1600340-012**	**EM1600340-013**	**EM1600340-014**	**EM1600340-015**
				Result	Result	Result	Result	Result
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**1.4**	<1.0	<1.0	<1.0	<1.0
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**293**	**323**	**386**	**392**	**377**
Lead	7439-92-1	5	mg/kg	**476**	**448**	**310**	**315**	**327**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			*Client sample ID*	20_BH10-250B	20_BH11-2A	20_BH11-2B	20_BH11-250A	20_BH11-250B
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-016**	**EM1600340-017**	**EM1600340-018**	**EM1600340-019**	**EM1600340-020**
				Result	Result	Result	Result	Result
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	<1.0	<1.0	<1.0	<1.0	<1.0
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**385**	**127**	**112**	**89**	**90**
Lead	7439-92-1	5	mg/kg	**339**	**381**	**370**	**317**	**312**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			*Client sample ID*	**1_BH18-2A**	**1_BH18-2B**	**1_BH18-250A**	**1_BH18-250B**	----
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	----
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-021**	**EM1600340-022**	**EM1600340-023**	**EM1600340-024**	--------
				Result	Result	Result	Result	Result
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	<1.0	<1.0	<1.0	<1.0	----
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	**56**	**54**	**52**	**53**	----
Lead	7439-92-1	5	mg/kg	**65**	**63**	**65**	**66**	----

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	**7_BH01-G1**	**7_BH01-G2**	**7_BH01-I1**	**7_BH01-I2**	**32_BH09-G1**
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-025**	**EM1600340-026**	**EM1600340-027**	**EM1600340-028**	**EM1600340-029**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	**0.06**	**0.05**	**----**	**----**	**0.04**
Lead	7439-92-1	0.01	mg/L	**0.53**	**0.54**	**0.03**	**0.02**	**0.71**

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	**32_BH09-G2**	**32_BH09-I1**	**32_BH09-I2**	**1_BH10-G1**	**1_BH10-G2**
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-030**	**EM1600340-031**	**EM1600340-032**	**EM1600340-033**	**EM1600340-034**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	**0.04**	----	----	**0.68**	**0.68**
Lead	7439-92-1	0.01	mg/L	**0.74**	**0.07**	**0.06**	**0.59**	**0.52**

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	**1_BH10-I1**	**1_BH10-I2**	**20_BH10-G1**	**20_BH10-G2**	**20_BH10-I1**
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-035**	**EM1600340-036**	**EM1600340-037**	**EM1600340-038**	**EM1600340-039**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	----	----	**1.20**	**1.23**	----
Lead	7439-92-1	0.01	mg/L	**0.02**	**0.01**	**1.63**	**1.61**	**0.06**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**20_BH10-I2**	**20_BH11-G1**	**20_BH11-G2**	**20_BH11-I1**	**20_BH11-I2**
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-040**	**EM1600340-041**	**EM1600340-042**	**EM1600340-043**	**EM1600340-044**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	----	**0.21**	**0.20**	----	----
Lead	7439-92-1	0.01	mg/L	**0.06**	**1.93**	**1.90**	**0.18**	**0.17**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**1_BH18-G1**	**1_BH18-G2**	**1_BH18-I1**	**1_BH18-I2**	**QC1-G1**
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-045**	**EM1600340-046**	**EM1600340-047**	**EM1600340-048**	**EM1600340-049**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	**0.04**	**0.04**	----	----	**6.57**
Lead	7439-92-1	0.01	mg/L	**0.23**	**0.23**	**0.02**	**0.02**	**4.49**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**QC1-G2**	**QC1-I1**	**QC1-I2**	**QC2-G1**	**QC2-G2**
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]	[14-Jan-2016]
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-050**	**EM1600340-051**	**EM1600340-052**	**EM1600340-053**	**EM1600340-054**
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	**6.84**	----	----	**0.03**	**0.03**
Lead	7439-92-1	0.01	mg/L	**4.61**	**0.12**	**0.11**	**0.01**	<0.01

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**QC2-I1**	**QC2-I2**	----	----	----
			Client sampling date / time	[14-Jan-2016]	[14-Jan-2016]	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EM1600340-055**	**EM1600340-056**	--------	--------	--------
				Result	Result	Result	Result	Result
EG005F: Dissolved Metals by ICP-AES								
Arsenic	7440-38-2	0.01	mg/L	----	----	----	----	----
Lead	7439-92-1	0.01	mg/L	<0.01	<0.01	----	----	----

ALS Environmental

QUALITY CONTROL REPORT

Work Order	: **EM1600340**	Page	: 1 of 4
Client	: **UNISA - CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION**	Laboratory	: Environmental Division Melbourne
Contact	: MR ALBERT JUHASZ	Contact	:
Address	: UNIVERSITY OF SOUTH AUSTRALIA CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION BUILDING X MAWSON LAKES CAMPUS MAWSON LAKES SOUTH AUSTRALIA 5095	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: albert.juhasz@unisa.edu.au	E-mail	:
Telephone	: +61 08 8302 6273	Telephone	: +61-3-8549 9600
Facsimile	: ----	Facsimile	: +61-3-8549 9601
Project	: Gold As / Pb BioAcc 2	QC Level	: NEPM 2013 B3 & ALS QC Standard
Order number	: ----	Date Samples Received	: 15-Jan-2016
C-O-C number	: ----	Date Analysis Commenced	: 18-Jan-2016
Sampler	: ALBERT JUHASZ	Issue Date	: 20-Jan-2016
Site	: ----	No. of samples received	: 56
Quote number	: ----	No. of samples analysed	: 56

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA

WORLD RECOGNISED
ACCREDITATION

NATA Accredited
Laboratory 825

Accredited for
compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out ir compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Herman Lin	Laboratory Manager	Melbourne Inorganics, Springvale, VIC

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :

Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA055: Moisture Content (QC Lot: 334119)									
EM1600331-017	Anonymous	EA055-103: Moisture Content (dried @ 103°C)	----	1	%	2.5	2.7	7.62	No Limit
EM1600331-025	Anonymous	EA055-103: Moisture Content (dried @ 103°C)	----	1	%	1.2	1.3	13.7	No Limit
EA055: Moisture Content (QC Lot: 334120)									
EM1600340-013	20_BH10-2A	EA055-103: Moisture Content (dried @ 103°C)	----	1	%	<1.0	<1.0	0.00	No Limit
EM1600343-001	Anonymous	EA055-103: Moisture Content (dried @ 103°C)	----	1	%	23.3	23.3	0.00	0% - 20%
EG005T: Total Metals by ICP-AES (QC Lot: 334755)									
EM1600235-002	Anonymous	EG005T: Arsenic	7440-38-2	5	mg/kg	10	10	0.00	No Limit
		EG005T: Lead	7439-92-1	5	mg/kg	26	27	0.00	No Limit
EM1600235-022	Anonymous	EG005T: Arsenic	7440-38-2	5	mg/kg	60	61	2.50	0% - 50%
		EG005T: Lead	7439-92-1	5	mg/kg	248	255	2.46	0% - 20%
EG005T: Total Metals by ICP-AES (QC Lot: 334756)									
EM1600340-009	1_BH10-2A	EG005T: Arsenic	7440-38-2	5	mg/kg	275	284	2.91	0% - 20%
		EG005T: Lead	7439-92-1	5	mg/kg	520	531	2.12	0% - 20%
EM1600340-018	20_BH11-2B	EG005T: Arsenic	7440-38-2	5	mg/kg	112	115	3.06	0% - 20%
		EG005T: Lead	7439-92-1	5	mg/kg	370	381	2.90	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG005T: Total Metals by ICP-AES (QCLot: 334755)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	21.7 mg/kg	106	79	113
EG005T: Lead	7439-92-1	5	mg/kg	<5	40 mg/kg	98.1	85	107
EG005T: Total Metals by ICP-AES (QCLot: 334756)								
EG005T: Arsenic	7440-38-2	5	mg/kg	<5	21.7 mg/kg	106	79	113
EG005T: Lead	7439-92-1	5	mg/kg	<5	40 mg/kg	100	85	107

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG005F: Dissolved Metals by ICP-AES (QCLot: 334354)								
EG005F: Arsenic	7440-38-2	0.01	mg/L	<0.01	1 mg/L	106	82	114
EG005F: Lead	7439-92-1	0.01	mg/L	<0.01	1 mg/L	97.1	84	116
EG005F: Dissolved Metals by ICP-AES (QCLot: 334355)								
EG005F: Arsenic	7440-38-2	0.01	mg/L	<0.01	1 mg/L	114	82	114
EG005F: Lead	7439-92-1	0.01	mg/L	<0.01	1 mg/L	104	84	116

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	*SpikeRecovery(%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG005T: Total Metals by ICP-AES (QCLot: 334755)							
EM1600235-006	Anonymous	EG005T: Arsenic	7440-38-2	50 mg/kg	98.9	78	124
		EG005T: Lead	7439-92-1	50 mg/kg	89.8	76	124
EG005T: Total Metals by ICP-AES (QCLot: 334756)							
EM1600340-010	1_BH10-2B	EG005T: Arsenic	7440-38-2	50 mg/kg	# Not Determined	78	124
		EG005T: Lead	7439-92-1	50 mg/kg	# Not Determined	76	124

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM1600340**	Page	: 1 of 6
Client	: **UNISA - CENTRE FOR ENVIRONMENT RISK ASSESSMENT & REMEDIATION**	Laboratory	: Environmental Division Melbourne
Contact	: MR ALBERT JUHASZ	Telephone	: +61-3-8549 9600
Project	: Gold As / Pb BioAcc 2	Date Samples Received	: 15-Jan-2016
Site	: ----	Issue Date	: 20-Jan-2016
Sampler	: ALBERT JUHASZ	No. of samples received	: 56
Order number	: ----	No. of samples analysed	: 56

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EG005T: Total Metals by ICP-AES	EM1600340--010	1_BH10-2B	**Arsenic**	7440-38-2	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005T: Total Metals by ICP-AES	EM1600340--010	1_BH10-2B	**Lead**	7439-92-1	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type Method	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
Dissolved Metals by ICP-AES	0	32	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)					
Dissolved Metals by ICP-AES	2	32	6.25	10.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
Dissolved Metals by ICP-AES	0	32	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)			*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA055: Moisture Content								
Plastic Tube (EA055-103)								
7_BH01-2A,	7_BH01-2B,	**14-Jan-2016**	----	----	----	**18-Jan-2016**	28-Jan-2016	✓
7_BH01-250A,	7_BH01-250B,							
32_BH09-2A,	32_BH09-2B,							
32_BH09-250A,	32_BH09-250B,							
1_BH10-2A,	1_BH10-2B,							
1_BH10-250A,	1_BH10-250B,							
20_BH10-2A,	20_BH10-2B,							
20_BH10-250A,	20_BH10-250B,							
20_BH11-2A,	20_BH11-2B,							
20_BH11-250A,	20_BH11-250B,							
1_BH18-2A,	1_BH18-2B,							
1_BH18-250A,	1_BH18-250B							
EG005T: Total Metals by ICP-AES								
Plastic Tube (EG005T)								
7_BH01-2A,	7_BH01-2B,	**14-Jan-2016**	**19-Jan-2016**	12-Jul-2016	✓	**20-Jan-2016**	12-Jul-2016	✓
7_BH01-250A,	7_BH01-250B,							
32_BH09-2A,	32_BH09-2B,							
32_BH09-250A,	32_BH09-250B,							
1_BH10-2A,	1_BH10-2B,							
1_BH10-250A,	1_BH10-250B,							
20_BH10-2A,	20_BH10-2B,							
20_BH10-250A,	20_BH10-250B,							
20_BH11-2A,	20_BH11-2B,							
20_BH11-250A,	20_BH11-250B,							
1_BH18-2A,	1_BH18-2B,							
1_BH18-250A,	1_BH18-250B							

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EG005F: Dissolved Metals by ICP-AES							
Miscellaneous Digest preserved (EG005F)							
7_BH01-G1, 7_BH01-G2, 7_BH01-I1, 7_BH01-I2, 32_BH09-G1, 32_BH09-G2, 32_BH09-I1, 32_BH09-I2, 1_BH10-G1, 1_BH10-G2, 1_BH10-I1, 1_BH10-I2, 20_BH10-G1, 20_BH10-G2, 20_BH10-I1, 20_BH10-I2, 20_BH11-G1, 20_BH11-G2, 20_BH11-I1, 20_BH11-I2, 1_BH18-G1, QC1-G1, 1_BH18-G2, 1_BH18-I1, 1_BH18-I2, QC1-G2, QC1-I1, QC1-I2, QC2-G1, QC2-G2, QC2-I1, QC2-I2	**14-Jan-2016**	----	----	----	**19-Jan-2016**	12-Jul-2016	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Moisture Content	EA055-103	4	35	**11.43**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-AES	EG005T	4	40	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Total Metals by ICP-AES	EG005T	2	40	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Total Metals by ICP-AES	EG005T	2	40	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Total Metals by ICP-AES	EG005T	2	40	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Dissolved Metals by ICP-AES	EG005F	0	32	**0.00**	**10.00**	×	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Dissolved Metals by ICP-AES	EG005F	2	32	**6.25**	**10.00**	×	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Dissolved Metals by ICP-AES	EG005F	2	32	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Dissolved Metals by ICP-AES	EG005F	0	32	**0.00**	**5.00**	×	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Moisture Content	EA055-103	SOIL	In-house. A gravimetric procedure based on weight loss over a 12 hour drying period at 103-105 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Total Metals by ICP-AES	EG005T	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-AES	EG005F	WATER	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. The ICPAES technique ionises the 0.45um filtered samples, emitting a characteristic spectrum which is compared against matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3)

APPENDIX E

Exposure Assessment

1.0 EXPOSURE ASSESSMENT – INTRODUCTION

In general terms, an exposure assessment assesses the amount, frequency, duration and routes of exposure to substances present in environmental media.

In this HRA, exposure is estimated as the concentration of a compound to which a receptor may be exposed over long-term (i.e. chronic) exposure periods. The sections below describe the pathways of exposure as identified in the CSM (Appendix C of the HRA report), the equations used to estimate a daily intake of the COPC from each of those pathways and a summary of the input parameters used in the exposure equations. The final sections present the results of the exposure assessment in the form of estimated daily intakes for the various scenarios modelled.

2.0 EXPOSURE PATHWAYS

The exposure pathways identified in the CSM (Appendix C of the HRA report) were the following:

- Incidental ingestion of soil and dermal contact with soil
- Inhalation and ingestion of outdoor dust
- Inhalation and ingestion of indoor dust
- Ingestion and dermal contact (bath/shower) with tank water or bottled water
- Ingestion of locally grown produce (eggs and lamb).

3.0 EXPOSURE EQUATIONS

The exposure equations 1-10 listed below were used to estimate, for each receptor, the daily intake of an individual chemical in soil and water, dust and food (land and eggs) for each of the potential exposure pathways. These equations are consistent with Australian health risk assessment frameworks (NEPC 2013, enHealth 2012a). Equation 11 is for the dermal absorbed dose which is used within Equation 6 to estimate the absorbed dose of a COPC during bathing or showering as per US EPA guidance (US EPA 2004).

SOIL INGESTION

$$EDI = C_s \text{ x } IR_{soil} \text{ x } BF_{oral} \text{ x } BA \text{ x } CF1 \text{ x } EF \text{ x } ED \ / \ BW \text{ x } DIY \text{ x } AT \qquad (1)$$

SOIL DERMAL ABSORPTION

$$EDI = C_s \text{ x } AF \text{ x } CF1 \text{ x } SSA_{soil} \text{ x } DAF \text{ x } EV \text{ x } EF \text{ x } ED \ / \ BW \text{ x } DIY \text{ x } AT \qquad (2)$$

WATER INGESTION - TANK

$$EDI = C_{tw} \text{ x } IR_{water} \text{ x } EF \text{ x } ED \ / \ BW \text{ x } AT \text{ x } DIY \qquad (3)$$

WATER INGESTION - BOTTLED WATER

$$EDI = C_b \text{ x } IR_{water} \text{ x } EF \text{ x } ED \ / \ BW \text{ x } AT \text{ x } DIY \qquad (4)$$

WATER INGESTION - BATHING/SHOWER

$$EDI = C_{tw} \text{ x } IR_{bath} \text{ x } T_{event} \text{ x } EV \text{ x } EF \text{ x } ED \ / \ BW \text{ x } AT \text{ x } DIY \qquad (5)$$

WATER DERMAL CONTACT - BATHING/SHOWER

$$EDI = DA_{event} \times EV \times ED \times EF \times SSA_{shower} / BW \text{ x } AT \text{ x } DIY \qquad (6)$$

FOOD INGESTION - LAMB

$$EDI = C_{lamb} \text{ x } CF1 \text{ x } IR_{lamb} \text{ x } BF_{oral} \; / BW \text{ x } AT \text{ x } DIY \qquad (7)$$

FOOD INGESTION - EGGS

$$EDI = C_{eggs} \text{ x } CF1 \text{ x } IR_{eggs} \text{ x } BF_{oral} \; / BW \text{ x } AT \text{ x } DIY \qquad (8)$$

DUST INHALATION - Outdoor

$$EDI = RDC_{outdoor} \text{ x } BF_{inh} \text{ x } LRF \text{ x } InhR \text{ x } CF2 \text{ x } ET_{out} \text{ x } EF \text{ x } ED / BW \text{ x } AT \text{ x } DIY \qquad (9)$$

DUST INHALATION - Indoor

$$EDI = RDC_{indoor} \text{ x } BF_{inh} \text{ x } LRF \text{ x } InhR \text{ x } CF2 \text{ x } ET_{in} \text{ x } EF \text{ x } ED / BW \text{ x } AT \text{ x } DIY \qquad (10)$$

Dermal Absorbed Dose - Water

$$DA_{event}\ (inorganics) = Kp \times (C_{tw} \text{ X } CF3\ ) \times T_{event} \qquad (11)$$

Table 1: Equation Symbols

Symbol	**Description (units)**
AF	Soil to skin adherence factor (mg/cm^2 - event)
AT	Averaging Time (years) – duration of exposure (ED) for non-carcinogens.
BF_{oral}	Relative oral bioavailability factor (unitless, chemical specific)
BF_{inh}	Relative inhalation bioavailability factor (unitless, chemical specific)
BA	Relative Bioaccessibility (unitless, chemical specific)
BW	Average body weight (kg)
C_s	Soil concentration (mg/kg)
C_{tw}	Tank water concentration (mg/L)
C_b	Bottled water concentration (mg/L)
C_{lamb}	Lamb meat concentration (mg/kg)
C_{eggs}	Egg concentration (mg/kg)
CF1	Conversion factor (0.000001 kg/mg)
CF2	Conversion factor (0.042 day/hr)
CF3	Conversion factor (0.001 L/cm^3)
DA_{event}	Absorbed dose per event (mg/cm^2 -event)
DAF	Dermal Absorption Factor (unitless, chemical specific)
DIY	Conversion factor (365 days / year)
EDI	Estimated daily intake (mg/kg-day) for each exposure pathway
ED	Duration of exposure (years)
EF	Exposure frequency (days / year)
ET_{out}	Exposure Time outdoors (hours / day)
ET_{in}	Exposure Time indoors (hours / day)
EV	Event frequency (events/day)

Symbol	Description (units)
InhR	Inhalation rate (m^3 / day)
IR_{soil}	Soil ingestion rate (mg/day)
IR_{water}	Water ingestion rate- tank or bottled (L/day)
IR_{bath}	Water ingestion rate during bathing/shower (L/hr)
IRe_{ggs}	Ingestion eggs (mg/day)
IR_{lamb}	Ingestion lamb (mg/day)
LRF	Lung Retention Factor (unitless, chemical specific)
Kp	Dermal permeability coefficient of compound in water (cm/hr)
$RDC_{outdoor}$	Respirable Dust Concentration outdoor (mg/m^3)
RDC_{indoor}	Respirable Dust Concentration indoor (mg/m^3)
T_{event}	Event duration (hr/event)
SSA_{soil}	Skin surface area available for contact - soil (cm^2)
SSA_{shower}	Skin surface area available for contact - bath/shower (cm^2)

4.0 EXPOSURE PARAMETERS

The approach to the exposure assessment has been to adopt reasonable ‘average’ and ‘upper estimate’ exposure parameters (with the exception of body weight) which are reflective of the typical experiences or expectations of the Australian population. Where possible, these are combined with TRV which aim to protect sensitive members of the population. Thus, average or median exposure parameters have been adopted along with 95th percentile values. Where possible, these parameters are based on Australian data (NEPC, 2013 and enHealth, 2012b). These documents were used as the primary references as they contain a compilation of the recommended default assumptions and sources of default exposure assumptions for use in Australia, such as Langley (1993), Langley and Sabordo (1996) and Langley and Taylor (1998). Where factors were not specified by the NEPC or enHealth, data consistent with other Australian (enHealth 2012a, 2012b) or US EPA (1989, 1991, 1997) guidelines have been adopted.

Reasonable default values for exposure parameters were adopted to model an ‘average’ Costerfield resident (living in Costerfield 365 days per year) and a weekend resident (living in Costerfield 2 days per week, 52 weeks per year). The exposure assumptions for the receptors adopted for the HRA are listed in Table 2 to Table 6. These tables present the values used as input in the exposure equations and the references and comment on the source of the value.

For body weight, only an ‘average’ value has been used as an input into the HRA. This is because the body weight is a key differentiator used to describe the receptors at different ages. Also, a lower body weight produces a higher potential risk estimate, therefore the adoption of an average is considered to be reasonably conservative. The impact of different body weights will be assessed in the sensitivity analysis presented in Appendix H. Full details of the references are provided in Section 5.0.

Table 2: Exposure Parameters - Body Weight

	Body Weight	
Receptor Description	**kg**	**Reference/comment**
Child 1 yr old	7	WHO (2009) cited by enHealth (2012)
Child 2 yr old	15	enHealth (2012)
Child 10 yr old	36	enHealth (2012)
Adult (>18 yrs)	70	enHealth (2012), (lifetime averaging (1))

Table 3: Exposure Parameters – Related to Time

Symbol	ED		AT		EF		ET_{out}		ET_{in}		EV		T_{event}	
Parameter	Duration of exposure		Averaging Time		Exposure frequency		Exposure Time outdoors		Exposure Time indoors		Event frequency (bath/shower)		Event duration (bath/shower)	
	yrs	Reference/ comment	yrs	Reference/ comment	days/yr	Reference/ comment	hrs/day	Reference/ comment	hrs/day	Reference/ comment	events/day	Reference/ comment	hr/event	Reference/ comment
Receptor - Resident														
1 yrs	1	-	1	Equal to exposure duration for non-cancer calculations	365	Days in year. For all pathways except soil.	0.4	enHealth (2012b)	23.6	enHealth (2012b)	1	enHealth (2012b)	0.35	enHealth (2012b) (bath)
					180	6 months, for soil exposures only[1]								
2 yrs	2	-	2		365	Days in year	4	enHealth (2012b)	20	enHealth (2012b)	1	enHealth (2012b)	0.35	enHealth (2012b) (bath)
10 yrs	10	-	10		365	Days in year	4	enHealth (2012b)	20	enHealth (2012b)	1	enHealth (2012b)	0.13	enHealth (2012b) (shower)
Adult (>18 yrs)	70	enHealth (2012b)	70	Lifetime	365	Days in year	4	enHealth (2012b)	20	enHealth (2012b)	1	enHealth (2012b)	0.13	enHealth (2012b) (shower)
Receptor - Weekender														
1 yrs	1		1		104	2 days/ week For all pathways except soil.	0.4	enHealth (2012b)	23.6	enHealth (2012b)	1	enHealth (2012b)	0.35	enHealth (2012b) (bath)
					52	2 days/ week for 6								

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[1] It is considered that for the first 6 months of an infant's life, their ingestion of soil is negligible, therefore the exposure frequency has been reduced to 182 days to represent 6 – 12 months of age when a child begins crawling and therefore has greater contact with soil and indoor dust.

Symbol	**ED**		**AT**		**EF**		**ET_{out}**		**ET_{in}**		**EV**		**T_{event}**	
Parameter	**Duration of exposure**		**Averaging Time**		**Exposure frequency**		**Exposure Time outdoors**		**Exposure Time indoors**		**Event frequency (bath/shower)**		**Event duration (bath/shower)**	
						months, for soil exposures only								
2 yrs	2		2		104	2 days/ week	4	enHealth (2012b)	20	enHealth (2012b)	1	enHealth (2012b)	0.35	enHealth (2012b) (bath)
10 yrs	10		10		104	2 days/ week	4	enHealth (2012b)	20	enHealth (2012b)	1	enHealth (2012b)	0.13	enHealth (2012b) (shower)
Adult (>18 yrs)	70		70		104	2 days/ week	4	enHealth (2012b)	20	enHealth (2012b)	1	enHealth (2012b)	0.13	enHealth (2012b) (shower)

Table 4: Exposure Parameters – Related to Ingestion

	Symbol	**IR_{water}**		**IR_{soil}**		**IR_{air}**		**IR_{bath}**		**IR_{lamb}**		**IR_{egg}**	
	Parameter	**Water ingestion rate-tank or bottled**		**Soil Ingestion**		**Inhalation Rate[1]**		**Water Ingestion - bath/shower**		**Lamb Consumption**		**Egg Consumption**	
Age Group	**Value**	**L/day**	**Reference/ comment**	**mg/day**	**Reference/ comment**	**m^3/day**	**Reference/ comment**	**L/hour**	**Reference/ comment**	**mg/day**	**Reference/ comment**	**mg/day**	**Reference/ comment**
1 yrs	Average	0.5	enHealth (2012b)	30	enHealth (2012b)	5.4	enHealth (2012b) (6-12 months)	0.025	Adapted from the number of mouthfuls ingested during swimming from Schets *et al* (2011).	10,100	enHealth (2012b), based on a 2 yr old	4,200	Assumed 2 yr intake, no data available
	Upper Estimate	1.1	enHealth (2012b)	60	enHealth (2012b)	8.1	enHealth (2012b) (6-12 months)	0.05	Adapted from the number of mouthfuls ingested during swimming from Schets *et al* (2011)	19,100	enHealth (2012b), based on a 2 yr old	6,700	Assumed 2 yr intake, no data available

	Symbol	IR_{water}		IR_{soil}		IR_{air}		IR_{bath}		IR_{lamb}		IR_{egg}	
	Parameter	**Water ingestion rate- tank or bottled**		**Soil Ingestion**		**Inhalation Rate[1]**		**Water Ingestion - bath/shower**		**Lamb Consumption**		**Egg Consumption**	
Age Group	**Value**	**L/day**	**Reference/ comment**	**mg/day**	**Reference/ comment**	**m^3/day**	**Reference/ comment**	**L/hour**	**Reference/ comment**	**mg/day**	**Reference/ comment**	**mg/day**	**Reference/ comment**
2 yrs	Average	0.4	enHealth (2012b)	50	enHealth (2012b)	9.5	enHealth (2012b)	0.025	Adapted from the number of mouthfuls ingested during swimming from Schets *et al* (2011)	10,100	enHealth (2012b), based on consumption of muscle meat	4,200	enHealth (2012b) for just eggs
	Upper Estimate	1	enHealth (2012b)	100	enHealth (2012b)	15.9	enHealth (2012b)	0.05	Adapted from the number of mouthfuls ingested during swimming from Schets *et al* (2011)	19,100	enHealth (2012b), based on consumption of mixed dishes	6,700	enHealth (2012b) for egg products and dishes
10 yrs	Average	0.5	enHealth (2012b)	50	enHealth (2012b)	12.4	enHealth (2012b) (6-11 yrs)	0.025	Adapted from the number of mouthfuls ingested during swimming from Schets *et al* (2011)	47,500	ABS (1995), enHealth (2012b)	7,900	ABS (1995), enHealth (2012b)
	Upper Estimate	1.3	enHealth (2012b)	100	enHealth (2012b)	18.7	enHealth (2012b) (6-11 yrs)	0.05	Adapted from the number of mouthfuls ingested during swimming from Schets *et al* (2011)	72,000	ABS (1995)	50,000	ABS (1995)
Adult (>18 yrs)	Average	2	enHealth (2012b), (lifetime averaging)	50	enHealth (2012b)	15	enHealth (2012b), long term exposure rates	0.03	Adapted from the number of mouthfuls ingested during swimming from Schets *et al* (2011)	47,500	ABS (1995), enHealth (2012b)	7,900	ABS (1995), enHealth (2012b)
	Upper Estimate	2.8	enHealth (2012b)	60	enHealth (2012b)	20	enHealth (2012b), long term exposure rates	0.06	Adapted from the number of mouthfuls ingested during swimming from Schets *et al* (2011)	72,000	ABS (1995)	50,000	ABS (1995)

Note: 1. The inhalation rate, suggested by enHeatlth (2012b), is for use in screening risk assessment for long-term exposure (more than 30 days) to airborne substances. Therefore, the same inhalation rate has been adopted for the outdoor and indoor inhalation calculation and short-term activity specific inhalation rates have not been adopted.

Table 5: Exposure Parameters – Related to Dermal Exposure

	Symbol	**SSA_{shower}**		**SSA_{soil}**		**AF**	
	Parameter	**Skin surface area - bath/shower**		**Skin Surface Area - soil exposure**		**Soil to skin adherence factor**	
Age Group	**Value**	**cm^2**	**Reference/ comment**	**cm^2**	**Reference/ comment**	**mg/cm^2**	**Reference/comment**
1 yrs	Average	4,500	enHealth (2012b) (6-12months)	1,250	enHealth (2012b) (6-12months) hands, feet, and 50% of arms + legs (i.e. lower legs and forearms)	0.04	enHealth (2012b) Weighted AF Day Care children playing indoors and outdoors (age 1-6.5 yrs)
	Upper Estimate	5,100	enHealth (2012b) (6-12months)	2,000	enHealth (2012b) (6-12months) hands, feet, arms and legs (i.e. whole legs and arms)	0.3	enHealth (2012b) Weighted AF Day Care children playing indoors and outdoors (age 1-6.5 yrs)
2 yrs	Average	6,100	enHealth (2012b)	1,550	enHealth (2012b) hands, feet, and 50% of arms + legs (i.e. lower legs and forearms)	0.04	enHealth (2012b) Weighted AF Day Care children playing indoors and outdoors (age 1-6.5 yrs)
	Upper Estimate	7,000	enHealth (2012b)	2,500	enHealth (2012b) hands, feet, arms and legs (i.e. whole legs and arms)	0.3	enHealth (2012b) Weighted AF Day Care children playing indoors and outdoors (age 1-6.5 yrs)
10 yrs	Average	10,800	enHealth (2012b) (6-11 yrs)	3,500	enHealth (2012b) (6-11 yrs) hands, feet, and 50% of arms + legs (i.e. lower legs and forearms)	0.12	enHealth (2012b) Weighted AF for children playing (8-12 yrs), averaged of AF for dry and wet soil based on assume 50% of playing time in each
	Upper Estimate	14,800	enHealth (2012b) (6-11 yrs)	5,700	enHealth (2012b) (6-11 yrs) hands, feet, arms and legs (i.e. whole legs and arms)	1.9	enHealth (2012b) Weighted AF for children playing (8-12 yrs), averaged of AF for dry and wet soil based on assume 50% of playing time in each
Adult (>18 yrs)	Average	20,000	enHealth (2012b)	7,450	enHealth (2012b) (adult male) hands, feet, and 50% of arms + legs (i.e. lower legs and forearms)	0.5	enHealth (2012b)
	Upper Estimate	24,000	enHealth(2012)	12,400	enHealth (2012b) (adult male) hands, feet, arms and legs (i.e. whole legs and arms)	1.7	enHealth (2012b)

Table 6: Exposure Parameters – Related to COPCs (Refer to Appendix F – Toxicity Assessment for further information)

	Symbol	**Kp**		**BF_{oral}**		**BA**		**$BF_{inhalation}$**		**LRF**		**DAF**	
	Parameter	**Dermal permeability coefficient of compound in water**		**Relative oral bioavailability factor**		**Relative bioaccessibility factor**		**Relative inhalation bioavailability factor**		**Lung Retention Factor**		**Dermal Absorption Factor**	
Age	**COPC**	**cm/hr**	**Reference/ comment**	**unitless**	**Reference/ comment**	**unitless**	**Reference/ comment**	**unitless**	**Reference/ comment**	**unitless**	**Reference/ comment**	**unitless**	**Reference/ comment**
1 yrs	antimony	0.001	US EPA RAGS E	0.15	US EPA (2004)	1	Site specific – refer Appendix D6	1	enHealth (2012)	1	NEPM 2013	0.0026	EC (2008)
	arsenic	0.001	US EPA RAGS E	0.7	NEPM 2013	0.23		1	enHealth (2012)	1	NEPM 2013	0.005	NEPM (2013)
	lead	0.00013	US EPA RAGS E (exhibit A-6)	0.5	NEPM 2013	0.49		1	enHealth (2012)	1	NEPM 2013	0.00001	NEPM (2013) negligible
2 yrs	antimony	0.001	US EPA RAGS E	0.15	US EPA (2004)	1		1	enHealth (2012)	1	NEPM 2013	0.0026	EC (2008)
	arsenic	0.001	US EPA RAGS E	0.7	NEPM 2013	0.23		1	enHealth (2012)	1	NEPM 2013	0.005	NEPM (2013)
	lead	0.00013	US EPA RAGS E (exhibit A-6)	0.5	NEPM 2013	0.49		1	enHealth (2012)	1	NEPM 2013	0.00001	NEPM (2013) negligible
10 yrs	antimony	0.001	US EPA RAGS E	0.15	US EPA (2004)	1		1	enHealth (2012)	1	NEPM 2013	0.0026	EC (2008)
	arsenic	0.001	US EPA RAGS E	0.7	NEPM 2013	0.23		1	enHealth (2012)	1	NEPM 2013	0.005	NEPM (2013)
	lead	0.00013	US EPA RAGS E (exhibit A-6)	0.5	NEPM 2013	0.49		1	enHealth (2012)	1	NEPM 2013	0.00001	NEPM (2013) negligible
Adult (>18 yrs)	antimony	0.001	US EPA RAGS E	0.15	US EPA (2004)	1		1	enHealth (2012)	1	NEPM 2013	0.0026	EC (2008)
	arsenic	0.001	US EPA RAGS E	0.7	NEPM 2013	0.23		1	enHealth (2012)	1	NEPM 2013	0.005	NEPM (2013)
	lead	0.00013	US EPA RAGS E (exhibit A-6)	0.15	NEPM 2013	0.49		1	enHealth (2012)	1	NEPM 2013	0.00001	NEPM (2013) negligible

5.0 EXPOSURE CONCENTRATIONS

The exposure concentrations adopted for each of the media are summarised is Table 7. The exposure concentrations are presented for each of the COPC identified in the CSM (Appendix C of the HRA report). Further information on how these concentrations were derived is provided in each of the data summary appendices (Appendix D of the HRA).

Table 7: Exposure concentrations

	Symbol	C_s	C_{tw}	C_b	C_{lamb}	C_{eggs}	$RDC_{outdoor}$	RDC_{indoor}
	Media	**Soil**	**Tank Water**	**Bottled Water**	**Lamb meat**	**Egg**	**Respirable Dust outdoor**	**Respirable Dust indoors**
COPC	**Receptor**	**mg/kg**	**mg/L**	**mg/L**	**mg/kg**	**mg/kg**	**mg/m^3**	**mg/m^3**
Antimony	Mean	275	0.02	0.001	0.022	*0.005*	0.000017	0.000017
	Upper Estimate	1210	0.032	0.001	0.035	*0.01*	0.000049	0.000049
Arsenic	Mean	30	*0.001*	*0.001*	*0.005*	*0.005*	0.00000056	0.00000056
	Upper Estimate	125	0.001	*0.001*	*0.01*	*0.01*	0.00000096	0.00000096
Lead	Mean	96	0.003	0.000009	0.02	0.04	0.0000014	0.0000014
	Upper Estimate	477	0.004	0.000009	0.04	0.1	0.0000035	0.0000035

Notes: Italics indicates where an LOR (or half the LOR) was adopted as the exposure concentration.

The indoor respirable dusts concentrations have been assumed to be the same as respirable dust concentrations outdoors. It is acknowledged that this is a conservative approach, however no available conversion factor was found to convert ambient dust from outdoors to indoors.

As the respirable dust concentrations (based on PM_{10} data) have been used in the HRA, a Lung Retention Factor of 1 has been adopted (NEPC, 2013) (Table 6).

6.0 ESTIMATED DAILY INTAKES

The Estimated Daily Intakes (EDI) for each COPC, each exposure pathway (e.g. soil ingestion), and each category of receptor (e.g. child 0-1 yrs) have been calculated from the exposure equations and input parameters described in Appendix E. The full model output is provided in Attachment A of this appendix. The section below provides a summary of the calculation results.

As discussed in Appendix E, the models consider a permanent resident who is present in Costerfield 7 days a week, and a weekend resident, present in Costerfield 2 days a week. The models also considered an average exposure scenario and an upper estimate or worst case scenario, and also assessed the difference in a resident who consumes tank water as their primary drinking source, or a resident who drinks only bottled water (but still bathes in the tank water).

6.1 Total Estimated Daily Intakes

The results of the intakes of antimony, arsenic and lead for each age group and exposure scenario is presented in Table 8 and Table 9 for permanent and weekend residents respectively.

The total EDI has also been presented graphically in Figure 1 (including tank water consumption) and Figure 2 (only bottled water for drinking purposes. These figures show the difference in the calculated EDI for the average (mean) scenario and the worst case (upper).

In general, the results show a decrease in the daily intake in the older age groups. This is largely due to the influence of body weight. The youngest children 0-1 year olds, as exposed to the same environmental conditions and although some parameters are adjusted down (for example, drinking water volume), the impact of the lower body weight is the largest influence in the calculation.

As expected, the EDI for the permanent resident is greater than the EDI for the weekend residents due to the reduced exposure time.

Table 8: Estimated Daily Intakes - Permanent Residents

Age Group	Metal	Scenario	Resident Status	EDI - including tank water consumption (mg/kg$_{bw}$/d)	EDI – bottled water only (mg/kg$_{bw}$/d)
01 yrs	Antimony	Mean	Permanent	0.00158	0.00024
01 yrs	Antimony	Upper	Permanent	0.00624	0.00144
01 yrs	Arsenic	Mean	Permanent	0.00010	0.00010
01 yrs	Arsenic	Upper	Permanent	0.00034	0.00034
01 yrs	Lead	Mean	Permanent	0.00029	0.00008
01 yrs	Lead	Upper	Permanent	0.00123	0.00061
02 yrs	Antimony	Mean	Permanent	0.00069	0.00019
02 yrs	Antimony	Upper	Permanent	0.00357	0.00154
02 yrs	Arsenic	Mean	Permanent	0.00005	0.00005
02 yrs	Arsenic	Upper	Permanent	0.00025	0.00025
02 yrs	Lead	Mean	Permanent	0.00017	0.00009
02 yrs	Lead	Upper	Permanent	0.00110	0.00084
10 yrs	Antimony	Mean	Permanent	0.00035	0.00009
10 yrs	Antimony	Upper	Permanent	0.00265	0.00153
10 yrs	Arsenic	Mean	Permanent	0.00003	0.00003
10 yrs	Arsenic	Upper	Permanent	0.00030	0.00030
10 yrs	Lead	Mean	Permanent	0.00009	0.00005
10 yrs	Lead	Upper	Permanent	0.00058	0.00044
Adult	Antimony	Mean	Permanent	0.00065	0.00010
Adult	Antimony	Upper	Permanent	0.00241	0.00117
Adult	Arsenic	Mean	Permanent	0.00004	0.00004
Adult	Arsenic	Upper	Permanent	0.00026	0.00026
Adult	Lead	Mean	Permanent	0.00009	0.00001
Adult	Lead	Upper	Permanent	0.00021	0.00005

Table 9: Estimated Daily Intakes - Weekend Resident

Age Group	Metal	Scenario	Resident Status	EDI - including tank water consumption (mg/kg$_{bw}$/d)	EDI – bottled water only (mg/kg$_{bw}$/d)
01 yrs	Antimony	Mean	Weekend	0.00045	0.00007
01 yrs	Antimony	Upper	Weekend	0.00178	0.00041
01 yrs	Arsenic	Mean	Weekend	0.00003	0.00003
01 yrs	Arsenic	Upper	Weekend	0.00010	0.00010
01 yrs	Lead	Mean	Weekend	0.00008	0.00002
01 yrs	Lead	Upper	Weekend	0.00035	0.00018
02 yrs	Antimony	Mean	Weekend	0.00020	0.00006
02 yrs	Antimony	Upper	Weekend	0.00102	0.00044
02 yrs	Arsenic	Mean	Weekend	0.00001	0.00001
02 yrs	Arsenic	Upper	Weekend	0.00007	0.00007
02 yrs	Lead	Mean	Weekend	0.00005	0.00003
02 yrs	Lead	Upper	Weekend	0.00031	0.00024
10 yrs	Antimony	Mean	Weekend	0.00010	0.00003
10 yrs	Antimony	Upper	Weekend	0.00075	0.00044
10 yrs	Arsenic	Mean	Weekend	0.00001	0.00001
10 yrs	Arsenic	Upper	Weekend	0.00009	0.00009
10 yrs	Lead	Mean	Weekend	0.00003	0.00001
10 yrs	Lead	Upper	Weekend	0.00017	0.00012
Adult	Antimony	Mean	Weekend	0.00018	0.00003
Adult	Antimony	Upper	Weekend	0.00069	0.00033
Adult	Arsenic	Mean	Weekend	0.00001	0.00001
Adult	Arsenic	Upper	Weekend	0.00007	0.00007
Adult	Lead	Mean	Weekend	0.00003	0.000002
Adult	Lead	Upper	Weekend	0.00006	0.00001

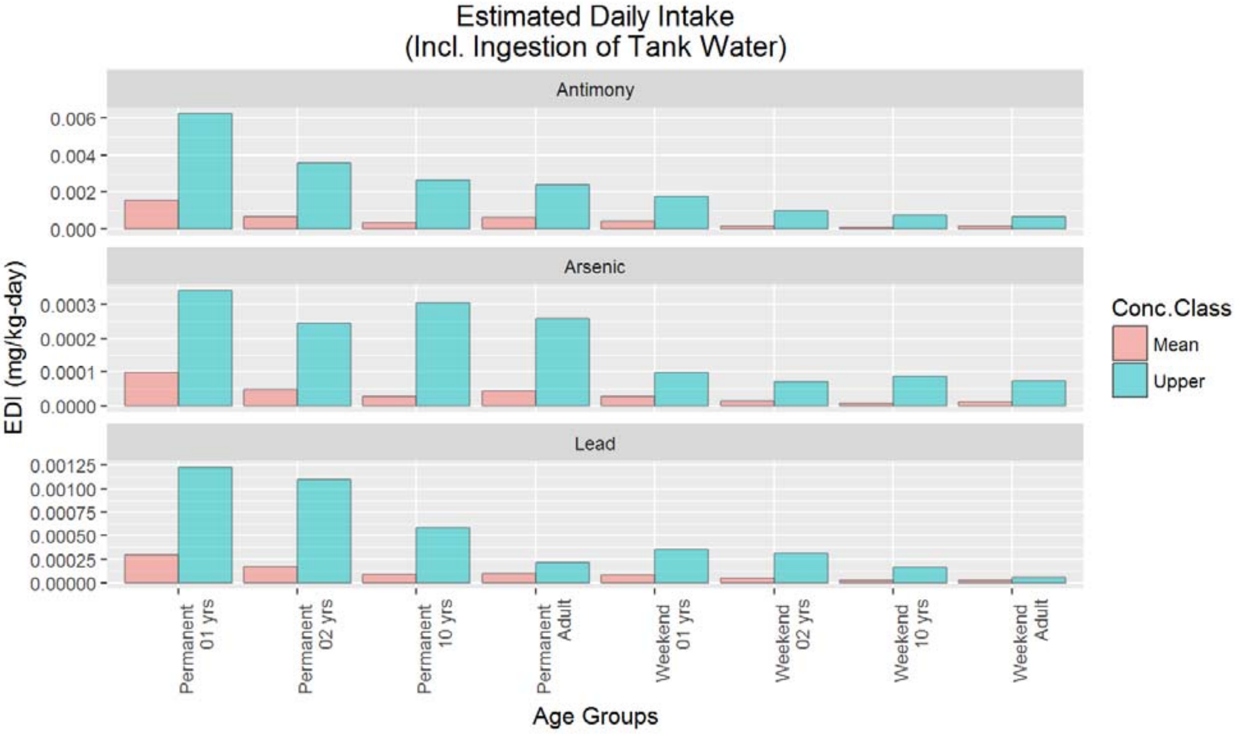

Figure 1: Estimated Daily Intakes - including tank water consumption

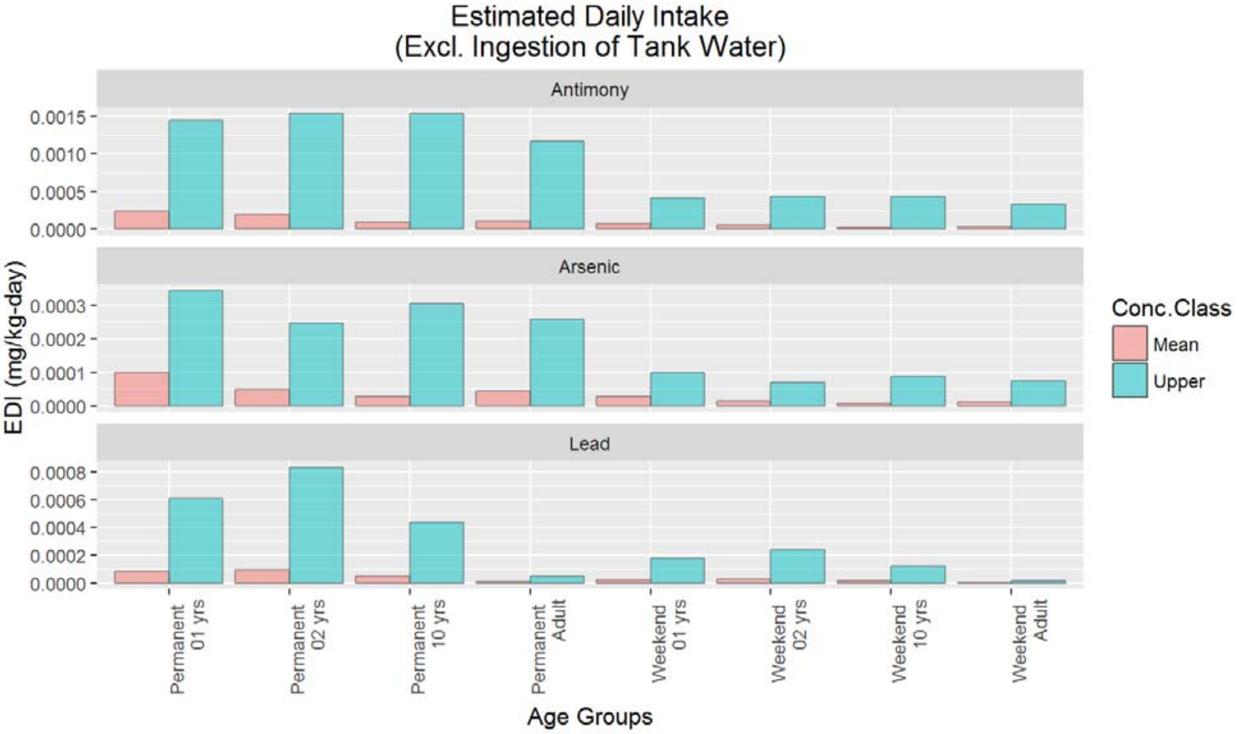

Figure 2: Estimated Daily Intakes - bottled water only

6.2 EDI for individual exposure pathways

The total EDI is a summation of the EDI from each exposure pathway modelled:

- Soil – incidental ingestion during outside activities (e.g. gardening, children playing)
- Soil – dermal contact during outside activities (e.g. gardening, children playing)
- Dust – inhalation outdoors and indoors
- Water – ingestion via drinking tank water or bottled water
- Water – dermal contact and ingestion whilst showering or bathing in tank water
- Water – dermal contact and ingestion whilst swimming in local dams or swimming pools
- Locally grown foods – ingestion of locally produced eggs and lamb

To understand the contribution each of these exposure pathways makes to the total EDI, the pathway specific EDI were plotted, refer Figure 3 for scenarios where tank water consumption was included, and Figure 4 for when residents drank bottled water.

The figures show that when tank water consumption is included, the largest intakes are as follows:

- Antimony – ingestion of tank water for all age groups.
- Arsenic – ingestion of tank water for all groups, with the exception of the following:
  - soil ingestion for the 2 year old worst case
  - dermal contact with soil for the 10 year old and adult worst case.
- Lead – ingestion of tank water for all groups, with the exception of the following:
  - soil ingestion for the 2 year old worst case and 10 year old worst case.

When bottled water replaces tank water for drinking purposes, the largest intakes are as follows:

- Antimony – soil ingestion for the 1 and 2 year old, dermal contact with soil for the 10 year old and adult.
- Arsenic – water ingestion (bottled water) for all age groups with the exception of the following:
  - soil ingestion for the 2 year old worst case
  - dermal contact with soil for the 10 year old and adult worst case.
- Lead – soil ingestion for all age groups.

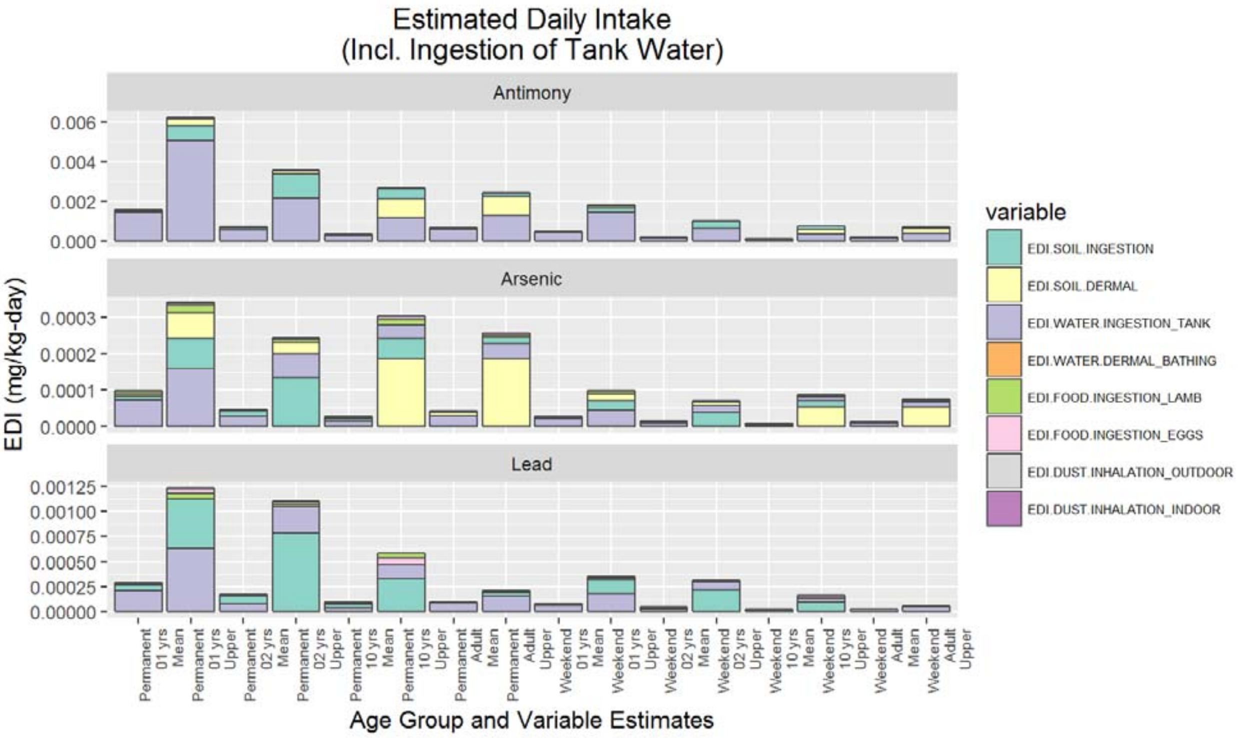

Figure 3: EDI by exposure pathway - including tank water consumption

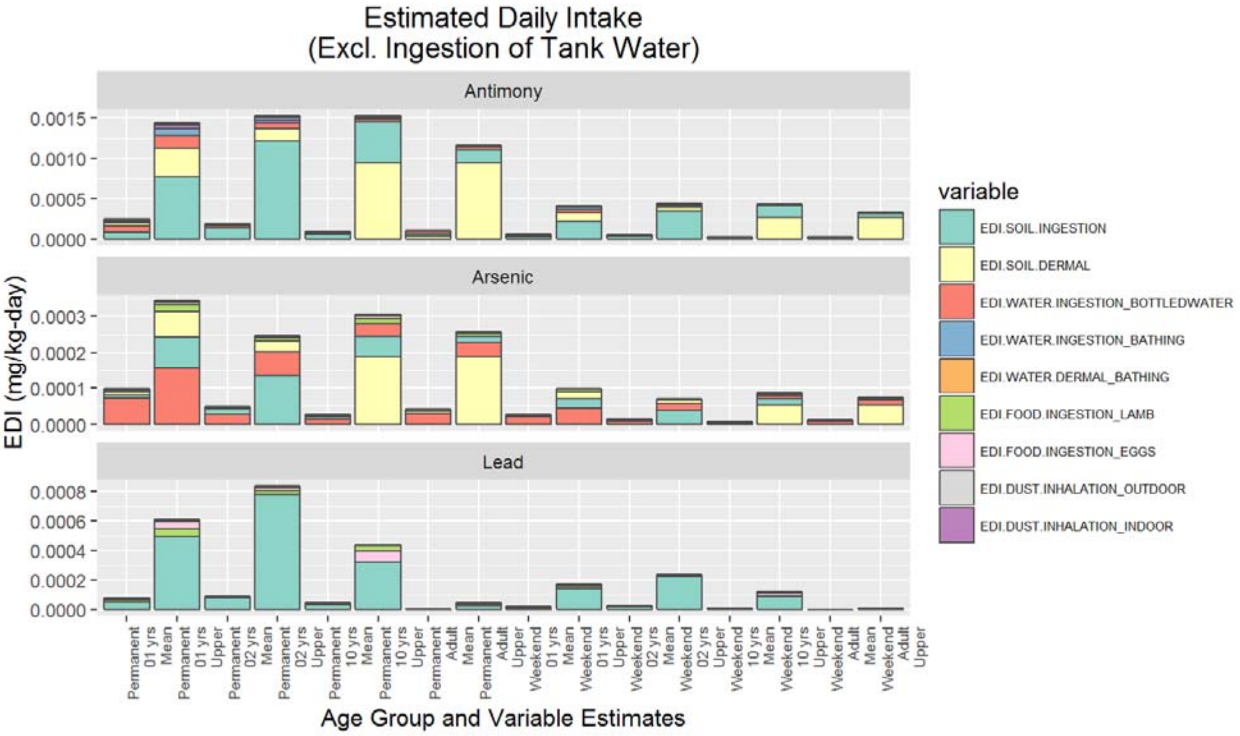

Figure 4: EDI by exposure pathway - bottled water only

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APPENDIX F

Toxicity Profiles

1.0 INTRODUCTION

Appendix F presents a review of toxicity information and an interaction profile for antimony, arsenic and lead. This includes the selection of the toxicological reference values (tolerable daily intake TDI) that will be used in the risk characterisation section of the health risk Assessment, HRA (refer Appendix G).

The Victorian Department of Health and Human Services have published Community fact sheets for all three chemicals of potential concern (COPC). The can be obtained at the following internet sites:

Antimony Community Fact Sheet

https://www2.health.vic.gov.au/about/publications/policiesandguidelines/Antimony%20Community%20fact%20sheet

Arsenic mine tailing and health web page

https://www.betterhealth.vic.gov.au/health/healthyliving/arsenic-mine-tailings-and-health

Lead exposure and poisoning

https://www.betterhealth.vic.gov.au/health/healthyliving/lead-exposure-and-poisoning

For health concerns related to antimony, speak to your doctor or go to the Department of Health and Human Services website.

The term TRV (toxicity reference value) and TDI (tolerable daily intake) is used in this appendix. TRV and TDI has an equivalent meaning within the context of the present health risk assessment (HRA). The term TRV is also applicable when route-specific values are needed (for example inhalation only toxicity values).

2.0 ANTIMONY

2.1 General

Antimony and its compounds are naturally present in the earth's crust. The concentration of antimony in the environment is normally low (less than 5 mg/kg in soil), with the exception of areas of natural enrichment such as Costerfield. Antimony in surface soils and natural water bodies is predominantly present in the pentavalent form (Sb V).

The mineral form of antimony is Stibnite (Sb_2S_3) and this is the form naturally found and mined in Costerfield. It is present in the trivalent form (Sb III). Rock containing stibnite typically contain 1-5% antimony and are mined (referred to as stibnite ore) and converted to a concentrate form (typically 50-60% antimony). The concentrate is then sent either to overseas smelters to produce antimony metal or refined into antimony compounds including antimony oxides (antimony trioxide (trivalent) and antimony pentaoxide (pentavalent)) and other antimony compounds such as antimony potassium tartrate (pentavalent) and antimony trichloride (trivalent) (ASTDR, 1992).

Antimony (Sb) is a silvery white metalloid (ASTDR, 1992). Antimony metal is inflexible and easily broken and therefore, has few uses on its own. Combined in copper, lead and tin alloys it has more uses, including solder, sheet and pipe metal, bearings, castings, type metal, ammunition and pewter (ASTDR, 1992).

Stibine is a gaseous antimony compound. It is formed by chemical reactions for example mixing strong acids with antimony containing alloys. In air it rapidly oxidises to form antimony trioxide. Industrial processes, including welding, soldering, refining, galvanising and etching may result in the accidental formation of stibine. Consequently exposure to stibine is most likely to occur in an occupational setting (e.g. welding and soldering) and exposure at home or in the general atmosphere is unlikely. Given its industrial origin it is not discussed further within this document as it is not relevant to the present health risk assessment.

Antimony trioxide (ATO, Sb_2O_3) is used in numerous products as either a flame retardant, a turbidifer in white enamel or as an initiator or additive in the production of polyethylene terephthalate (PET).

Antimony compounds have been used in human medicines. Soluble pentavalent antimony compounds are used as specific therapeutics against different forms of the disease, leishmaniasis (WHO, 2003). Potassium antimony tartrate (APT) was formerly used as an emetic to induce vomiting in poisoning cases (WHO, 2003).

The properties of antimony compounds are important to understand because different properties influence its behaviour in the environment and also its toxicity. The solubility in water varies depending on the form of antimony. Metal, mineral and refined forms (stibnite and ATO) are less soluble than oxidised forms (antimony pentoxide). Soluble pentavalent forms of antimony appear to be the dominant form in water. Less soluble species tend to adsorb onto clay or soil particles and sediments (particularly those containing iron manganese or aluminium). In water, antimony is likely to be present as the pentavalent form (WHO, 2003, Skeaff, 2012). Trivalent forms are generally considered more toxic than pentavalent forms and this likely to reflect the different solubilities of these compounds (Monash 2014).

2.2 Absorption, Distribution, Biotransformation and Excretion

Even in soluble forms, antimony does not appear to be readily absorbed via the gastrointestinal tract, irrespective of the valence state (WHO, 2003). This is despite the solubility of ATO in synthetic gastric juice being shown to be 20 mg/L after 24 hr (WHO, 2003). Animal studies have indicated an absorption rate of between 5% and 20% and an absorption rate of 5% was observed during examination of four people following involuntary acute intoxication with ATP (WHO, 2003).

The Monash University (2014) literature review states that:

- absorption after oral ingestion is slow and incomplete (Tylenda & Fowler, 2007; ATSDR 1992),
- the amount and rate of systemic absorption from the gut is highly dependent on the chemical form and solubility, the valence state (see speciation below) and the matrix in which the antimony is ingested.
- soluble antimony salts (e.g $SbCl_3$ and antimony tartrate) are absorbed more completely than insoluble salts.
- the extent of absorption after oral administration has been reported to range up to 20%, but there is some variability with antimony speciation. For example, estimates of oral absorption for soluble antimony salts have been reported as 5% in humans, but higher uptakes have been reported in cattle (18%) and rodents (7-15%).

The US EPA (2004) default for oral bioavailability of antimony is 15%.

The bioaccessible fraction (i.e. the amount of antimony that can be release from soil and is available to uptake into the body) of antimony in soil has not been determined at Costerfield. However the source ore (stibnite) and the predominant form (pentavalent) has been confirmed. In addition speciation testing was conducted. This testing indicated that most of the soil-bound antimony is present as antimony-silicate complex with limited solubility. Thus, the bioavailability in soil is expected to be limited.

To consider the soil antimony bioavailability a literature search was conducted. This included consideration of solubility as well as bioaccessibility studies of soils affected by antimony.

Table 1 summarises the findings of the available studies. Following comparison of the US EPA (2004) default oral bioaccessible fraction against the literature reviewed it is considered conservative to adopt 15% for the Sb soil bioavailability.

Table 1: Summary of Studies Regarding Soil Antimony (Sb) Bioavailability

Study	Study summary	Result	Comment
Leeder (2014)	Speciation testing was conducted on 8 soil samples from Costerfield. Soil speciation can only be performed on soluble species (i.e. those that dissolve in a mild acid digest (aqueous regia)). Only 2-4% of the total antimony was dissolvable indicating that most of the soil bound antimony is present as antimony-silicate complex. Of the dissolvable fraction the predominant form was pentoxide.	2 – **4%**	Although limited in the number of samples. The Costerfield results are consistent with the general expectation that in oxic soild the predominant Sb form is pentoxide (Arai 2010). The limited solubility is indicative of the likely bioaccessibility of antimony.
Li et al (2014)	Bioaccessibility study at Sb mine, Hunan, China was conducted using *in vitro* extraction methods, Simplified Bioaccessibility Extraction Test (SBET) and Physiologically Based Extraction Test (PBET). Soils in the Sb mine area were mainly contaminated by Sb (74.2–16,389; mean: 3061 mg/kg).	The average bioaccessibility value of Sb was approximately **6**% (range 0.37% to 10.8%) for the SBET extraction and approximately 8%(range 0.37-25.1) for the PBET (Gastric) extraction.	The authors note that the bioaccessible Sb was significantly positively correlated with the total concentrations, but negatively correlated with the Fe, Al, Mn and organic matter (OM) contents in soils.

Gal et al (2014)	Single-step extraction procedure was carried out using 1M NH_4NO_3 solution to determine readily soluble Sb content. The soils tested included acidic or slightly alkaline; pH*CaCl*$_2$ varied between 2.62 and 6.81 (4.46 median) while Eh*CaCl*$_2$ ranged from −41 to 224 mV (89 mV median). The total Sb in soil ranged between 10.3–1,200 mg/kg with a mean of 196 mg/kg.	Mobile Sb 0.01-8.8% (median **0.35%,** mean 1.2%)	Consistent with expectation of limited solubility of mineral associated Sb.
Flynn et al (2003)	Soil from five British former mining and smelting sites were assessed. The total Sb concentrations ranged from 11.89 to 709.84 mg/kg. The pH of soil varied between 3.72 – 8.07. The solubility was tested using an extraction solution and process[1] (concentrated nitric acid, sulphuric and perchloric acid and hydrochloric acid).	Soluble Sb 0 to 42% [2], with a mean level of only **2.5%.** The majority of the samples had less than 1% soluble Sb.	This indicates that Sb is unavailable at different sites, both mining and smelting locations, across a range of pH values (3.72–8.07), with no relationship between pH and water soluble levels or percentage solubility.

[1] The extract solution is vigorous compared to bioaccessibility extract media. That is it is likely to over predict bioaccessibility in the gastrointestinal tract. For each sample 100 mg of soil was placed into digestion tubes with 3 ml of concentrated nitric acid and left overnight. Then 500 ml of sulphuric acid and 300 ml of perchloric acid were added and the digestion was carried out in a series of timed increments at varying temperature; 20°C to 140°C— 25 min, 140°C to 200°C—8 min, 200°C to 280°C—24 min. Once cooled, the contents of each tube were made up to 10 ml with 10% hydrochloric acid. Soil water was extracted by making the samples up to a 1:10 soil/water mixture by adding 10 ml of deionised water to 1 g of the oven dried soil. The mixtures were then shaken for 2 h on an end-over end shaker at approximately 50 rev./min.

[2] The sample with a solubility of 42% did not originate from an antimony mining/smelting location. Wheal Betsy Scotland was principally mined for lead and copper but also for arsenic.

Dermal availability of antimony in soil is low. The US EPA uses a default dermal permeability coefficient (K_p) of 0.001 cm/hr for metals (US EPA, 2004).

The European Commission recommends a value of 0.26% for dermal absorption of antimony (EC, 2008).

ASTDR (1992) report that antimony is poorly absorbed following inhalation. However, a specific inhalation bioavailability factor is not provided. Where chemical-specific data are not available, enHealth (2012) recommends a value of 100% for absorption of respirable particles.

Following absorption, it is thought that antimony will bind to red blood cells and be transported mainly to the spleen, liver and bones (WHO, 2003). Trivalent antimony, in the form of antimony trihydroxide ($Sb(OH)_3$), is reported to have a longer elimination half-time compared with pentavalent antimony (94 h versus 24 h respectively). This is thought to be due to antimony hydroxide lack of electrical charge which means it can easily pass through cell membranes. There are limited data on the *in vivo* reduction on pentavalent antimony to trivalent antimony.

2.3 Estimated Background Exposure

The 20th Australian Total Diet Survey (2002) estimated the mean daily dietary exposures to antimony from food to be up to 0.00025 mg/kg bw/day for infants and up to 0.00008 mg/kg bw/day for male adults (FSANZ, 2003). These values were calculated using the median analytical results for a range of foods. Antimony is not commonly detected in drinking water (Coliban Water 2014).

2.4 Human health

Antimony is not an essential element for humans or plants (WHO, 2003)

In humans, antimony is used in medicine to treat severe parasite related diseases (Leishmaniosis). The World Health Organisation recommends a schedule of injections in the muscle or veins of 20,000 micrograms pentavalent antimony per kilogram body-weight per day for 10–20 days. This is based on a maximal daily dose of 850,000 micrograms antimony per day (Berman 1988; WHO 2010). Side effects have been noted. Antimony can cause cardiac toxicity when given by injection at doses higher than 20,000 micrograms per kilogram pentavalent antimony (Tylender & Fowler 1997)

Antimony-based medicine (tartar emetic) was historically used in medicine for inducing vomiting. Single oral doses of antimony at concentrations of 30,000 to 60,000 micrograms cause vomiting and other intestinal symptoms such as nausea and abdominal pain (Tylender & Fowler 1997). These doses are equivalent to 430 to 850 micrograms of antimony per kilogram bodyweight.

As previously stated the toxicity of antimony appears to be dependent on its form, specifically its solubility and oxidation state. WHO(2003) reports that in general, antimony(III) is more toxic than antimony(V) and the inorganic compounds are more toxic than the organic compounds (WHO, 2003). The most toxic form of antimony (by inhalation) appears to be stibin (SbH_3), which is a lipophilic gas.

In oral studies there appeared to be a large difference in toxicity between ATO and APT, which is thought to be due to the high water solubility of APT and the insoluble nature of ATO (WHO, 2003). Antimony trioxide has been shown to be genotoxic only in some *in vitro* tests but not *in vivo*, whereas soluble antimony(III) salts exert genotoxic effect *in vitro* and *in vivo* (WHO, 2003). This difference is thought to be due to the lower bioavailability of antimony trioxide (WHO, 2003). In experimental animals, the oral LD_{50} of APT was reported to range from about 115 mg/kg of body weight in rabbits and rats to 600 mg/kg of body weight in mice. Whereas, ATO was reported to be practically non-toxic (LD_{50} > 20 000 mg/kg of body weight) (WHO, 2003).

A no observed adverse effect level (NOAEL) in a sub-chronic drinking-water study of ATP in rats conducted by Poon et al. (1998, cited by WHO, 2003) was suggested (by Lynch et al., 1999, cited by WHO, 2003) to be 6.0 mg/kg body weight per day based on decreased body weight gain and reduced food and water intake (WHO, 2003). At higher doses (45 mg/kg of body weight), marked but reversible decrease in body-weight gain occurred, together with slight changes to liver and spleen, probably related and in conjunction with distinctly reduced food and water intake at this dose. Sub-chronic dietary studies in rats for ATO reported no significant toxicological findings in any dose groups, where the highest dose was 20 000 mg/kg for 90 days (Hext et al., 1999, cited by WHO, 2003). The highest dose equates to a NOAEL of 1685.9 mg of ATO per kg of body weight per day. The WHO adopted the NOAEL of 6 mg/kg of body weight for derivation of a drinking water guideline of 0.02 mg/L (WHO, 2003).

The Australian Drinking Water Guideline (ADWG) (NHMRC, NHMRC 2014) has set an antimony guideline of 0.003 mg/L. This guideline was derived based on a study from 1970 which reported 0.43 mg/kg body weight per day as the lowest observed adverse effect level (LOAEL) based on decreased lifespan and altered blood levels of glucose and cholesterol in a lifetime study using rats (Schroeder et al. 1970, cited in NHMRC, 2014. The US EPA (IRIS, 1987) adopts an oral Reference Dose (RfD) of 0.0004 mg/kg bw/day, which is also derived based on values reported in the Schroeder et al. 1970 study. However, due to the age of the study, the WHO (2003) concluded that this study was inappropriate for characterisation of the APT toxicity.

Limited information is available to assess reproductive effects of antimony in humans (WHO, 2003). One incomplete study did report that respired antimony compounds could trigger premature births and spontaneous abortions.

Irritation of the respiratory tract and myocardial and liver damage has been reported for chronic respiratory update of antimony containing dust (WHO, 2003). The US EPA Integrated Risk Information System (IRIS) list an inhalation reference concentration (RfC) for antimony trioxide of 0.002 mg/cm^3. This value is primarily based on a study by Newton et al. (1994, cited by US EPA IRIS, 1995). The chronic study involved groups of rats being exposed to antimony trioxide over a 1 year period, with pulmonary toxicity and chronic intestinal inflammation reported.

A study indicated that inhalation exposure to ATO in workplaces was associated with increased incidences of lung cancer, but not with tumours of other organs (WHO, 2003). The International Agency for Research on Cancer (IARC) classifies diantimony trioxide (Sb_2O_3) as Group 2B (1989) and diantimony trisulphide (Sb_2S_3) as Group 3 (1989) (IARC, 2015). These classifications are based on studies via the inhalation route. Antimony is not classified as a carcinogen by the oral or dermal route. However, it is noted that there are limited studies and information to assess these exposure routes.

2.5 Toxicological Reference Values

The toxicological reference values (TRV) adopted for antimony in this assessment are summarised in Table 2

Table 2: Toxicological Reference Values - Antimony

Type	Reference Value	Reference	Safety factor	Effects	Comments
Tolerable Daily Intake	6 µg/kg bw/day	WHO (2003)	1000 Uncertainty factor: 100 for interspecies and intraspecies variation and 10 for short duration of the study)	Decreased body weight gain and reduced food and water intake	Based on ATP. 90-day drinking-water study of rats administered APT (Poon et al., 1998)
Reference Concentration	0.0002 mg/m^3	IRIS US EPA (1995)	300 Uncertainty factor: 10 for protection of sensitive human subpopulations and 3 for interspecies extrapolation and 10 for uncertainty in the database.	Pulmonary toxicity, chronic interstitial inflammation	Based on ATO. Rat, 1-year inhalation toxicity study (Newton et al., 1994)

2.6 Health Based Air Guideline Value – 24 hour averaging time

A health based short term guideline value with a 24 hour averaging time is available from the Texas toxicology division of the Texas Centre for Environmental Quality (TCEQ). A value of 5 µg/m^3 (antimony as PM_{10}) was derived. This is based on the occupational exposure limit of 0.5 mg/m^3 for antimony oxide and an uncertainty factor of 100. The value is a reasonable estimate for a short term health guidelines given the OEL TWA is based on protection of inhalation toxicity. The uncertainty factor is also conservative given it is acute duration guideline.

However for screening purposes a screening value that is protective of both short term and long term health effects with a 24 hour averaging time was not available.

The Human Toxicology & Air Standards Section, Standards Development Branch, Ontario Ministry of the Environment (Ontario MfE) have developed a method to calculate 24-hour screening criteria that are set at concentrations that are protective against effects that may occur during continuous lifetime exposure. The converted 24-hour screening criterion is not directly linked to an effect and instead provides an indication whether the effects-based annual average air guideline value may be exceeded.

In this HRA the US EPA Inhalation Reference Concentration of 0.0002 mg/m^3 (0.2 µg/m^3) is used for comparison to the annual average ambient antimony levels. To compare individual 24 hour results for antimony a screening criteria based on the Ontario MfE method was derived using equation 1.

$C_{long} = C_{short} (t_{short}/t_{long})^p$ (equation 1)

Where:
C_{long}= the concentration for the longer averaging time
C_{short}= the concentration for the shorter averaging time
T_{short} = the shorter averaging time (in minutes)
T_{long} = the longer averaging time (in minutes)
and, p = the power law exponent

For ambient air assessments, the MOE calls for using a value of p = 0.28

Using the US EPA RfC for antimony as the annual guideline the conversion to a 24 hour screening criterion is calculated as follows:
$C_{annual} = C_{24hr} (t_{24hr}/t_{annual})^{0.28}$, or,

$C_{annual} = C_{24hr} (24/8760)^{0.28}$
$C_{annual} = C_{24hr} (0.19)$
$C_{24hr} = C_{annual} / (0.19)$
$C_{24hr} = 0.2$ µg/m^3 / (0.19) = 1.052 µg/m^3 rounded to 1 µg/m^3 .

The 24 hour screening criterion is used in Appendix D3 for comparison to 24 hour antimony PM_{10} values in Costerfield.

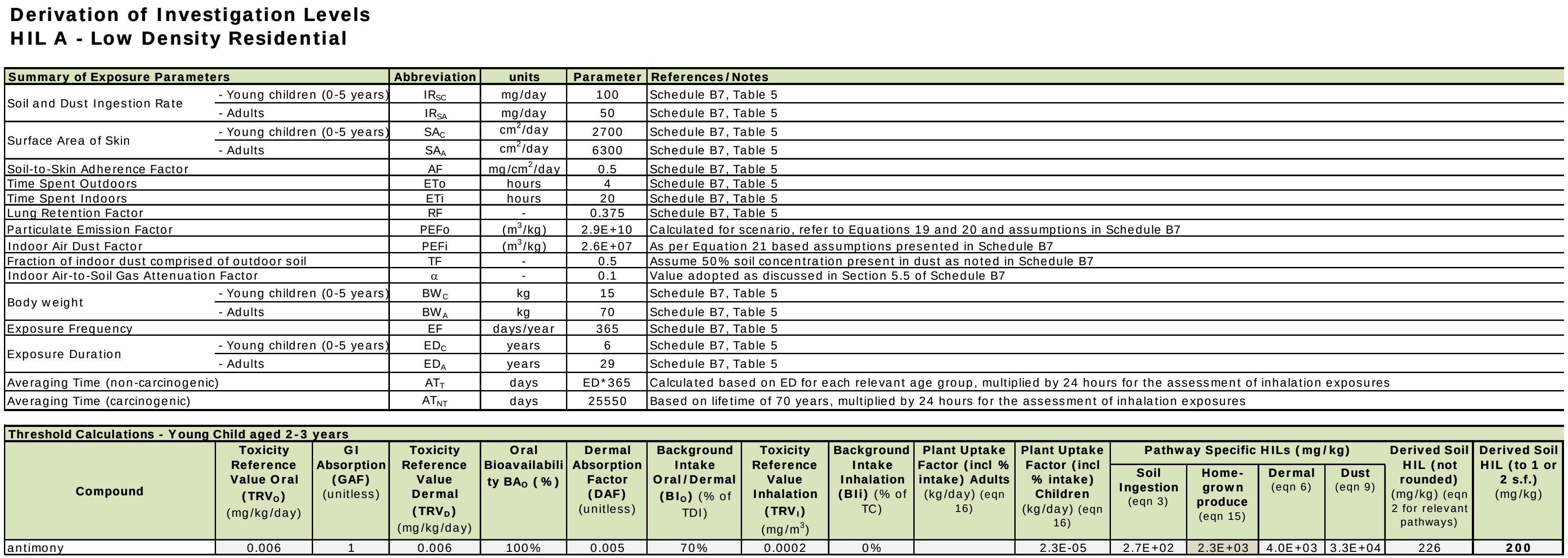
2.7 Health Based Soil Screening Criterion

Schedule B7 of the Australian Site Contamination National Environment Protection Measure (ASC NEPM 2013) defines Australian methodology for the derivation of Australian health based soil screening criteria known as 'Health Investigation Levels' HIL.

HIL A is intended for a residential setting with garden and accessible soil. Schedule B7 is accompanied by a spreadsheet that allows for the calculation of HIL for compounds not included within the ASC NEPM.

The HIL spreadsheet was utilised to derive a soil screening criterion for antimony (refer Figure 1) . The same parameters used to calculate a HIL for arsenic were used. Two values specific to antimony were included. The WHO TDI 0f 6 µg/kg bw/d is a chemical specific parameter entered for antimony. The proportion of the TDI allocated to other sources was conservatively set to 70%.

The resulting antimony soil screening criterion was 200 mg/kg. It is noted that the WHO TDI is expressed as total antimony and not to any particular form of antimony.



Derivation of Investigation Levels
HIL A - Low Density Residential

Summary of Exposure Parameters		Abbreviation	units	Parameter	References/Notes
Soil and Dust Ingestion Rate	- Young children (0-5 years)	IR_{SC}	mg/day	100	Schedule B7, Table 5
	- Adults	IR_{SA}	mg/day	50	Schedule B7, Table 5
Surface Area of Skin	- Young children (0-5 years)	SA_C	cm^2/day	2700	Schedule B7, Table 5
	- Adults	SA_A	cm^2/day	6300	Schedule B7, Table 5
Soil-to-Skin Adherence Factor		AF	mg/cm^2/day	0.5	Schedule B7, Table 5
Time Spent Outdoors		ETo	hours	4	Schedule B7, Table 5
Time Spent Indoors		ETi	hours	20	Schedule B7, Table 5
Lung Retention Factor		RF	-	0.375	Schedule B7, Table 5
Particulate Emission Factor		PEFo	(m^3/kg)	2.9E+10	Calculated for scenario, refer to Equations 19 and 20 and assumptions in Schedule B7
Indoor Air Dust Factor		PEFi	(m^3/kg)	2.6E+07	As per Equation 21 based assumptions presented in Schedule B7
Fraction of indoor dust comprised of outdoor soil		TF	-	0.5	Assume 50% soil concentration present in dust as noted in Schedule B7
Indoor Air-to-Soil Gas Attenuation Factor		α	-	0.1	Value adopted as discussed in Section 5.5 of Schedule B7
Body weight	- Young children (0-5 years)	BW_C	kg	15	Schedule B7, Table 5
	- Adults	BW_A	kg	70	Schedule B7, Table 5
Exposure Frequency		EF	days/year	365	Schedule B7, Table 5
Exposure Duration	- Young children (0-5 years)	ED_C	years	6	Schedule B7, Table 5
	- Adults	ED_A	years	29	Schedule B7, Table 5
Averaging Time (non-carcinogenic)		AT_T	days	ED*365	Calculated based on ED for each relevant age group, multiplied by 24 hours for the assessment of inhalation exposures
Averaging Time (carcinogenic)		AT_{NT}	days	25550	Based on lifetime of 70 years, multiplied by 24 hours for the assessment of inhalation exposures

Threshold Calculations - Young Child aged 2-3 years

Compound	**Toxicity Reference Value Oral (TRV_O)** (mg/kg/day)	**GI Absorption (GAF)** (unitless)	**Toxicity Reference Value Dermal (TRV_D)** (mg/kg/day)	**Oral Bioavailability BA_O (%)**	**Dermal Absorption Factor (DAF)** (unitless)	**Background Intake Oral/Dermal (BI_O)** (% of TDI)	**Toxicity Reference Value Inhalation (TRV_I)** (mg/m^3)	**Background Intake Inhalation (BIi)** (% of TC)	**Plant Uptake Factor (incl % intake) Adults** (kg/day) (eqn 16)	**Plant Uptake Factor (incl % intake) Children** (kg/day) (eqn 16)	**Pathway Specific HILs (mg/kg)**				**Derived Soil HIL (not rounded)** (mg/kg) (eqn 2 for relevant pathways)	**Derived Soil HIL (to 1 or 2 s.f.)** (mg/kg)
											Soil Ingestion (eqn 3)	**Home-grown produce** (eqn 15)	**Dermal** (eqn 6)	**Dust** (eqn 9)		
antimony	0.006	1	0.006	100%	0.005	70%	0.0002	0%		2.3E-05	2.7E+02	2.3E+03	4.0E+03	3.3E+04	226	**200**

Figure 1: Antimony HIL Derivation Spreadsheet

3.0 ARSENIC

3.1 General

Arsenic is naturally present in the environment in oxidation states of –3, 0, +3 (III) and +5 (V), most commonly in minerals such as realgar (As_4S_4), orpiment (As_2S_3), arsenolite (As_2O_3) and associated with sulphur in the form of arsenopyrite (FeAsS) (ATSDR, 2007; USEPA, 2005). Arsenic III is more toxic than V. In soils, inorganic arsenate also binds to iron and aluminium or other cations (e.g., calcium, zinc, magnesium, lead) as well as organic matter (US EPA, 2005). Arsenic V and III predominate in contaminated soils and waters, depending upon the redox potential and pH. The following factors increase arsenic bioavailability in soils: low clay content, low redox potential, and high pH (US EPA, 2005).

In water, it is mostly present as arsenate (+5), but in anaerobic conditions, it is likely to be present as arsenite (+3) (WHO, 2011b). In water, As (III) is removed by sulphides and As (V) by clays. Iron (III), chromium (III) and barium also reduce arsenic toxicity. Methylation of arsenic to non-toxic forms is a common detoxification mechanism in algae. In oxidising environments, e.g. surface water, inorganic species of arsenic predominate (as As(V)), with As(III) predominating under reducing conditions in groundwater (ANZECC and ARMCANZ, 2000).

3.2 Human Health

Arsine (AsH_3) is considered to be the most toxic form, followed by the arsenites, the arsenates and organic arsenic compounds (WHO, 2011). Arsenic is found in the diet, particularly in fish and shellfish, in which it is found mainly in the less toxic organic form. There are only limited data on the proportion of inorganic arsenic in food, but these indicate that approximately 25% is present in the inorganic form, depending on the type of food (WHO, 2011a).

The fate of arsenic in the human body varies depending on its form. When ingested, elemental arsenic is poorly absorbed and largely eliminated unchanged. Inorganic arsenic can accumulate in skin, bone, liver, kidney, and muscle, with a typical half-life of 2 to 40 days and is eliminated from the urine. Soluble arsenic compounds are rapidly absorbed from the gastrointestinal tract and arsenic(V) and organic arsenic are rapidly and largely eliminated via the kidneys (WHO, 2011a).

IARC (2012) has classified arsenic and inorganic arsenic compounds as carcinogenic to humans (Group 1). US EPA IRIS has classified arsenic as a carcinogen (group A), based on sufficient evidence from human data. US EPA IRIS found that an increased lung cancer mortality was observed in multiple human populations exposed to arsenic primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic.

WHO (2011b) have found that there remains considerable uncertainty over the actual risks at low concentrations, and that available data on mode of action do not provide a biological basis for using either linear or non-linear extrapolation. Consequently, WHO (2011b) have not derived a TDI for arsenic, and a provisional water quality guideline of 10 µg/L is based on the practical quantification limit.

JECFA (1989) derived a Provisional Tolerable Weekly Intake (PWTI) of 0.015 mg/kg/week, subsequently converted to a provisional maximum Tolerable Daily Intake (TDI) of 0.002 mg/kg/day. The JECFA TDI value was adopted by NHMRC (2004) in development of drinking water guidelines for Australia. RIVM (2001) also adopted the JECFA TDI value, but applied an additional uncertainty factor of 2 to account for observational errors anticipated in the use of epidemiological studies. A TDI of 0.001 mg/kg/day was therefore adopted by RIVM. The JECFA PWTI was withdrawn by JECFA (WHO 2011a) following further review.

In Canada, the human health based soil guideline for arsenic is 12 mg/kg (CCME, 2001). The WHO (2011b) drinking water guideline for arsenic is 0.01 mg/L.

The Australian Pesticides and Veterinary Medicines Authority (APVMA, 2005) conducted a toxicity review of arsenic and concluded that arsenic appears to behave like a carcinogen which exhibits a threshold effect. Based on the assessment that a threshold dose-response approach for the assessment of carcinogen effects associated with arsenic exposure is considered appropriate, NEPC (2013) adopted a Tolerable Daily Intake (TDI) of 2 µg/kg/day for derivation of a soil Health Investigation Level (HIL). The chosen TDI value was based on the TDI being at the lower end of the range derived from JECFA (WHO 2011a) and is also within the range presented by the European Food Safety Authority (EFSA cited in NEPC 2013). The TDI value is also within the range of no observable adverse effect levels (NOAELs) identified by RIVM (2001), US EPA (US EPA 1998) and ATSDR (2007) that are associated with non-carcinogenic effects of 0.08 – 8 µg/kg/day.

3.3 Bioavailability

The bioavailability of arsenic in soil has been assessed by USEPA (2009) in several studies. Soils assessed in these studies came from a range of sites, including those with mining and smelting activities, pesticide facilities, cattle dip vats and chemical plants. Based on these studies, USEPA Region 8 concluded that a relative oral bioavailability of arsenic in soil (compared to water) of 50% can be considered a generally conservative default value. It is noted that this value of 50% was derived from assessment of soils that included those contaminated by arsenic from anthropogenic sources (pesticides, smelting, etc.), and may overestimate the bioavailability of arsenic from natural soils, such as those in the Santa Isabel area.

However, NEPC (2013) adopted a bioavailability of 70 – 100% for derivation of the Health Investigation Levels in the NEPM. NEPC (2013) report that oral bioavailability may vary from around 25 – 70%. Based on this, a bioavailability of 70% has been adopted for this HRA.

Dermal availability of arsenic in soil is low. NEPC (2013) adopts dermal absorption value of 0.5% for arsenic for derivation of the Health Investigation Levels in the NEPM. The US EPA RAGS E recommends a dermal permeability coefficient (K_p) of 0.001 cm/hr for arsenic (US EPA, 2004).

3.4 Toxicological Reference Values

The TRVs adopted for antimony in this assessment are summarised in Table 3.

Table 3: Toxicological Reference Values – Arsenic

Exposure Route	TRV	Reference
Oral/dermal	0.002 mg/ kg bw/day	Adopted by NEPC 2013
Inhalation	0.001 mg/m^3	Adopted by NEPC 2013, derived by RIVM 2001.

4.0 LEAD

4.1 General

Lead is a naturally occurring element, making up about 0.0013% of the Earth's crust (UNEP 2006). There are three chemical forms of lead: metallic lead, inorganic lead compounds and organic lead compounds (containing carbon). Lead is usually obtained from sulphide ores, often in combination with other elements such as zinc, copper and silver. The main lead mineral is galena (PbS). Other common varieties include cerussite (PbCO3), plattnerite (PbO2) and angelsite (PbSO4).Lead exists in three oxidation states: Pb(0) - the elemental form, Pb(II) and Pb(IV). Metallic lead, Pb (0), exists in nature, but its occurrence is rare (UNEP 2006; ATSDR 2007).

Historically, lead paint was used on the inside and outside of homes in Australia, In the 1960s lead paint began to be phased out, and it's use in Australian domestic paint has now been banned (NHMRC 2014). Despite this, exposure to lead paint remains a problem in old homes and buildings, where children and pets can ingest flecks of paint as it chips or peels from walls. Renovations of older homes and buildings can result in human lead exposure in close proximity to the renovation and to others who are exposed as the dust moves into the wider environment (BL Gulson, JJ Davis & J Bawden-Smith 1995 cited in NHMRC 2014).

Lead in petrol was phased out nationally following interventions in Western Australia and Queensland in 2000 and 2001 respectively (NHMRC 2014).

Evidence suggests soil contamination may be an important source of lead exposure in urban Australia. For example, analysis of 41 residential housing soil samples from an inner-Sydney suburb found that 68% exceeded the National Environmental Protection Council 300 mg/kg residential soil lead guideline (National Environment Protection Council 2013; Royal Prince Alfred Hospital and Central and Southern Sydney Area Health Service 1988 cited in NHMRC 2014). A recent review of existing evidence concluded that previous use of lead in petrol and paint has contaminated urban soils in the older inner suburbs of large Australian cities, and that the risks to human health remain poorly understood due in part to a lack of knowledge of the distribution of soil lead concentrations across Australia (MAS Laidlaw & MP Taylor 2011 cited in NHMRC 2014).

4.2 Absorption, Distribution, Biotransformation, Excretion

The absorption and distribution of Pb varies depending on duration and intensity of the exposure, age, and various physiological variables (e.g., nutritional status, pregnancy, and menopause) (ATSDR 2007).

Absorption of Pb deposited in the respiratory tract is influenced by particle size and solubility, as well as by the pattern of regional deposition within the respiratory tract. Fine particles (<1 µm) deposited in the bronchiolar and alveolar region can be absorbed after extracellular dissolution or can be ingested by phagocytic cells and transported from the respiratory tract (ATSDR 2007). In quantitative studies with human volunteers the proportion of Pb particles absorbed was approximately 95% of the deposited Pb within the bronchiolar and alveolar region (ATSDR 2007, USEPA 2006). Larger particles (>2.5 µm) that are primarily deposited in the ciliated airways (nasopharyngeal and tracheobronchial regions) can be transferred by mucociliary transport into the oesophagus and swallowed (ATSDR 2007).

The extent and rate of GI absorption of ingested inorganic Pb are influenced by physiological states of the exposed individual (e.g., age, fasting, nutritional calcium and iron status, pregnancy) and physicochemical characteristics of the Pb-bearing material ingested (e.g., particle size, mineralogy, solubility, Pb species) (US EPA 2006).

Human studies investigating the absorption of water soluble Pb compounds indicate that 40-50% of ingested Pb is absorbed in children (2 week old infants to approximately 8 year old children) while only 3-10% of ingested Pb is absorbed by adults (ATSDR 2007, US EPA 2006). The difference is thought to be due to differences in physiological and dietary factors.

The US EPA RAGS E recommends a dermal permeability coefficient (K_p) of 0.00013 cm/hr for $Pb(NO_3)_2$ and 0.0000005 cm/hr for $Pb(Ch_3CO_2)_2$ (US EPA, 2004).

4.3 Human Health

The toxicity of organic lead compounds differs from inorganic lead compounds, as organic lead is soluble in fat, it mainly affects the central nervous system and can penetrate the skin. Inorganic lead can be absorbed following inhalation or through oral or dermal exposure, although dermal absorption is a less efficient pathway.

Lead poisoning is primarily a chronic to sub-chronic disease caused by the gradual accumulation of lead in the body. Chronic low-level exposure to inorganic lead is associated with interference in the biosynthesis of haem in blood, effects on the peripheral nervous system and central nervous system, and renal dysfunction (ATSDR, 2007). An association between lead exposure early in life and increased blood pressure late in life has also been reported (ATSDR, 2007). This is thought to result from the mobilisation of lead stored in bones in people of advancing age as the bone density decreases.

In general, infants and children, particularly those under five years of age, are more susceptible to chronic lead toxicity than adults, and exhibit more severe toxicity at lower exposures than adults (ATSDR, 2007). ATSDR (2007) reported the following health effects can occur following exposure to lead either in utero, during infancy, or during childhood:

- delays or impairment of neurological development
- neurobehavioral deficits including intelligence quotient (IQ) deficits
- low birth weight
- low gestational age
- growth retardation
- delayed sexual maturation in girls.

The critical effect of particular concern for environmental exposures to the general public is the effect of lead on the central nervous system. Epidemiological studies suggest that low level exposure of the foetus and developing child may impair the learning capacity and the neuropsychological development. Studies of children indicate a correlation between higher lead contents in the blood and a lower IQ (ATSDR 2007). The studies used to investigate these endpoints are not precise and the outcomes are influenced by such things as genetics, socio-economic status and early life experience/environment (NHMRC 2009). Given the imprecise nature and outcomes the NHMRC recently concluded that it is not possible to make a definitive statement on what constitutes a ‘safe level’ or ‘level of concern’ for blood lead and recommend a blood lead level below 10 µg/dl for all Australians.

The International Agency for Research on Cancer (IARC, 2006) has classified inorganic lead as probably carcinogenic to humans (Group 2A), based on sufficient evidence in animal studies and limited evidence in humans. IARC (2006) also concluded that there was inadequate evidence on the carcinogenicity of organic lead compounds, consequently classified them as Group 3 not classifiable as to their carcinogenicity to humans.

No carcinogenic lead TRV were identified in the literature reviewed. US EPA (2004) stated that “*quantifying lead's cancer risk involves many uncertainties, some of which may be unique to lead. Age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead. In addition, current knowledge of lead pharmacokinetics indicates that an estimate derived by standard procedures would not truly describe the potential risk.*”

In addition there is evidence from human studies that adverse effects other than cancer may occur at lower lead levels (WHO 2011). For this reason the risk characterisation focuses on adverse effects most relevant to sensitive subpopulations as this approach is considered to also be adequately protective of carcinogenic effects (ASC NEPM 2013).

A recent expert evaluation by the NHMRC (2014) concluded:

- *blood lead levels <5 µg/dL are associated with adverse cognitive (academic achievement and IQ decrements) effects in children (although literature suggests uncontrolled confounding may play an important role in the findings regarding IQ);*
- *blood lead levels <10 µg/dL are associated with the following health effects:*
  - *adverse behavioural (attention, impulsivity and hyperactivity) effects among children;*
  - *delay in sexual maturation or puberty onset in adolescent girls and boys; and*
  - *increased blood pressure and increased risk of hypertension among adults and pregnant women (although there is uncertainty regarding the clinical significance of the findings regarding an increase in blood pressure).*

Given these conclusions the toxicity reference value (equivalent to a Tolerable daily intake) is needed for both children and adults.

4.4 Toxicological Reference Values

An oral Provisional Tolerable Weekly Intake (PTWI) of 0.025 mg/kg/w (25 µg/kg/w) for the non carcinogenic effects of lead was developed by JECFA (1999). A Provisional Tolerable Daily Intake (PTDI) of 0.0035 mg/kg/d can be derived by dividing the PTWI by 7. The PTWI established by JECFA was based on metabolic studies in infants in which a mean daily intake of 3 - 4 µg/kg/d was not associated with an increase in blood lead levels or in the body burden of lead, whereas an intake of 5 µg/kg body weight or more resulted in lead retention.

This PTWI was adopted as the oral TDI in the derivation of drinking water guidelines by WHO (2003).

WHO (2011) have derived a drinking water guideline for lead of 0.01 mg/L. The guideline is not based on a NOAEL, as there does not appear to be a threshold for the key effects of lead. The guideline value is provisional on the basis of treatment performance and analytical achievability.

The Joint FAO/WHO Expert Committee on Food Additives (JECFA 2011) concluded that it was not possible to establish a threshold for the neurological effects of lead in children. On this basis the PTWI was rescinded.

JECFA focussed on the extensive data that were available on adverse effects in humans, thus avoiding uncertainties in extrapolation from animal studies. They calculated benchmark doses (BMDs) and their lower 95% confidence limits (BMDLs) for the effects of lead most likely to be relevant to dietary exposure in different subgroups of the general population. The detailed dose response analysis lead the Committee to report that a lead exposure level of 0.3 µg kg^{-1} bw day^{-1} was estimated to be associated with a population decrease of 0.5 IQ points. A lead exposure level of 1.9 µg kg^{-1} bw day^{-1} was calculated to be associated with a population decrease of 3 IQ points, the Committee deemed this to be of concern.

The critical study used in the JECFA dose response modelling is Lanphear et al. (2005 cited in COT 2013). This was a pooled analysis of data from seven prospective cohort studies concerning the quantitative relationship between performance on IQ tests and measures of blood lead concentration, among children followed from infancy. The primary outcome measure was full-scale IQ, assessed at an age between four years 10 months and 10 years. This was related to four measures of blood lead: concurrent blood lead (the most recent measurement before IQ was assessed), maximum blood lead (the highest concentration of blood lead that had been measured at any time before IQ was assessed), average lifetime blood lead (the mean of blood lead measurements from age 6 months up to the time that IQ was assessed) and early childhood blood lead (the mean of measurements between 6 and 24 months of age). After adjustment for covariates, IQ was inversely related to each of these measures of blood lead (COT 2013).

JECFA conducted modelling based on concurrent blood lead levels since they showed the highest correlation with IQ. Initially, six different models were considered – four with linear form and two sigmoidal.

The European Food Safety Authority (EFSA 2010) has also undertaken dose response modelling using the same approach as JECFA. However EFSA used a smaller subset of models.

JECFA used a bilinear model. EFSA used a 'piecewise' linear model . The JECFA model did not constrain the inflexion in the dose-response relationship to be at a pre-specified blood lead concentration. The bilinear model was chosen to characterise the relationship of blood lead to IQ, since it provided a better fit than four of the other models, and it was considered that it would give better estimates of effect than the one other model with similar fit, when non-dietary exposures to lead were unknown or highly variable. Using this model, the chronic dietary exposure of a 20 kg child corresponding to a decrease of 1 IQ point was estimated to be 0.6 µg/kg bw per day with a 90% confidence interval of 0.2-7.2 µg/kg bw per day (COT 2013). Using the same data set EFSA estimated a decrease of 1 IQ point was estimated to be 0.5 µg/kg bw per day (i.e. a very similar value).

Given the JECFA modelling provided a more comprehensive range of models the JECFA values were used in the present HRA.

The BMDL of 0.6 µg/kg bw per day was for a small effect (a one-point difference in IQ), derived from pooled analysis of multiple cohort studies of exposures in infants and children. There are several layers of conservatism embedded in this estimation. As such this value can be used as a value that is equivalent to a tolerable daily intake for risk characterisation (UK COT 2013).

To put this intake value into context as a blood lead level, according to the WHO (2011) a 1 IQ point decrement is associated with a blood Pb level of 2 µg/dL as a reasonably conservative estimate (WHO, 2011). Thus, in children it is postulated that 0.6 µg/kg bw/day is associated with a blood Pb level of 2 µg/dL and this value should in turn be associated with a 1 IQ decrement (based on the NHMRC 2014 review this is a conservative estimation of a *de minimis* population level). The use of a 1 IQ decrement is very conservative. This is well within normal variation in IQ levels. It is also noted that the dose response modelling used to derive this value is conservative as it relies on an apparent steep dose response curve in a single study in Rochester USA. The slope of the dose response curve would have a significant impact on the BMDL (UK COT 2013).

The US EPA (2013) have developed national ambient air standard for lead based on a blood lead level of 5 µg/dL. Even though the dose response modelling suggests that at this blood lead level the IQ change would be greater than 1, even at 5 µg/dL (more than double the value selected for this HRA) the IQ difference is within the standard error of measurement for IQ tests (generally in the range of ±2.8 IQ points (Sattler, 2001)).

5.0 INTERACTION PROFILE

5.1 Summary

An interaction profile evaluates data on the joint toxic actions of chemicals in a mixture in order to recommend approaches for the exposure based assessment of the potential hazard to public health (ATSDR (2001). ASTDR (2001) defines a mixture as "*any combination of two or more chemicals, regardless of source and spatial or temporal proximity, that may jointly contribute to actual or potential effects in a receptor population*". The mixture of COPCs identified within the study area includes antimony, arsenic and lead.

Table 5 summarises the outcomes of the interaction profile for these metals, with further information provided in the following sections.

Interactions of Pb with other metals are inconsistent, depending on the endpoint measured, the tissue analysed, the animal species, and the metal combination (US EPA 2006 p E20). Two of the most commonly reported Pb-element interactions are between Pb and Ca and between Pb and Zn. Both calcium and zinc are essential elements in organisms and the interaction of Pb with these ions can lead to adverse effects both by increased Pb uptake and by a decrease in Ca and Zn required for normal metabolic functions (US EPA 2006 p E23, Ahamed et al. 2007).

Table 4: Toxicity Category Summary Table

Contaminant of Potential Concern	Target Organs of Concern	Toxicity Category		
		Genotoxic	Carcinogenic[a]	Reproductive Toxicant
Antimony (Sb)	Respiratory (pneumoconiosis in humans).	N	N (IARC 2B)	N
Arsenic (As)	Respiratory; skin; reproductive/developmental; cardiovascular; nervous system; lung cancer.	**Y**	**Y** (IARC 1, USEPA A)	N
Lead (Pb)	Impaired neurobehavioural functioning and IQ in children.	N	N (IARC 2B, USEPA B2)	**Y**

[a] For the purposes of this report category 1 (known human carcinogens) and 2A (probable human) carcinogens have been designated with a “Y” for carcinogenicity. A Category 2B or 3 classification does not mean that a substance is not carcinogenic, only that the information available is insufficient for classification (WHO 2003).

5.2 Possible Toxicity Interactions

ATSDR (2001) state that “*interactions are defined as deviations from the results expected on the basis of additivity*”. Hence interactions between compounds in a mixture may increase or decrease the apparent toxic effect expected based on the toxicity of the individual compounds present in the mixture. The ATSDR (2001, table 2) provide the following definitions of various interactions that may influence the toxicity of compounds in a mixture:

Additivity: When the effect of the mixture can be estimated from the sum of the exposure levels (weighted for potency) or the effects of the individual components.

No apparent influence: When a component which is not toxic to a particular organ system does not influence the toxicity of a second component on that organ system.

Synergism: When the effect of the mixture is greater than that estimated for additivity on the basis of the toxicities of the components.

Potentiation**:** When a component that does not have a toxic effect on an organ system increases the effect of a second chemical on that organ system.

Antagonism*:* When the effect of the mixture is less than that estimated for additivity on the basis of the toxicities of the components.

Inhibition*:* When a component that does not have a toxic effect on a certain organ system decreases the apparent effect of a second chemical on that organ system.

Masking: When the components produce opposite or functionally competing effects on the same organ system, and diminish the effects of each other, or one overrides the effect of the other.

In strict biological terms an interaction would only be expected if chemicals were affecting the same tissue types in an equivalent manner (e.g.by the same mode of action). Typically in risk assessments all chemicals are conservatively assumed to act in an additive manner. This is done even when there is no evidence that an additive interaction will occur hence it is important to consider the level of conservatism underlying this assumption.

The health effects associated with the chemicals of potential concern (COPC) have been summarised in Tables Table 4 and Table 5. Tick marks denote whether specific tissues are a target of toxicity. The tables are used to identify target tissues and hence assumed additive toxicity that may result due to exposure from a chemical mixture.

The present review did not evaluate the mode of action of the individual compounds in particular organs and tissues thus the interactions assessment only identifies possible interactions. It does not assess whether such additive interaction would occur at exposure levels predicted within the risk assessment. The simple approach used in Table Table 4 and Table 5 to identify potential additive relationships of a complex exposure is appropriate for a screening level assessment of additive toxicity based on default assumptions of additivity.

Although all three metals can affect the endpoint developmental toxicity and cancer, in each case lead acts in different ways. Lead affects IQ by displacing Ca^{2+} in cell interactions around the body. Neither arsenic nor antimony act in this manner. Antimony and arsenic do act on the cardiovascular system however the effects are at different points of the cardiovascular system (arsenic – vascular, antimony cells within the heart). The kidney tumours due to lead exposure are likely due to a mechanism specific to lead.

WHO (2003) note that Sb(OH)3, like As(OH)3, readily reacts with thiol groups. "*Both trivalent metal species accumulate in vitro in cultured mammalian cells and seem to exert mutually additive or sub-additive toxicity in combined incubation (Felicetti et al., 1974; Buchet et al., 1980; Bailly et al., 1991; Gebel, 1997, 1998; Schaumlöffel & Gebel, 1998 cited in WHO 2003)*". Elimination of antimony(III) and arsenic(III) from cells follows the same ATP dependent mechanisms and explains the cross-resistance between both trivalent elements in bacterial and mammalian cells (Rosen et al., 1988; Mukhopadhyay et al., 1996; Wang et al., 1996 cited in WHO 2003). On this basis it is possible that antimony and arsenic toxicity interact in an additive manner. Studies demonstrating a synergetic relationship were not identified in the WHO (2003) review or other literature consulted. This has been accounted for within the risk characterisation by adding the hazard quotients for antimony and arsenic together.

Table 5: Summary of Target organs (a tick indicates a causal relationship or proven effect in animal studies that is relevant to humans)

Systemic Effects	Arsenic	Antimony	Lead
Neurological	✓ peripheral neuropathy		✓ CNS - behavioural
Haematological	✓ vascular disease		✓ heme synthesis
Cardiovascular	? [c] Hypertension (vascular system)	✓ (cardio system)	✓ Hypertension (vascular system)
Renal	✓		✓ function
Testicular			✓ sperm prod.
Dermal lesions	✓ (blackfoot disease)	✓ (different to arsenic)	
Respiratory [b]	✓	✓ Pneumoconiosis	
Cancer	✓ skin, urinary bladder, and lung	✓ Lung [b]	✓ Kidney, brain
Genotoxicity	×	×	×
Hepatic			
Bone	×	×	✓
Developmental	✓ (mortality at high concentrations)	✓ (mortality at high concentrations)	✓ IQ loss in young children, reduced birth weight

a References used to determine health effects are summarised within the toxicity profile for each compound.

b. following inhalation exposure to high concentrations of antimony trioxide particles.

c. Weak (non causal) evidence for a relationship.

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Derivation of Investigation Levels
HIL A - Low Density Residential

Summary of Exposure Parameters		**Abbreviation**	**units**	**Parameter**	**References/Notes**
Soil and Dust Ingestion Rate	- Young children (0-5 years)	IR_{SC}	mg/day	100	Schedule B7, Table 5
	- Adults	IR_{SA}	mg/day	50	Schedule B7, Table 5
Surface Area of Skin	- Young children (0-5 years)	SA_C	cm^2/day	2700	Schedule B7, Table 5
	- Adults	SA_A	cm^2/day	6300	Schedule B7, Table 5
Soil-to-Skin Adherence Factor		AF	mg/cm^2/day	0.5	Schedule B7, Table 5
Time Spent Outdoors		ETo	hours	4	Schedule B7, Table 5
Time Spent Indoors		ETi	hours	20	Schedule B7, Table 5
Lung Retention Factor		RF	-	0.375	Schedule B7, Table 5
Particulate Emission Factor		PEFo	(m^3/kg)	2.9E+10	Calculated for scenario, refer to Equations 19 and 20 and assumptions in Schedule B7
Indoor Air Dust Factor		PEFi	(m^3/kg)	2.6E+07	As per Equation 21 based assumptions presented in Schedule B7
Fraction of indoor dust comprised of outdoor soil		TF	-	0.5	Assume 50% soil concentration present in dust as noted in Schedule B7
Indoor Air-to-Soil Gas Attenuation Factor		α	-	0.1	Value adopted as discussed in Section 5.5 of Schedule B7
Body weight	- Young children (0-5 years)	BW_C	kg	15	Schedule B7, Table 5
	- Adults	BW_A	kg	70	Schedule B7, Table 5
Exposure Frequency		EF	days/year	365	Schedule B7, Table 5
Exposure Duration	- Young children (0-5 years)	ED_C	years	6	Schedule B7, Table 5
	- Adults	ED_A	years	29	Schedule B7, Table 5
Averaging Time (non-carcinogenic)		AT_T	days	ED*365	Calculated based on ED for each relevant age group, multiplied by 24 hours for the assessment of inhalation exposures
Averaging Time (carcinogenic)		AT_{NT}	days	25550	Based on lifetime of 70 years, multiplied by 24 hours for the assessment of inhalation exposures

Threshold Calculations - Young Child aged 2-3 years

Compound	**Toxicity Reference Value Oral (TRV_O)** (mg/kg/day)	**GI Absorption (GAF)** (unitless)	**Toxicity Reference Value Dermal (TRV_D)** (mg/kg/day)	**Oral Bioavailability BA_O (%)**	**Dermal Absorption Factor (DAF)** (unitless)	**Background Intake Oral/Dermal (BI_O)** (% of TDI)	**Toxicity Reference Value Inhalation (TRV_I)** (mg/m^3)	**Background Intake Inhalation (BIi)** (% of TC)		**Plant Uptake Factor (incl % intake) Adults** (kg/day) (eqn 16)	**Plant Uptake Factor (incl % intake) Children** (kg/day) (eqn 16)	**Pathway Specific HILs (mg/kg)**				**Soil Vapour HIL (mg/m^3)** (eqn 12)	**Derived Interim Soil Gas HIL - Threshold (to 1 or 2 s.f.)** (mg/m3)	**Derived Soil HIL (not rounded)** (mg/kg) (eqn 2 for relevant pathways)	**Derived Soil HIL (to 1 or 2 s.f.)** (mg/kg)	**Notes**
												Soil Ingestion (eqn 3)	**Home-grown produce** (eqn 15)	**Dermal** (eqn 6)	**Dust** (eqn 9)					
antimony	0.006	1	0.006	100%	0.005	70%	0.0002	0%			2.3E-05	2.7E+02	2.3E+03	4.0E+03	3.3E+04			226	**200**	

APPENDIX G

Risk Characterisation (HRA Results)

1.0 INTRODUCTION

This Appendix presents the risk characterisation, which contains the results and findings of the HRA.

The risk characterisation process integrates the information from the problem formulation, toxicity assessment and exposure assessment and quantifies risks associated with these three metals. It combines the estimated daily intakes calculated in the exposure assessment (Appendix E) with the tolerable daily intake (TDI) from the toxicity assessment (Appendix F) to produce numerical indices. These indices are then used to make decisions regarding the potential for health risk.

An evaluation of the quality of the assessment and the degree of confidence in the estimates of risk and conclusions drawn is present in in the variability assessment in Appendix H.

1.1 Introduction to Hazard Quotients (HQ) and Hazard Index (HI)

Where chemicals are not categorised as genotoxic carcinogens the estimated daily intake over a lifetime is compared to a health based benchmark described in this report as a tolerable daily intake (TDI). A TDI for a chemical is generated by expert bodies and is designed to be protective of public health. The TDI is compared to the estimated daily intake (EDI) from the exposure assessment. This comparison is termed a hazard quotient (HQ) which is the ratio of the EDI to the TDI.

Thus a hazard quotient is calculated for each metal using the equation below.

Hazard Quotient:

$$HQ = \frac{EDI}{TDI} \qquad (1)$$

Where TDI = Tolerable Daily Intake ($mg/kg_{bw}/d$) (refer Appendix F)

EDI = Estimated Daily Intake ($mg/kg_{bw}/d$) (refer Appendix E)

It is conventional to calculate a HQ by estimating a lifetime average daily intake and dividing this by the TDI. This is done so because the TDI is intended to be protective of public health over a lifetime. However in this report in order to err on the side of caution the HQ is calculated for each chemical by a number of age groups; an infant (1 year old), a young child (2 year old), an older child (10 year old), and an adult.

For assessing the potential effects of the mixture of metals it has been assumed individual components may have additive effects and an overall hazard index (HI) is calculated (US EPA 2000). The hazard index (HI) is the sum of all the hazard quotients.

Hazard Index:

$$HI = \sum HQ \qquad (2)$$

Where HQ = Hazard quotient for each individual metal (unitless ratio)

$\sum$ = Symbol for Sum ($HQ_i + HQ_x + HQ_y$ +..).

The hazard index is not an evaluation predicting whether health effects will or will not occur, but rather whether the TDI will or will not be exceeded. If the TDI is not exceeded then it follows that health effects are very unlikely to occur, if the TDI is exceeded it does not naturally follow that health effects will occur. The reasons for this include:

- The hazard index approach assumes that each of the metals can cause health effects in the same way as each other. This is not the case for antimony, arsenic and lead. The health effects of these three metals are different (refer Appendix F).
- TDIs inherently contain safety factors to protect against adverse health effects being caused by exposure to the metal. Each TDI has been established following careful evaluation of relevant studies

(animal and human). Depending on the confidence in the studies, a number of safety factors are included in the derivation of the TDI. The overall safety factor typically ranges between 100 to 10,000.

1.2 Interpretation of hazard quotients and indices

Given the conservatism built into risk assessment, a hazard quotient (HQ) and hazard index (HI) of less than 1 are generally considered to present no cause for concern.

When the hazard index is greater than 1, closer examination of the assumptions is needed (HI above 1). This closer examination can either lead to refinement of the risk estimates or management actions to reduce exposure.

The HI calculation allows focus on components that are likely contributors to health risks either because their individual exposure levels exceed the TDI (as determined by the HQ), or because joint toxic action with other components, including additivity or interactions, may pose a health hazard (as determined by the HI being greater than 1, although. individual HQs are less than 1).

Generally mixture components whose hazard quotients are very low (HQ less than 0.1) are considered unlikely to pose a health hazard due to interactions, and unless there are a relatively large number of components that act similarly, are not likely to pose an increased hazard due to additivity. This is why 15 of 18 metals tested in the various environmental media were screened out at an early stage in this HRA (refer Appendix D). Given that these metals are at or below background levels, or below health screening guidelines for soil or water, their hazard quotients are expected to be low and they are not likely to interact to produce adverse health effects.

1.3 Assessment of Carcinogenic Chemicals

Chemicals that cause cancer by directly altering genetic material are known as genotoxic carcinogens. There are three general groups of carcinogens:

- known human carcinogens where a link between human exposure and particular types of cancer have been proven,
- probable human carcinogens where a link is probable and so these are treated equivalently to known human carcinogens, and,
- possible carcinogens where the link to humans is not certain.

Known human carcinogens and probable human carcinogens that cause cancer via a genotoxic mechanism of action are assessed in a different way to that described in Section 1.1.

Antimony is not categorised as a known or probable human carcinogen. The International Agency for Research on Cancer (IARC) classifies diantimony trioxide (Sb_2O_3) as a Group 2B agent "*Possibly carcinogenic to humans*" (1989) and diantimony trisulphide (Sb_2S_3) as a Group 3 agent "*Not classifiable as to its carcinogenicity to humans"* (1989) (IARC, 2015). These classifications are based on studies via the inhalation route. Diantimony trioxide is classified as *suspected of causing cancer by inhalation* (ECHA, 2015). Antimony is not classified as a carcinogen by the oral or dermal route. It is assessed in the risk characterisation using the approach outlined in Section 1.1.

IARC (2012) has classified arsenic and inorganic arsenic compounds as carcinogenic to humans (Group 1). Studies of workers exposed to high workplace concentrations of inorganic arsenic found an association with increased lung cancer mortality. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. Three Australian expert reviews (NHMRC 2011, APVMA 2005, NEPC 2013) have concluded that arsenic appears to behave like a carcinogen which exhibits a threshold effect. On this basis it is assessed in the risk characterisation using the approach outlined in Section 1.1.

The IARC (2006) has classified inorganic lead as "*Probably carcinogenic to humans*" (Group 2A), based on sufficient evidence in animal studies and limited evidence in humans. The mechanism of cancer formation is not considered a direct genotoxic effect. In addition there is evidence from human studies that adverse effects other than cancer may occur at lower exposure levels (WHO 2011). For this reason the risk characterisation focuses on adverse effects most relevant to sensitive subpopulations as this approach is considered to also be adequately protective of carcinogenic effects (NEPC 2013).

2.0 RISK CHARACTERISATION

The risk characterisation assesses the potential for health impacts using the hazard index approach described in Section 1.0. There are at least three factors that need to be considered when interpreting the HQ and HI:

- The frequency of co-occurrence of the soil and water concentrations used for calculation of the HQ. The values used in the HRA are described in Appendix E. These are statistical values for the Costerfield Dome each chosen in a conservative manner. When assessed in combination (soil+water and for antimony, arsenic and lead) the estimation of hazard indices also adds to the conservatism in the assessment.
- The appropriateness of and the degree of conservatism in the TDI used to calculate the hazard quotient of individual chemicals.
- The legitimacy of adding hazard quotients for compounds that have different toxicological effects, i.e. assuming there will be a toxicological interaction if co-exposure occurs.

The above points are all aspects that allow the risk characterisation to err on the side of caution. It is necessary to build this precaution into the assessment to account for sensitive subpopulations and also for uncertainties in the data and assumptions made during the risk assessment.

To allow an evaluation of the contribution of tank water consumption, the risk characterisation results provides for two scenarios:

- Residents use tank water as the primary drinking water source. Until June 2014 this was the most frequently used source of drinking water.
- Residents do not use tank water as a primary drinking water source but do use tank water for bathing.

For each scenario the risk characterisation provides results for

- Permanent Residents (residents present in Costerfield every day of the week), and,
- Weekend Residents (i.e. those who are present at the residence two days per week).

For each scenario and status of resident the HRA provides results for an infant (0-1 yrs), young child (1-2 yrs), older child (10 yrs) and adult.

In order to assess the confidence and uncertainties associated with individual input parameters to the exposure model and provide advice on how to manage any potential risks two exposure estimates were conducted:

- Average Case; and
- Upper Estimate

In all, the risk characterisation calculates 128 HQ and HI results. This is to allow a comprehensive assessment of health risk at Costerfield. The results for each scenario and each case are presented and interpreted in the following sections.

Given that the purpose of the HRA is to identify potential risks associated with the Costerfield Dome and the mining activities within it, the risk characterisation results (HQ and HI) are presented with and without lead.

This is important for the following reasons:

- Appendix I Figure 1 and 2 provides a statistical analysis of the three metals in ore, road, and soil samples. Box plots and probability density functions are provided. These show that the ore levels of antimony and arsenic exceed the distribution of these metals in soil. This analysis shows that antimony and arsenic levels are elevated due to the geological and mining legacy present in Costerfield. Whereas for lead, the analysis in Appendix I suggests that although there is a level of naturally occurring lead, the higher concentrations are more likely representative of anthropogenic sources.
- Radioisotope analysis was undertaken on four samples of soil in Costerfield. The four samples were characteristic of elevated lead in soil. The isotope analysis found that the lead is unlikely to be naturally related to the Costerfield Dome and could be due to anthropogenic sources of lead. The analysis is described in Appendix D6.
- There are marked differences in the toxicity of antimony and arsenic. For instance antimony has not been associated with arsenic's hallmark adverse health effect blackfoot disease and related skin cancers. However there is some inconclusive evidence that the mode of action for some antimony and arsenic (cardiovascular effects) may be similar. Given the similarities it is reasonable to add the HQ's for antimony and arsenic.
- Evidence that antimony and lead act by similar mode of actions was not identified. The health effects of antimony and lead do not suggest evidence for an interaction. Additional information on interactions is provided in Appendix F. Given the mode of action is different it is reasonable to review the HQ for lead separately to antimony and arsenic.

2.1 Risk Characterisation Results – Antimony and Arsenic

Table 1 summarises the risk characterisation results for antimony and arsenic.

All hazard quotients are at or below a HQ of 1. These results do not indicate a cause for concern for adverse health effects.

The upper estimate case for infants has a total hazard index of 1.2. The result is a consequence of the conservative approach taken in the assessment. The upper estimate assessment takes one of the highest concentrations in tank water and combines it with one of the highest soil concentrations. This is statistically valid but in reality these two concentrations are unlikely to co-occur at any individual property. The tank water data set used in the HRA is that taken before tank cleaning, collected between June and October 2014. This dataset had the highest concentrations measured. Tank water ingestion is a significant contributor to the overall exposure to antimony and arsenic.

Overall, it is considered that the risk characterisation for permanent residents and weekend residents does not indicate a cause for concern for adverse health effects.

Table 1: Hazard Quotient (HQ) and Hazard Index (HI) for antimony and arsenic – All Scenarios

Age Group	**Average Case**			**Upper Estimate Case**		
	HQ Antimony	**HQ Arsenic**	**HI**	**HQ Antimony**	**HQ Arsenic**	**HI**
Permanent Residents (Including Tank Water) [a]						
01 yrs	0.3	0.05	0.35	1.0	0.2	1.2
02 yrs	0.1	0.02	0.12	0.6	0.1	0.7
10 yrs	0.1	0.01	0.11	0.4	0.2	0.6
Adult	0.1	0.02	0.12	0.4	0.1	0.5
Weekend Residents (Including Tank Water)						
01 yrs	0.1	0.01	0.11	0.3	0.05	0.35
02 yrs	0.03	0.01	0.04	0.2	0.03	0.23
10 yrs	0.02	0.004	0.024	0.1	0.04	0.14
Adult	0.03	0.01	0.04	0.1	0.04	0.14
Permanent Residents (Excluding Tank Water)						
01 yrs	0.04	0.05	0.09	0.2	0.2	0.4
02 yrs	0.03	0.02	0.05	0.3	0.1	0.4
10 yrs	0.02	0.01	0.03	0.3	0.2	0.5
Adult	0.02	0.02	0.04	0.2	0.1	0.3
Weekend Residents (Excluding Tank Water)						
01 yrs	0.01	0.01	0.02	0.1	0.05	0.15
02 yrs	0.01	0.01	0.02	0.1	0.04	0.14
10 yrs	0.004	0.004	0.008	0.1	0.04	0.14
Adult	0.005	0.01	0.015	0.1	0.04	0.14

Note: **red bold** values >1 [a] In order not to imply a higher level of precision than the estimates represent the values are rounded to one significant figure).

2.2 Risk Characterisation Results – Antimony, Arsenic and Lead

Table 2 summarises results for all three metals (i.e. includes lead). The results are presented for several scenarios and cases, and the results are different for different scenarios. In order to provide context, the results are discussed separately in the text below.

2.2.1 Weekend Resident Results (Average and Upper Estimate Cases) – Including Tank Water Use

The weekend resident scenario assumes that some residents only spend weekends in Costerfield two days per week. All other factors within the HRA are equivalent to the Permanent Resident Scenario and are provided in Appendix E. Two estimates are provided an average and an upper estimate case.

All of the hazard quotients and hazard indices are less than 1. The results show that there is a negligible risk for adverse health effects for these residents.

2.2.2 Permanent Residents

The permanent resident scenario assumes that residents are present in Costerfield 24 hours a day each day of the year. The exposure estimate (provided in Appendix E) includes multiple exposure pathways including exposure to metals in soil, water, air and homegrown food (eggs and meat). Two cases are investigated an average case and an upper estimate case. The average case uses reasonable estimates that represent an average exposure to a resident in Costerfield.

Including Tank Water Use - Average Case Results

All of the hazard quotients and hazard indices for the average case results are less than 1. The results show that there is a negligible risk for adverse health effects for these residents.

Including Tank Water Use - Upper Estimate Case Results

The HQs for antimony and arsenic are all within the target of 1 (0.01 to 1) while the HQs for lead (Pb) in some cases exceed 1 (0.2 to 2.0). The HQs for children (0-1 and 2-3 year old) exceed 1.

The percent (%) contribution of lead to the HI in children ranges between 28% and 72% of the total HI.

The most significant exposure route changes depending on the age of a child because of changes in exposure characteristics. Infants have lower contact with soil and consume 1 litre of tank water per day. As a consequence the ingestion of tank water is the highest contributor to the HQ in this age group. In young and older children intimate soil contact is assumed, and soil ingestion accounts for 55-71% of the HQ.

The upper estimate case result reflects the widespread historical uses for lead. Lead is still used in flushing on roofs and was used as a solder component for pipe joints. As a consequence it has been reported to be present in tank water around Australia. Appendix I provides additional information on lead in tank water in urban areas around Australia.

A detailed examination of the high results for lead in soil is described in Appendix I of the HRA report. The examination revealed that the high results are unlikely of geological origin (i.e. not natural rock, ore or concentrate from mining).

It is likely that the high results are characteristic of urban environments where lead is a widespread contaminant due to its long history of use in manufactured products such as fuel and paint. This is a common finding in many urban areas of Australia and as such does not appear related to the natural history or mining legacy at Costerfield (refer Appendix I).

Without tank water use - Average Case Results

The risk characterisation found that none of the HQs or HIs for the average exposure of the permanent residents not using tank water exceeded a value of 1. Therefore, no unacceptable risks are predicted under this exposure scenario.

Without tank water use - Upper Estimate Case Results

In the scenario where tank water in not used for drinking, one of the HQ for lead was found to exceed a value of 1. That was for a 2 year old. Most (approximately 90%) of this HQ for lead was found to be due to soil contact. It is likely that the lead concentration modelled in the risk characterisation is typical of urban environments where lead is a widespread contaminant due to its long history of use in fuel and paint. This is a common finding in many urban areas of Australia and as such does not appear related to the natural history or mining legacy at Costerfield.

Overall, it is considered that the risk characterisation for permanent residents and weekend residents does not indicate a cause for concern for adverse health effects.

2.2.3 Summary of all results

Table 2 presents a summary of all the HQ and HI calculations for all scenarions.

Table 2: Hazard Quotient (HQ) and Hazard Index (HI) for all metals – All Scenarios

Age Group	Average Case				Upper Estimate Case			
	HQ Antimony	HQ Arsenic	HQ Lead	Total HI	HQ Antimony	HQ Arsenic	HQ Lead	Total HI
Permanent Residents (Including Tank Water) [a]								
01 yrs	0.3	0.05	0.5	0.8	1.0	0.2	**2.0**	**3.3**
02 yrs	0.1	0.02	0.3	0.4	0.6	0.1	**1.8**	**2.5**
10 yrs	0.1	0.01	0.2	0.2	0.4	0.2	1.0	**1.6**
Adult	0.1	0.02	0.1	0.2	0.4	0.1	0.2	0.7
Weekend Residents (Including Tank Water)								
01 yrs	0.1	0.01	0.1	0.2	0.3	0.05	0.6	0.9
02 yrs	0.03	0.01	0.1	0.1	0.2	0.03	0.5	0.7
10 yrs	0.02	0.004	0.04	0.1	0.1	0.04	0.3	0.4
Adult	0.03	0.01	0.02	0.1	0.1	0.04	0.05	0.2
Permanent Residents (Excluding Tank Water)								
01 yrs	0.04	0.05	0.1	0.2	0.2	0.2	1.0	**1.4**
02 yrs	0.03	0.02	0.2	0.2	0.3	0.1	**1.4**	**1.8**
10 yrs	0.02	0.01	0.1	0.1	0.3	0.2	0.7	**1.1**
Adult	0.02	0.02	0.01	0.05	0.2	0.1	0.04	0.4
Weekend Residents (Excluding Tank Water)								
01 yrs	0.01	0.01	0.04	0.1	0.1	0.05	0.3	0.4
02 yrs	0.01	0.01	0.04	0.1	0.1	0.04	0.4	0.5
10 yrs	0.004	0.004	0.02	0.03	0.1	0.04	0.2	0.3
Adult	0.005	0.01	0.002	0.01	0.1	0.04	0.0	0.1

Note: **red bold** values >1 [a] In order not to imply a higher level of precision than the estimates represent the values are rounded to one significant figure).

3.0 RISK MANAGEMENT CONSIDERATIONS

3.1 Risk Management

The HRA provides considerable detail about the context of exposure to metals in Costerfield and the magnitude of potential risks. The results are intended to be reviewed by all stakeholders in the context of how can exposure be reduced. The process for considering measures to minimise exposure is called risk management.

The main elements of risk management, as outlined in AS/NZS 4360:2009, are:

- communicate and consult : This is an ongoing process and is not a single event or outcome.
- establish the context :
- identify risks
- analyse risks
- evaluate risks
- treat risks
- monitor and review.

3.2 Risk Communication

The risk management process can be used to address some of the current issues at Costerfield. Many of these are identified within the RM Consulting Group (RMCG 2015) report. In particular issues around communication and establishing the context have been improved since May 2014.

In addition to the communication strategies and protocols that have been implemented since May 2014, the Victorian Government should produce and communicate advice to residents about ways of reducing exposure to metals in the environment. Many of these messages have been published in previous newsletters and factual communications. However these should be revisited in light of the detailed analysis presented in the HRA. The emphasis in such communications should be on ways to reduce exposure. Some of the messages to consider include:

- Cleaning inside your house regularly to reduce the collection of indoor dust bymopping dust frequently with a damp cloth
- Using gloves when gardening and wash hands thoroughly before eating
- Washing locally grown vegetables clean of soil with water that meets Australian Drinking Water Guidelines before eating
- Keeping toys clean of any soil or dust
- Ensuring children clean their hands thoroughly after playing outside
- Considering covering bare soil in play areas and garden beds with a layer of fresh soil or mulch where preschool-aged children may be present

3.3 Dust management

Mining and processing project risks are generally identified and managed at all stages of an operation’s life cycle. Significant risks that are defined, communicated, understood and satisfactorily addressed early in the mine life cycle are more likely to be accepted as well managed by stakeholders who have an interest in the mining project. Materials stewardship provides a central framework for an integrated risk approach to responsible management of materials used in mining and mineral processing, particularly wastes, hazardous substances and products. The project risks should be reviewed on a regular basis.

In terms of air quality, elevated PM_{10} and PM_{10} antimony concentrations were reported on days when winds were blowing both from the direction of current mining activities, and not from the direction of the current mining activities suggesting that the source of PM_{10} and PM_{10} antimony in Costerfield are diverse. The levels of PM_{10} and antimony are within national standards and health based air guideline values respectively. Dust from current mining activities was found to contribute to dust and antimony levels in air on approximately a third of the days in the monitoring period.

The dust deposition model presented in Appendix D3 investigated each activity within the current mining operation that could contribute to dust emissions. It was found that truck movement was the largest factor for dust emissions.

Although a reactive dust management strategy is in place and improvements to dust management have been made, a continuous improvement culture should be encouraged to review dust management practices on a regular basis with the aim of achieving dust levels as low as reasonably practicable.

3.4 Use of Tank Water

Rainwater tanks attached to house roofs when used as the primary source of drinking water were found to be a significant contributor to exposure to antimony and also lead. Many tank water results were higher than the Australian Drinking Water Guidelines for antimony. A few results were higher than the Australian Drinking Water Guidelines for lead.

A program of cleaning the tanks and refilling these with drinking water from a reticulated water supply did reduce levels of antimony. However within 6 months the antimony levels were above the guideline levels.

As discussed in Appendix I even a small amount of dust, within compliance levels for dust deposition, is likely to contribute to antimony levels in rain water tanks attached to roofs. As a consequence:

- At present tank water should not be used as a source of drinking water in Costerfield. This includes use in preparing food for infants.
- A cost benefit analysis should be conducted to consider a range of alternative supply options as well as technologies that can be applied to tanks or taps to remove metals from the water.

3.5 Maintenance of Swimming Pools

The pool results for antimony reported concentrations less than the adopted primary contact recreation (swimming) guideline, with the exception of the initial round of sampling undertaken in October 2014. The pool was emptied, cleaned and refilled with potable water following the first round of sampling, resulting in the decreased antimony concentration in subsequent sampling. However, it is noted that the reported antimony concentrations appeared to be increasing each month from December to May.

As a consequence:

- Swimming pools should be cleaned on a regular basis.
- Measures to avoid dust deposition should be considered.

Dust management practices at the current mining operations should be reviewed and aim to achieve dust levels as low as reasonably practicable.

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APPENDIX H

Variability, Sensitivity and Uncertainty Analysis

1.0 INTRODUCTION

This Appendix looks at the conservatism in the risk characterisation calculations (Appendix G), the variability in selected exposure parameters and the sensitivity of the calculated risks to this variability.

2.0 CONSERVATISM IN RISK CHARACTERISATION

The results noted in Appendix G represent the potential for health risks under and 'average' and 'upper estimates' exposure concentrations (adopting average and upper estimate concentrations of COPC and exposure parameters) and under conservative receptor scenarios. A variety of conservative assumptions and approaches were adopted in order to account for uncertainties and potential variability in environmental data and exposure scenario.

A conservative approach is adopted in the HRA process at the beginning in the initial problem formulation and development of the conceptual site model (CSM). The CSM considers exposures across a community and assumes that an individual may be exposure via all potential pathways (for example, that all age groups consume home grown eggs and lamb). As discussed in the CSM (Appendix C) there may also be sensitive or susceptible sub-populations within the residents of Costerfield, such as adults or children with chronic illness, pregnant women or lactating mothers. Although these groups may have different exposure characteristics, adopting a conservative approach in all aspects of the risk assessment was sufficient to address these groups.

In general, a conservative approach was undertaken for the following reasons:

- To account for uncertainties in site specific data or due to absence of environmental data, the approach therefore allows an estimated reasonable 'maximum' exposure scenario to be adequately assessed. These data gaps and uncertainties are present in all environmental contamination assessments.
- To provide an assessment that would be acceptable to typical third-party stakeholders, including regulators and the community. The approach and opinion of such third-parties can vary significantly and can range from highly-precautionary to 'real-world'.
- To ensure compliance with published guidelines and standards, in the absence of a definitive methodology approved by all authorities, adopting the more conservative aspects of each available guideline will be required.

Actual, 'real-world' exposure conditions are anticipated to be significantly lower than those estimated for the 'upper estimate' exposure conditions, as the 'upper estimate' concentration and parameters are unlikely to all coincide for a particular individual.

To assess the impacts this conservative approach has on the risk estimate outcomes, a quantitative sensitivity analysis of key parameters of interest and adopted environmental concentrations was conducted as detailed in Section 4.0.

3.0 VARIABILITY ANALYSIS

There is inherent variability in the input parameters used the HRA modelling as point values are used to describe the heterogeneity of environmental and human characteristics. The variability in the parameters and the impact on the calculated risk estimates in the HRA can be better understood through analysis of the available information as described below, and a sensitivity analysis (section 4.0).

3.1 Environment Data

The environmental data used in the HRA is described in detail in Appendix D. The available data for each media is assessed as to whether the data is suitable to represent the concentrations to which the residents of Costerfield may be exposed. This has been assessed through consideration of:

- Appropriate sampling program design and sampling methodology; and
- Appropriate quality assurance and quality control, including field and laboratory procedures.

These items are detailed and discussed in each of the data review sections in Appendix D. Overall, it is considered that the data collected is suitable for the purposes of the HRA, and that the variability in the data sets are due to the heterogeneous nature of chemicals in the environment rather than due to systematic or systemic errors in the sample collection or laboratory analysis.

The variability in the chemical results can also be assessed using statistical analysis such as distribution plots and summary statistics such as minimum and maximum values, arithmetic and geometric means, 95th percentile values and 95% upper confidence intervals where appropriate. To address the variability in environmental data, the HRA has used point estimates for an 'average' concentration and an 'upper estimate' concentration. The statistical calculation of these values is different for each of the environmental data sets and the description and justification for the values selected is presented in the relevant sections in Appendix D.

3.2 Exposure Parameters

The parameters adopted to describe the typical physical characteristics and behavioural patterns of the adults and children modelled in the HRA have been adopted from national guidance provided by enHealth (2012) *Australian Exposure Factor Guidance - Guidelines for assessing human health risks from environmental hazards*. This document presents Australian exposure factor information as well as available overseas data to present a summary of the values typically required to describe exposures in an environmental health risk assessment.

The variability for each parameter is addressed by presenting data on the exposure factors as tables with percentiles or ranges of values, and/or as estimated values, with a brief discussion of the uncertainty in the estimates (enHealth, 2012). For this HRA, this data has been reviewed and an appropriate 'average' input value and an 'upper estimate' value have been adopted for the exposure modelling.

4.0 SENSITIVITY ANALYSIS

The sensitivity analysis provides a quantitative estimate of the effect of uncertainty and/or variability in the input parameters on the results of the risk assessment. As discussed in the risk characterisation (Appendix G) the key drivers for risk in Costerfield were the tank water ingestion and soil ingestion pathways. The quantitative sensitivity assessed the impact of changing individual exposure parameters and the concentration in environmental media between the average and upper estimate. This gives an indication of the parameters that have the greatest influence on the calculated hazard index.

To assess the impact on the overall HI of selecting the 'average' and 'upper estimate' concentrations in environmental media and exposure parameters, the exposure model and HI calculations have been run varying the metals concentrations or an individual exposure parameter from average to upper. In these model runs, the remaining input parameters were maintained at either the average (orange bars on Figure 1) or upper value (blue bars on Figure 1). The variation in the HI calculated is shown by the size of the bars in the plots below for each age bracket.

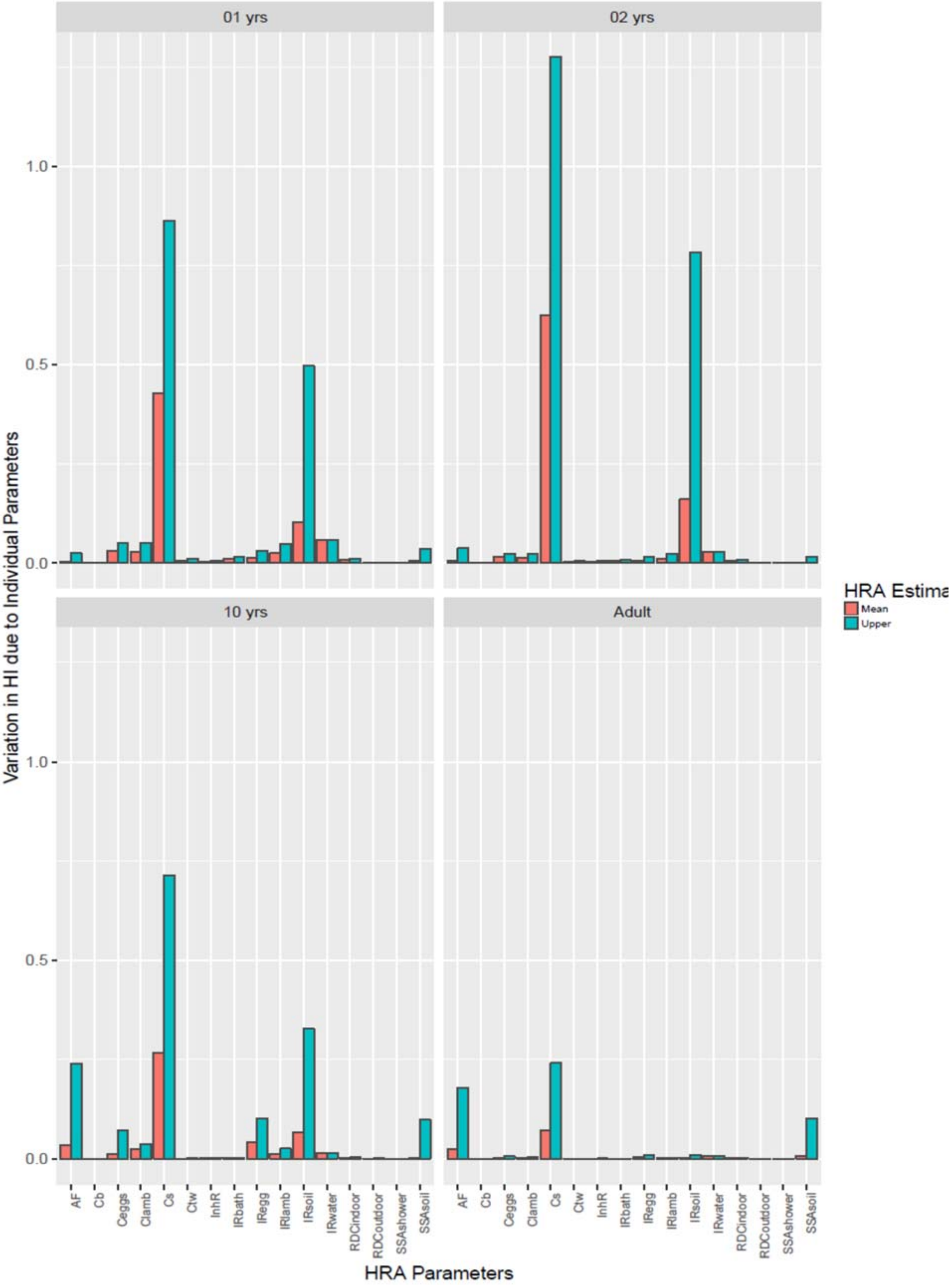

Figure 1: Variability Analysis (including tank water)

The plots show that the greatest variation in HI is observed where the following parameters are changes from average (mean) to upper estimate values:

- 1 year old – soil concentration (C_s) and soil ingestion rate (IR_{soil})
- 2 year old – soil concentration (C_s) and soil ingestion rate (IR_{soil})
- 10 year old – soil concentration (C_s) and soil ingestion rate (IR_{soil}) and soil adherence factor (AF)
- Adult – soil concentration (C_s) and soil adherence factor (AF) and skin surface area for soil contact (SSA_{soil})

As expected given the HRA risk estimates, the HI calculations are influenced most by the parameters describing soil exposure. The magnitude of the change in HI, as shown by the height of the bars, is significantly higher for the child age brackets than for the adult. The parameter values for soil ingestion rate (IR_{soil}), soil adherence factor (AF) and skin surface area for soil contact (SSA_{soil}) have all been adopted from guidance provided by enHealth (2012). The following information is provided on these parameters:

Soil ingestion rate

The soil ingestion rate describes inadvertent ingestion of soil both from outdoor activities and of indoor dusts. EnHealth (2012) note that young children are particularly prone to ingest soil as they have greater contact with soil during play and have not developed avoidance strategies of older children and adults. Around 50% of indoor dust can be attributed to soil particles that have been tracked inside from outdoors. Australian soil ingestion studies are not available; however enHealth (2012) provides a review of a number of relevant international studies. The soil ingestion rates for the HRA are consistent with the recommendations from enHealth (2012) and are considered suitable to describe the scenarios modelled in the HRA.

Soil adherence factor

The soil adherence factor (AF) describes the amount of soil adhering to the skin per area of skin. enHealth (2012) note three key factors that influence the amount of adherence:

- activity patterns such as occupation (farming, gardening, excavation) or recreational activities (time spent outdoors, sport).
- skin properties – soil adherence varies considerably across different parts of the body; the highest occurs on common contact points such as hands, knees and elbows and the lowest on the face.
- properties of the soil (i.e. adherence increases with increasing moisture content and decreases with increasing particle size).

enHealth (2012) present arrange of soil adherence factors for different activity patterns, ages groups, and body parts, this information was used to derive the AF values for each receptor in the HRA. For the one and two year old child, the HRA adopted AF values for a day care child playing outdoors and indoors, for a 10 year old child the HRA adopted a weighted AF for children playing (8-12 yrs), averaged of AF for dry and wet soil based on assume 50% of playing time in each and for the adult, the default enHealth (2012) recommendation were adopted. For each age group, the HRA adopted the central tendency value as the 'average' and the 95th percentile as the 'upper' estimate. The soil ingestion rates for the HRA are consistent with the recommendations from enHealth (2012) and are considered suitable to describe the scenarios modelled in the HRA.

Skin surface area for soil contact (SSAsoil)

The skin surface area (SSAsoil) describes the amount of skin available for soil adherence to occur on any one occasion. Australian soil ingestion studies are not available; however enHealth (2012) provides a review of a number of relevant international studies and algorithms relating body weight to skin surface area. enHealth (2012) present a range of data describing skin surface area in terms of age, gender and body part. For each age group, the HRA adopted the mean (average) and 95th percentile surface area values for hands, feet, and 50% of arms + legs (i.e. lower legs and forearms). This approach assess an individual is wearing shorts and a t-shit, but no shoes during each exposure (i.e. every day). This is considered to be a generally conservative approach, it is consistent with the recommendations from enHealth (2012) and are considered suitable to describe the scenarios modelled in the HRA.

Soil Concentration

The variability in the soil data has been discussed in general in section 3.1. The range of concentrations of antimony, arsenic and lead measured in the soil are large, as is expect in environmental systems. A discussion of the input concentrations selected for the HRA is present in Appendix D6 and further statistical review of the data is presented in Appendix I. The input concentrations selected for HRA were the average of the property averages, and the 95th percentile of the full data set for the Costerfield Dome. Whilst this concentration does not capture the maximum soil concentration encountered, it is considered to cover a reasonable upper estimate. This is because the nature of the soil sampling targets discrete locations, where as a person engaged in outside activities are much more likely to be exposure to a range of locations (been within the same property). Therefore in any one day, a person's exposure will be to a range of concentrations that represent that soil, rather than the individual location. This is particular the case for lead, the key driver of the HI for soil contact, which has been shown to be most likely due to anthropogenic sources (refer Appendix I).

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APPENDIX I

Sources of Metals in the Environment

1.0 INTRODUCTION

Appendix I presents an assessment of the potential sources of antimony, arsenic and lead in the Costerfield environment. An understanding of the possible sources is needed to assist in developing effective management measures to address the potential health risks due to the presence of these metals. The assessment of sources will consider the data that has been presented in the other Appendices of this report and will consider a range of possible sources, including the potential impact of the historic and current mining operations on the magnitude and extent of the chemical concentrations in the Costerfield environment.

The assessment of sources of metals in the Costerfield environment has been conducted through examining the following lines of evidence:

- Review of the soil data sets and consideration of depth profiles, concentration correlations and typical regional background concentrations (section 3.0).
- Outcomes from the isotope analysis for lead in soil (section 4.0).
- Review of the ambient air quality data considering the direction and magnitude of the wind and the PM_{10} concentrations reports, and the deposited dust data compared to modelled mining dust deposition rates (section 5.0).
- Estimation of the added load of antimony to surface soils in Costerfield due to the deposition of mine generated dust (section 6.0).
- Review of the tank water data sets against data from other regions.

A summary of the findings and the key conclusions is presented in in section 8.0)

2.0 POTENTIAL SOURCES OF METALS IN THE ENVIRONMENT

The Desktop Review (Appendix A) provides information to support the understanding of the nature, transport and distribution of antimony and related chemicals in the environment, in the Costerfield area. It is focused on antimony, but also provides a review of other chemicals that may be present in the Costerfield area, either due to geological conditions, mining and/or other development activities.

The key findings, relevant to the assessment of sources of metals in the Costerfield environment were as follows:

- The main source of antimony in the Costerfield area is mineralised zones of sulphide minerals such as stibnite and adjacent altered host rocks of the Costerfield Formation. Historical mining activities have resulted in the relocation (and in some cases) concentration of antimony in the Costerfield environment.
- During historic mining activities, mine wastes have been distributed widely within the township and across the landscape. There may also be some local point sources of chemicals in the Costerfield environment primarily related with processing and/or extraction of antimony and gold. Early processing occurred around waterways leading to direct discharges without containment. Potential mining related chemicals include manganese, copper, gold, bismuth, lead, mercury, zinc, chlorine, flotation agents, acids, alkalis and cyanide. These chemicals may also be present within areas of Costerfield.

The HRA assessed antimony, arsenic and lead. Each of these metals is found naturally in the Costerfield formation. Further details on their concentrations in the ore are presented in Table 1.

2.1 Historic Mining

The Desktop Review (Appendix A) described the historical activities which have occurred in the Costerfield area, which may have resulted in contamination of the environment, particularly relating to disturbance of soil/rock and the movement of soil and mine wastes. In summary, mining within the regional area of Costerfield-Heathcote commenced in the 1850's. Over 20 mine and shaft sites have been identified within the Costerfield area, many of which are located adjacent to the Costerfield anticline. Historic mining occurred by both open cut and underground mining and was most productive during two periods, 1860 to 1883 and 1904 to 1925, with only intermittent small scale production during 1934 to 1950. A site walkover (described in detail in Appendix A) observed historical mining waste within the Costerfield area, and many of the tailings locations observed were consistent with indications on the 1926 map of Costerfield (Figure 1).

A summary of key mine sites and ore extraction processes undertaken in Costerfield is provided in Appendix C of the Desk Top report (Appendix A). This summary notes that cyanide and mercury have been used in historical processing. There is no mention of lead, however there is the potential that some of these activities may have used lead nitrate in the processing (as is used in the current mining operations). Information on the current mining process is also included in Appendix A, this identified lead as present in both the mining process and tailings (Figure 20, Appendix A).

Whilst some of the soil sampling location have been with areas noted as tailing or mine waste, the location were not specifically targeting these features, and as such the data does not show specific patterns in relation to the concentration of lead in the waste.

From the information present in Appendix A, it is considered that in addition to antimony and arsenic present in the ore, there is the potential for lead to be present in historic mining waste in the Costerfield area to processing activities. However as targeted sampling of the waste has not been conducted, the typical concentrations of lead due to historic processing cannot be confirmed.

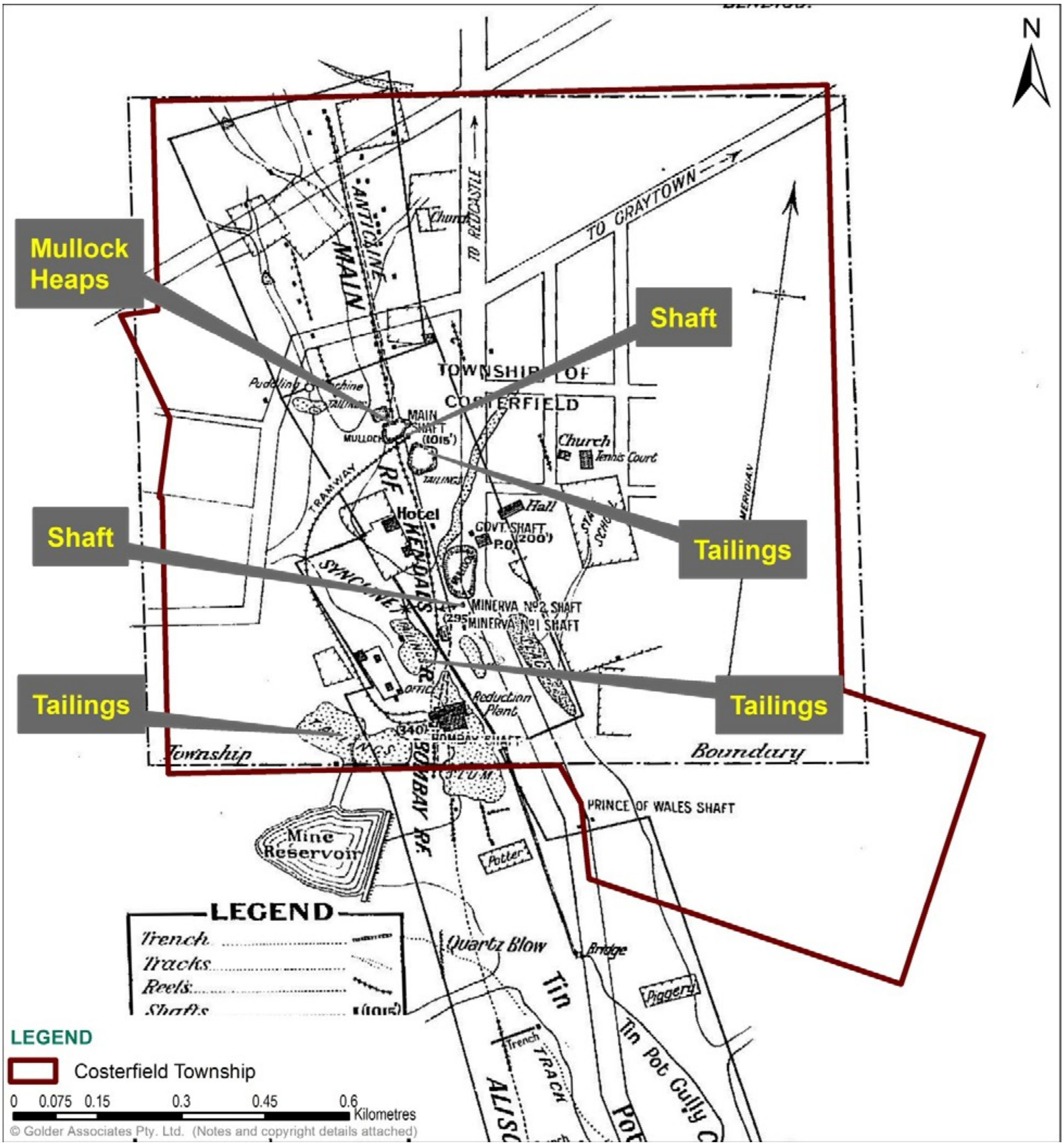

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Figure 1: Location of Mine waste, including tailings, within the township of Costerfield during 1926

2.2 Current Mining

The ore mined is mostly made up of stibnite Sb_2S_3 but also contains some bournonite, a lead antimony sulphide $PbCuSbS_3$ and other lead sulphides which make up the lead content. The concentrations of antimony, arsenic and lead in the ore are presented in Table 1.

Lead in the format of lead nitrate is used in the current mining process as an activator for stibnite (Sb_2S_3) in antimony ores. In the current process lead nitrate is added during the flotation process to produce the mineral concentrate. It is added within an aqueous system. As such it is not expected to enter the environment as dust or be emitted to the environment with waste rock. A limited environmental assessment of Mandalay's processes (undertaken by Snowden, 2012) reported that potential contaminants to the environment associated with the Costerfield mines may include antimony (from stibnite), arsenic from (arsenopyrite), cyanide (from historical processing) as well as lead (lead nitrate), caustic soda, acids and other flotation reagents used in the gold extraction process (Snowden, 2012).

With respect to lead, current reagent consumption rates for lead nitrate is 400 g per one dry metric tonne of processed ore (Mandalay 26/02/16). Lead nitrate ($Pb(NO_3)_2$)is added in liquid solution into the slurry (ore rock mixed with water) during the processing of ore to aid recovery of metals. The process occurs in a liquefied form and no dust is generated. This is equivalent to a concentration of 400 mg/kg, which remains mainly in the flotation circuit although some could be expected to be in the processed ore (concentrate) and tailings.

Data on the composition of the concentrate and tailings is limited. Mandalay Resources proved two sets of data, one is as referred to in Appendix D5 (Mandalay 07/07/15 email re:'Concentrate' Place:Frangos) and more recent information provided in February 2016 (Mandalay 26/02/16 email re:'Concentrate data - lead analysis' Brauns:Foot).

In the tailings, Mandalay report that the lead concentration is 224 mg/kg due to the addition of the lead nitrate in processing. Mandalay advise that the liquid tailings are pumped by closed pipeline to the Brunswick tailings storage facility where solids settle out and sink below the water level (Mandalay 26/02/16).

In the concentrate, Mandalay (26/02/16) report that the lead concentration ranges from 1100 mg/kg to 2000 mg/kg (results taken from 6 of the last 8 shipments to China), due to the concentration of antimony minerals including bournonite which contains naturally occurring lead. The concentrate is thickened and pressed into polypropylene concentrate bags and sealed in sea containers for shipping to China. Mandalay advise that the concentrate has an average moisture content of 14% (2015 average moisture content) and no dust is generated during packing and shipment.

3.0 METALS CONCENTRATIONS IN SOIL

3.1 Data Sets

Review of the metals concentrations in soils has considered the following data sets:

1. Soil data from properties and roads within the study area. This data set is discussed in Appendix D1 and is referred to throughout this appendix as 'soil data'. This data set was divided into results for property surface samples (0-0.05 m depth), deeper samples (0.2-0.3 m depth) and road samples. The data has also been considered for inside and outside the Costerfield Dome.

2. Soil data for Heathcote. The regional assessment (section 3.4) considers background and regional metals concentrations. This includes consideration of soil data collected by Golder from locations in Heathcote, approximately 15 km south west of Costerfield. This data set is presented in the attachment 1 to this appendix and is referred to as the 'Heathcote data'. The regional assessment also considered some published soil data that is described within section 3.4.

3. Costerfield Formation ore data collected by Mandalay Resources. This data is presented in The Golder Desktop Review (refer Appendix A) and referred to as 'ore data'. Further details are provided below.

4. Shallow soil data collected by the former Department of Environment and Primary Industries (DEPI)[1]. This data (for only antimony, arsenic and gold)[2] is presented in The Golder Desktop Review (refer Appendix A) and referred to as 'DEPI data' Further details are provided below.

The Desktop Review (refer Appendix A) presents the Mandalay ore data from August 2014. Twenty samples (10 ore samples and 10 low grade samples) were analysed for a range of metals including arsenic (As), antimony (Sb) and lead (Pb). The results for these metals are presented in Table 1. These results have been included in the plots in Figure 2 and Figure 3.

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[1] Now Victorian Department of Economic Development, Jobs, Transport and Resources

[2] Appendix B of the Desktop Review noted the "Department of Primary Industries (DPI) dataset of geochemical results across central Victoria, containing 73,812 samples that were tested for the following metals: gold (Au), silver (Ag), arsenic (As), antimony (Sb), mercury (Hg), tungsten (W), aluminium (Al), calcium (Ca), iron (Fe) and manganese (Mn).' This text should also have included lead (Pb).

Table 1: Costerfield Formation Ore Data - August 2014

Analyte	Arsenic	Antimony	Lead
Units	mg/kg	mg/kg	mg/kg
OREGrade 1	783	11400	29
OREGrade 2	954	12800	25
OREGrade 3	440	20400	25
OREGrade 4	724	50000	23
OREGrade 5	536	32400	17
OREGrade 6	410	24800	21
OREGrade 7	324	25000	20
OREGrade 8	736	9900	22
OREGrade 9	443	2400	31
OREGrade 10	293	10100	19
LOWGrade 1	379	31700	18
LOWGrade 2	274	18500	18
LOWGrade 3	583	40600	24
LOWGrade 4	630	22100	23
LOWGrade 5	454	100000	29
LOWGrade 6	479	17000	23
LOWGrade 7	760	17100	24
LOWGrade 8	482	24400	17
LOWGrade 9	132	21600	12
LOWGrade 10	846	21100	14

The Desktop Review (refer Appendix A) also presents DEPI soil, sediment and rock data collected within the Costerfield area and surrounds, for the purpose of mineral exploration (Arne and House, 2009).

Golder has extracted the DEPI data, collected within the Costerfield Dome and separated the data into the following inferred soil units:

- *Shallow soils (0-30 cm)* - comprising both disturbed and natural soils.
- *Inferred alluvial soils (30 cm to 6 m)* - likely to comprise predominantly of alluvial soils of the Wappentake Formation, but may include disturbed soils/fill within the near surface and weathered soils of the Costerfield Formation.
- *Bedrock (soils greater than 6 m below ground level)* - inferred to be Costerfield siltstones.

A summary of DEPI data for antimony and arsenic is presented in Table 2. The data for shallow soils is included in figures

Table 2: Summary of DEPI soil and Bedrock data within the Costerfield Dome

Metal	Depth (m bgl)	Sample Count	Minimum (mg/Kg)	Maximum (mg/Kg)	Mean (mg/Kg)*	95% Upper Confidence Limit (mg/Kg)*
Antimony	0-0.3	4375	2	710,000	46.5	47.6
	0.3 to 6	272	2	10,000	9.4	10.5
	> 6	50	4	950	27.7	29.1
Arsenic	0-0.3	298	2	200	11.4	12.5
	0.3 to 6	272	2	999	10.2	11.3
	> 6	50	2	251	10.4	11.9

* NOTE: The original datasets are skewed to the right, so the mean and confidence intervals were calculated on natural log-transformed data, and then transformed back to the original scale by inversing the log summary statistics.

3.2 Concentration depth profile

The concentrations of antimony, arsenic and lead in the Golder soil data set have been assessed against depth. The focus is on these three metals as these are the chemicals that have been reported at sufficient concentrations to require a site specific HRA (refer Appendix D1). The purpose of the depth profile assessment is to assist in assessing whether the measured concentrations of the metals in the surface soil is likely due to dust deposition and therefore confined to the surface, or if the distributions are consistent with depth, suggesting that the concentrations are more likely associated with the natural geological conditions in the area.

Figure 2 shows a box plot of the data soil data within the dome (split into the surface, deeper and roads samples) and the ore data. The plot graphically presents the statistics of the data sets: the bottom and top of the box are the first and third quartiles, and the band inside the box is the second quartile (the median).

Figure 3 shows the distribution of the individual results for antimony, arsenic and lead inside and outside the dome as a kernel density plot. This is a non-parametric way to estimate the probability density function for the data sets. These have then been separated into the same groups (shallow, deep, roads and ore) as Figure 2. The plots also show the ore data. Where two distribution plots overlap, this indicates that there is very little difference in the results reported in those two groups. Where the plots are distinctly different, this indicates that there is possibly a different dominant source of the particular metal in soil.

From these two figures, the following observations were made:

- The concentrations on antimony and arsenic in the ore a significantly higher than those found in the soil data. This suggests that the concentrations in soil of these two metals may be from the ore or similar or surrounding metal enriched zones of the Costerfield Formation that are naturally occurring.
- The concentrations of lead in the ore, are similar to the concentrations of lead in the deeper samples, but the concentrations of lead in surface soil are generally higher, with the outlier being significantly higher. This suggests that the high concentrations of lead in surface soils are due to a source other than the ore.
- Concentrations of each of the three metals are generally higher in the surface samples than the deeper samples. This suggest that there are activities or processes that have impact on surface soils, for example, the spreading of tailings or dust deposition (the deposition of dust is discussed further in section).
- The concentrations of each of the three metals in the road side samples are similar to the surface and subsurface samples. Although mine water (potentially containing high levels of antimony) have been used to wet down roads to supress dust in the past, the concentrations suggest that this activity has not contributed to an increase load of antimony, arsenic or lead in the soil immediately adjacent to the roads.

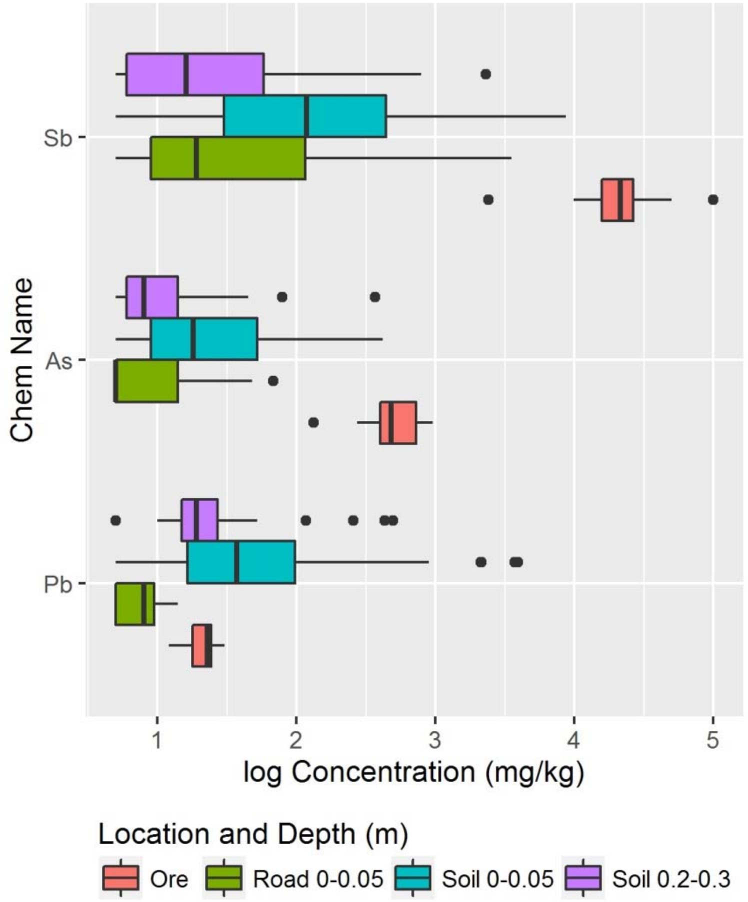

Figure 2: Box Plot - distribution of Antimony (Sb), Arsenic (As) and Lead (Pb). The box plot is used to compare distributions between several groups or sets of data, in this case soil at two depths, roads and ore data. The bottom and top of the box are the first and third quartiles, and the band inside the box is the second quartile (the median). The first quartile (Q1) is defined as the middle number between the smallest number and the median of the data set. The second quartile (Q2) is the median of the data. The third quartile (Q3) is the middle value between the median and the highest value of the data set. The dots represent outlier results

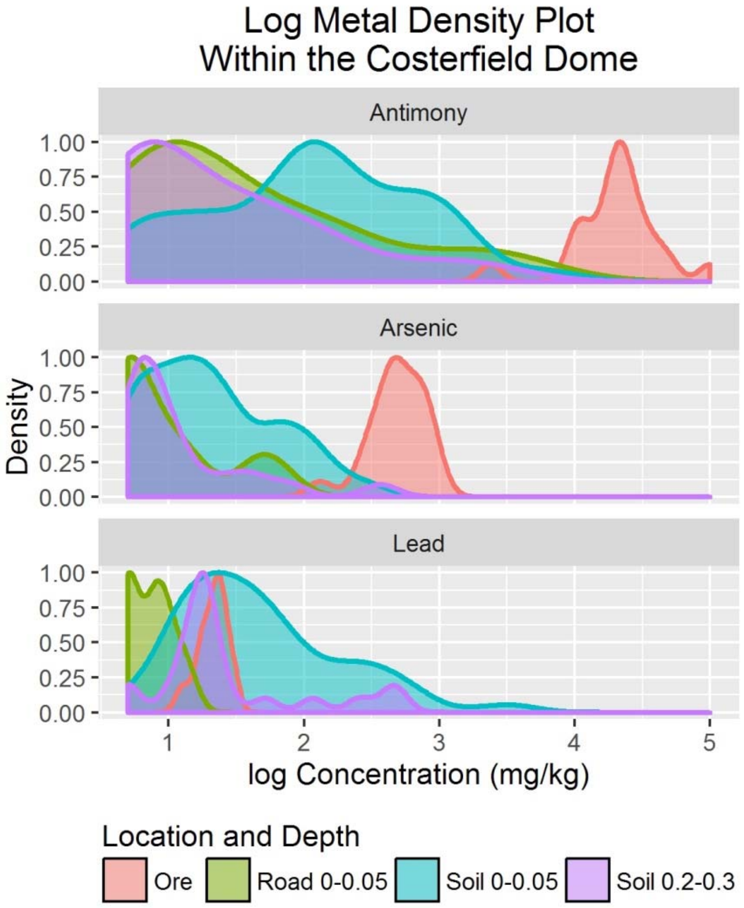

Figure 3: Kernel Density Plot - Antimony, Arsenic and Lead. The Density axis shows the cumulative probability (of a soil value occurring at a certain concentration (horizontal axis).

3.3 Concentration correlations

The relationship between the concentrations of antimony, arsenic and lead in the soil can assist in understanding whether there is a common source of these metals in the environment. This can be explored through the scatter plots (Figure 4) where the concentration of one metal is plotted against another for individual soil samples. The scatterplot is used to graphically represent the relationship between two concentrations, the closer the concentrations are correlated (related to each other) the closer the plot will be to a straight line (linear correlation), and the closer the correlation coefficient value will be to 1. The correlation coefficient is also shown in

The most closely correlated metals are arsenic and antimony, with a correlation coefficient of 0.821. This is expected as these metals are found naturally together in the Costerfield Dome ore deposit and associated metal enrichment halos. This is consistent with the findings from the Desktop Review (Appendix A) and the review of the DEPI work that found arsenic concentrations in Costerfield soils positively correlate with elevated antimony soil concentrations (i.e. where antimony concentrations are high, arsenic concentrations are also likely to be elevated) (Arne, 2009).

Lead and antimony correlation (correlation coefficient 0.618), appears stronger at lower concentrations. Where there are high concentrations of lead, the corresponding antimony concentrations are not significantly higher than other samples. This suggests that at the lower concentrations, the presence of the two metals is correlated, as would be expected within Costerfield, as lead is present in the ore, however at higher concentrations there may be an alternative source of lead in the environment.

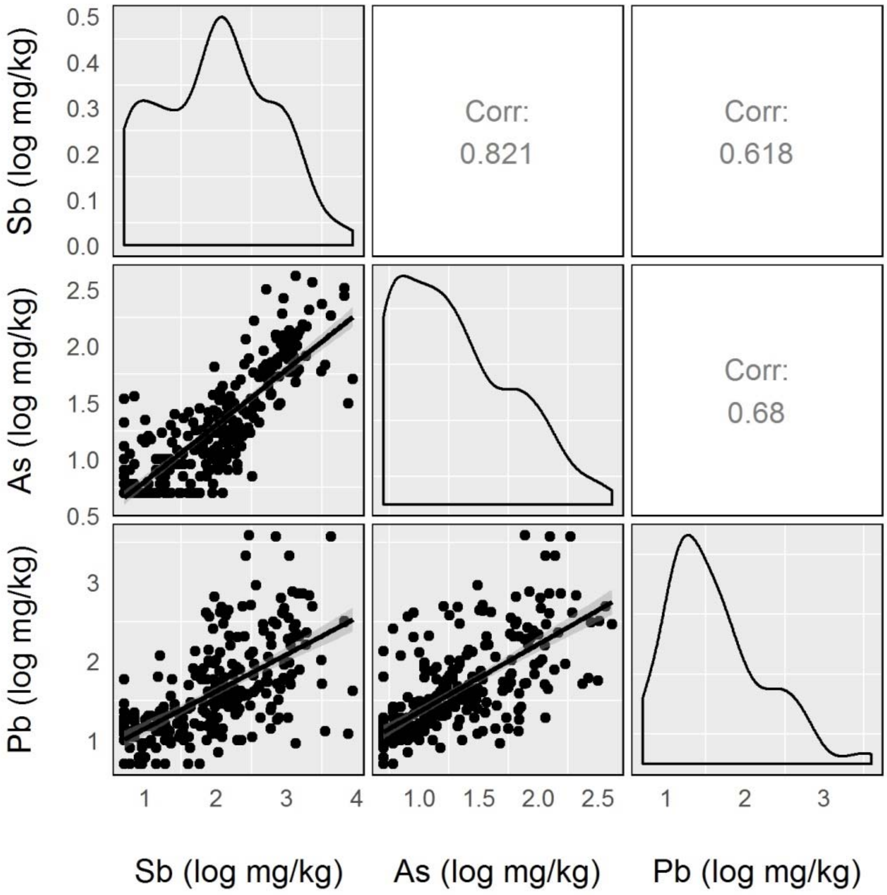

Figure 4: Linear correlation using Pearson correlation coefficient - Antimony (Sb), Arsenic (As) and Lead (Pb)

3.4 Comparisons with regional concentrations

An assessment of the soil data was undertaken comparing the results against the soil data within the Costerfield Dome to the following data sets:

1) regional soil concentrations from the Heathcote sampling (collected by Golder, refer Attachment Table I.1);
2) soil data from properties within the Costerfield area but outside the Costerfield Dome; and
3) published data sets for background metals concentrations from Olszowy et al (1995).

Olszowy et al (1995) conducted a study into background levels of a number of metals in soil samples from urban areas in Adelaide, Brisbane, Melbourne and Sydney. Samples were collected from residential properties, and categorised as either old or new suburbs, and as areas of high or low traffic volume. Samples were also collected in rural areas of Queensland. The soils were tested for arsenic and lead, but not antimony. The data set selected from Olszowy et al (1995) was the Victorian old suburb where properties are older than 40 years, with low traffic volume (<50 cars per hour). This was considered to be the closest fit to Costerfield, as the rural data was only from Queensland (difference geology), and these samples were collected from national parks, state forests and bushland at least one kilometre from any urbanisation, rather than private properties.

This comparison has used the plots below showing the distributions, this approached was used in preference to the box plots or density plots to allow inclusion of the Olszowy et al (1995) data which was only available as summary statistics.

The following observations were made on the relationships between the data sets:

- Antimony and Arsenic – the concentration of antimony in the soils within the Costerfield Dome are consistently higher that samples taken outside the Dome (but within the Costerfield region) and in Heathcote. This is expected to be an indicator of the natural geology within the Dome, where antimony and arsenic are both naturally occurring. This is consistent with the pattern observed in the correlation plots.
- Lead – the concentrations of lead within the Dome appear to follow a similar distribution to the Olszowy et al (1995) for a Victorian old suburb with low traffic volume. This suggests that the lead in the Costerfield environment is similar to that of an established urban environment with low impact from vehicle traffic. The concentrations of lead within the Dome are higher on average than those found in Heathcote and outside the Dome, it is noted that the Heathcote sample were collected from schools and public spaces, and as such are not directly comparable to property samples taken from within the Dome. The reason for the difference in the distributions between the DEPI data set and the Golder data set from within the Dome is unclear.

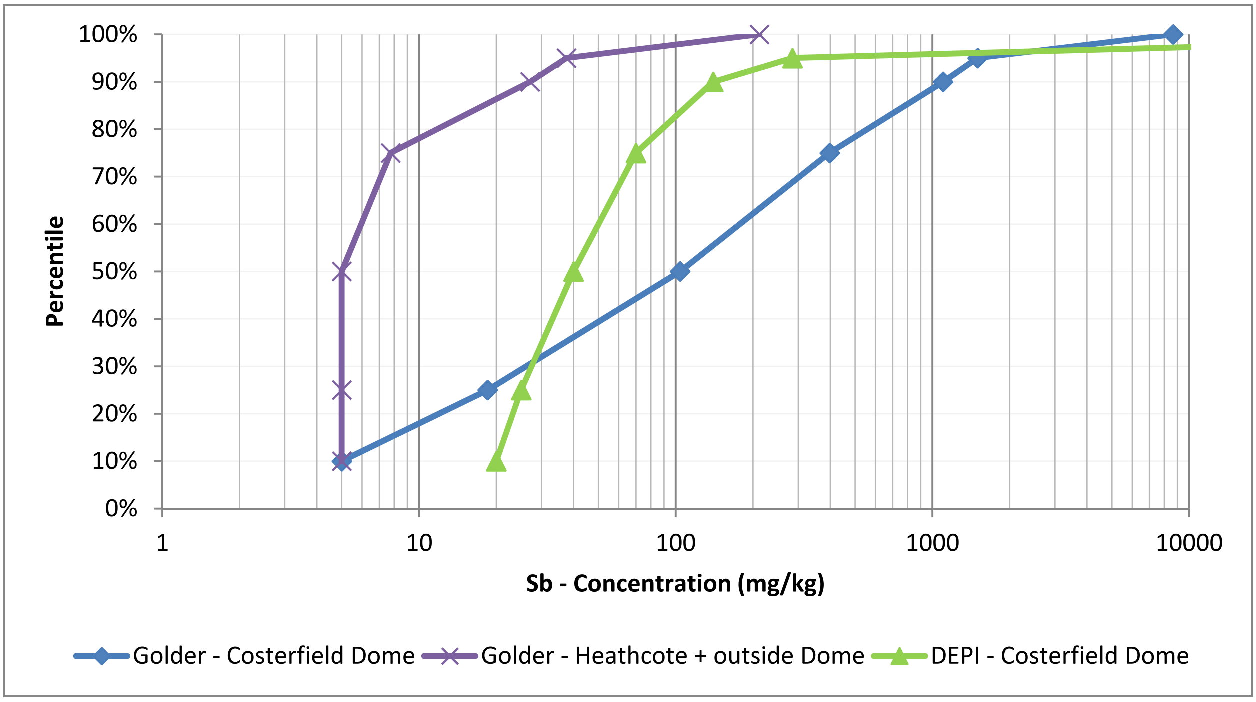

Figure 5: Antimony Distribution

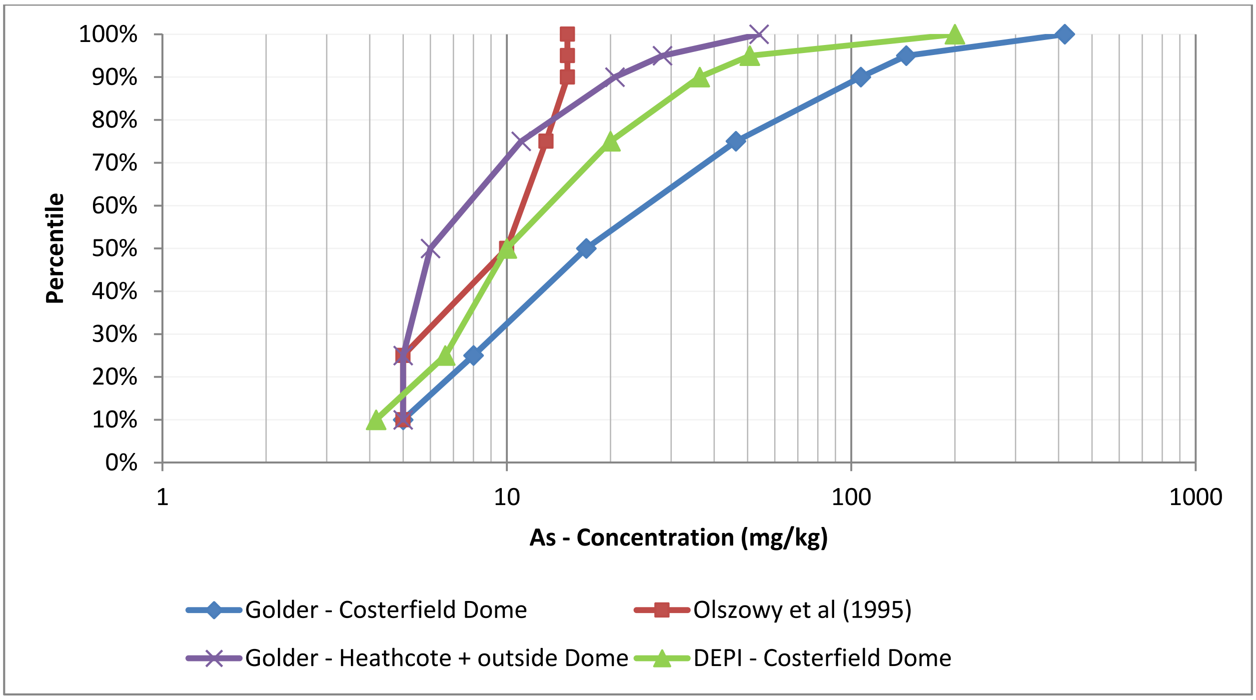

Figure 6: Arsenic Distribution

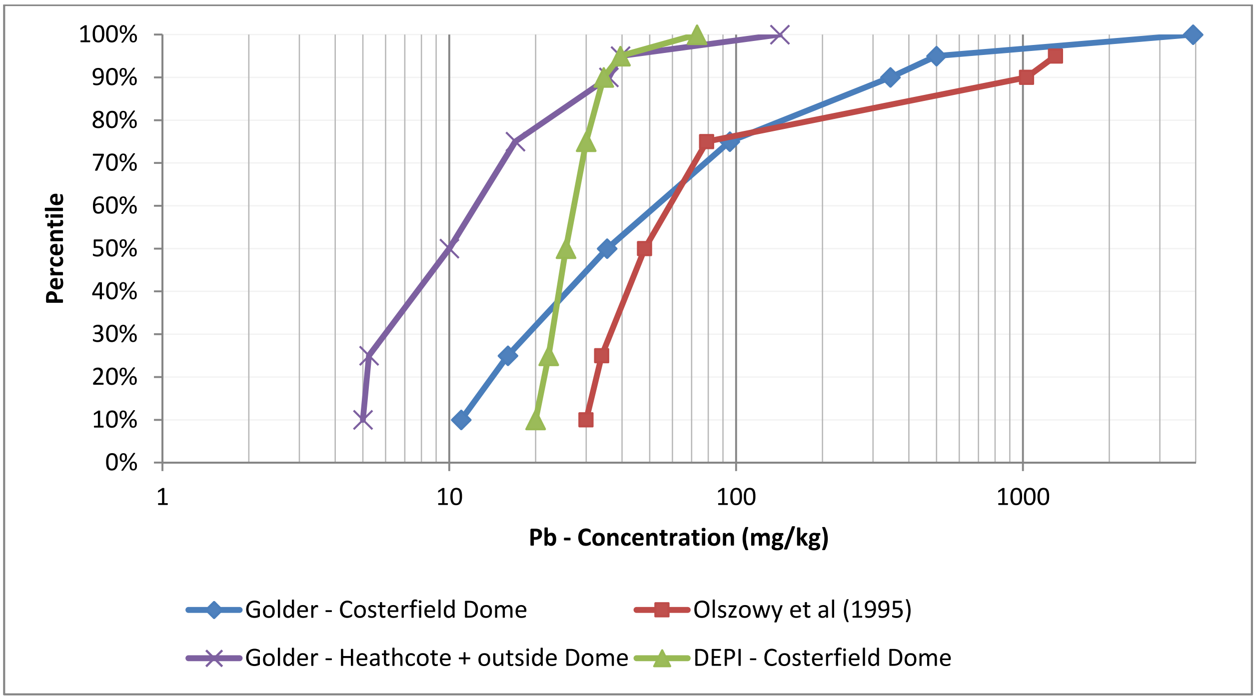

Figure 7: Lead Distribution

4.0 SOIL ISOTOPE ANALYSIS

The lead isotope study (refer Appendix D6) found that the lead in the four soil samples tested was likely to be a mixture of sources rather than a unique single source.

The assessment found that the isotope signatures of the soil samples are more primitive (less radiogenic, lower^{206}Pb/^{204}Pb ratio) than the Costerfield ore sample.

This means that the Costerfield ore is unlikely to be the sole source of lead in the soil samples. It is likely that there is a mixture of anthropogenic (man made) sources. It is not possible to distinguish these sources based on the information summaries in tin Appendix D6.

This conclusion supports the findings of the soil data assessment in section 3.0.

5.0 AMBIENT AIR QUALITY

A review of the air quality monitoring program conducted by Golder at two residences in Costerfield for the period November 2014 to August 2015 is presented in Appendix D3. The review of the ambient air PM_{10} and $PM_{2.5}$ data with respect to wind direction suggests some air quality impact from current mining activities. The estimated increase in PM_{10} concentrations due to current mining activities is approximately 15%.

In summary:

- The highest PM_{10} concentrations monitored at Residence 1 (residence approximately 1.3 km north of the Brunswick Plant) were during winds blowing from the north and northwest, unlikely to be as a result of the mining activities which were to the south and southeast of Residence 1.
- The highest PM_{10} concentrations monitored at Residence 2 (Approximately 1 km southeast of the Brunswick Plant) were also during winds blowing from the north, however in this case, this was potentially due to the mining activities to the north of Residence 2. However there were also high concentrations experienced on days when the wind was blowing from the south-southeast, which were unlikely to be due to mining activities.
- The highest antimony concentrations monitored at Residence 1 were during winds blowing from the south, however, there were high concentrations monitored during winds from the north-northeast and west-north-west suggesting impacts from sources unrelated to the current mining activities.
- The highest antimony concentrations monitored at Residence 2 were during winds from the north and northeast, possibly due to emissions from the crushing plant, however, there were also high concentrations monitored during winds from the west and southwest, which indicates that there were antimony impacts from sources unrelated to the current mining activities.

In summary, elevated PM_{10} and PM_{10} antimony concentrations were reported on days when winds were blowing both from the direction of current mining activities, and not from the direction of the current mining activities suggesting that the source of PM_{10} and PM_{10} antimony are diverse but do include current mining activities.

Appendix D3 also provides a review of the deposited dust monitoring data (collected by Mandalay Resources) and the predictive modelling of dust deposition conducted by Golder (refer Appendix D3). The key finding supported the above findings in relation to PM_{10} and PM_{10} antimony, that the concentrations reported are not solely from the current mining activities.

Whilst there was some dust impact on the boundary of the processing plant, it was concluded that the current mining activities have not had a significant influence on deposited dust further away. In summary:

- The highest deposited dust (insoluble solids) statistics were reported in the township at the furthest monitoring location from current mining activities

- The highest deposited antimony statistics were reported on the boundary of the processing plant.
- Predictive modelling of dust deposition (refer Appendix D3) suggests significant dust impacts are limited to a few hundred meters (<500 m) from current mining activities and therefore it is likely that other sources and/or background levels are contributing significantly to the monitoring data. This finding is supported by the monitoring results.

6.0 ESTIMATE OF AMBIENT DUST DEPOSITED TO SOIL

The deposited dust impact assessment for the Costerfield Gold-Antimony Mine is provided in Appendix D6. The assessment predicted average and maximum deposition rates (g/m^2/month) and compared these results to the measured dust at 8 dust deposit gauge locations (refer Figure 8), and also predicted the extent of deposited dust. The modelling predicted that deposited dust attributable to the mine activities (including the August mine and the Brunswick processing plant) was for the most part confined to the sites and the land immediately surrounding them and did not impact the town of Costerfield.

As reported in Appendix D6, since March 2006, deposited dust monitoring has been conducted by the mine at eight locations in the vicinity of the mine using dust deposit gauges (DDG). The measured dust deposition rates have been used to assess the potential contribution of the current mining activities on the soil concentrations reported in Appendix D1.

An estimate of the cumulative soil concentration due to deposited dust can be calculated from deposition to soil minus any soil losses due to natural processes such as leaching, erosion and runoff.   Assuming that the soil loss is negligible, the concentration can be calculated using the following equation from US EPA (2005):

$$C_s = 100 . tD . [(Dypd + Dywv)/(Z_s . BD)] \qquad \text{(Equation 1)}$$

Where

C_s = *Average soil concentration over exposure duration (mg/kg)*
100 = *units conversion factor (mg-m^2/kg-cm^2)*
$Dypd$ = *Unitized yearly dry deposition from particulate phase (g/m^2-yr)*
$Dywv$ = *Unitized yearly wet deposition from vapour phase (g/m^2-yr)*
tD = *Time period over which deposition occurs (yr)*
Z_s = *soil mixing zone depth (cm)*
BD = *soil bulk density (g/cm^3)*

For this assessment, it is assumed that *Dypd* + *Dywv* is equal to the deposition of antimony as measured monthly in the DDG. The data for the DDG has been provided to Golder by Mandalay, as reported in Appendix D6 and summarised in Table 3. Two annual deposition rates (*Dypd* + *Dywv*) have been modelled: an ‘average’; and ‘upper estimate’. The ‘average’ rate is the total deposition, which assumes October 14 – September 15 represents a typical year, and the maximum deposition rate is the maximum monthly result multiplied by 12 to give a yearly result.

Location CD10 was selected as an indicator for dust deposition because it is located within the town of Costerfield (refer Figure 8).

The soil concentration (Cs) has been modelled in yearly time steps, for ten years as the current underground mining operations commenced in 2006 (Snowden 2012). The result is the concentration of antimony added to the surface soil each year due to the deposition of dust at location CD10. The approach assumes that all dust deposited at location C10 is due to the mine activities. Given the information provided in the deposited dust impact assessment (refer Appendix D6), this is a conservative estimation (i.e. overestimate) because dust from the current mining operations would not be expected to impact CD10. The inputs to equation 1 are summarised in Table 4.

The results presented in Table 5 and Table 6 show the added soil concentration at year ten ranges from 7.7 mg/kg to 18.7 mg/kg. Compared to the geometric mean for all antimony concentrations reported inside the dome (85 mg/kg), this is an estimated of 9% to 22% increase in surface soil antimony concentration that could be attributed over ten years of current mining operations.

The wind direction from the direction of the current mining activities would also influence this result. The predicted soil concentration result assumes wind does not influence deposition. Given the wind direction towards CD10 occurs approximately a third (31% refer Table 7 Appendix D3) of the year, the percent contribution to soil concentrations is likely to be lower than that provided in Table 6.

Table 3: Dust Deposition Gauge Results

	Deposited Dust – Antimony (µg/m^2/month)							
	CD1	**CD 04**	**CD 06**	**CD 07**	**CD 09**	**CD 10**	**CD 12**	**CD 14**
Oct-14	582	210	196	157	3110	758	1230	523
Nov-14	2280	307	846	8650	2170	2280	1860	637
Dec-14	5200	2880	1010	40600	2810	2710	1710	392
Jan-15	912	816	1190	4250	752	574	792	422
Feb-15	62	0.5	0.5	965	47	26	40	0.5
Mar-15	1590	1920	2170	10700	2490	1670	1270	645
Apr-15	1150	1180	713	10300	1510	1140	1080	422
May-15	1270	1290	781	5010	1770	1020	608	224
Jun-15	901	978	2410	5670	2280	1020	1970	439
Jul-15	3930	1850	2460	13400	2270	3650	3840	1100
Aug-15	1150	1730	1130	6790	3960	2950	2120	820
Sep-15	4480	2700	2550	5780	4270	4670	3320	2600
TOTAL (µg/m^2/yr)	***23507***	***15862***	***15457***	***112272***	***27439***	***22468***	***19840***	***8225***
Minimum (µg/m^2/month)	*62*	*0.5*	*0.5*	*157*	*47*	*26*	*40*	*0.5*
Maximum (µg/m^2/month)	*5200*	*2880*	*2550*	*40600*	*4270*	*4670*	*3840*	*2600*
Average (µg/m^2/month)	*1959*	*1322*	*1288*	*9356*	*2287*	*1872*	*1653*	*685*

Table 4: Input Parameters

Parameter	**Description**	**Value and units**	**Reference/Comment**
Dypd + Dywv	Deposition Rate	Average – 22,468 µg/m^2/yr Maximum – 56,040 µg/m^2/yr	Dust Deposition Gauge Results – CD10, representative of Costerfield township
tD	Time period over which deposition occurs	10 years	
Z_s	soil mixing zone depth	2 cm	default value USEPA (2005)
BD	soil bulk density	1.5 g/cm^3	default value USEPA (2005)

Table 5: Modelling of Average Deposition Rate - Antimony

Time Step (tD)	Average Modelled Added Soil Antimony (Cs) (mg/kg)	Proportion of the Geometric Mean Soil Concentration[3]	Average Annual Deposition Rate (g/m^2-yr)
Year 1	0.75	0.88%	0.023
Year 2	1.5	1.76%	0.023
Year 3	2.3	2.64%	0.023
Year 4	3.0	3.52%	0.023
Year 5	3.7	4.41%	0.023
Year 6	4.5	5.29%	0.023
Year 7	5.2	6.17%	0.023
Year 8	6.1	7.12%	0.023
Year 9	6.9	8.09%	0.023
Year 10	7.7	9.08%	0.023

Table 6: Modelling Upper Estimate Deposition Rate - Antimony

Time Step (tD)	Average Modelled Added Soil Antimony (Cs) (mg/kg)	Proportion of the Geometric Mean Soil Concentration	Upper Estimate Annual Deposition Rate (g/m^2-yr)
Year 1	1.9	2.20%	0.056
Year 2	3.7	4.40%	0.056
Year 3	5.6	6.59%	0.056
Year 4	7.5	8.79%	0.056
Year 5	9.3	10.99%	0.056
Year 6	11.2	13.19%	0.056
Year 7	13.1	15.38%	0.056
Year 8	14.9	17.58%	0.056
Year 9	16.8	19.78%	0.056
Year 10	18.7	21.98%	0.056

Although the estimated soil concentrations in Table 6 are likely overestimates at any particular location they do show that there is a potential for a small contribution to soil concentrations in Costerfield due to current mining operations and emphasise that dust management practices require careful management.

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[3] The geometric mean was selected for comparison as it is the lower of the statistical means, if the arithmetic mean was adopted, the proportion of the soil concentration attributable to the mine would be lower.

Figure 8: Dust Deposition Monitoring Locations (Mandalay Resources)

7.0 TANK WATER

The tank water sampling program and results are presented in Appendix D2. The results show that within the Costerfield Dome, there were concentrations of a range of metals in the tank water samples, but antimony and lead were considered to be the key chemicals of potential concern for the HRA[4] as the concentrations of these metals were consistently found above the Australian Water Quality Guidelines (NHMRC and NRMMC 2011). Arsenic was reported as less than the adopted assessment criteria (0.01 mg/L) in the tank water samples.

The results were different outside the Dome, where lead and zinc were reported above the Australian Water Quality Guidelines (NHMRC and NRMMC 2011).

The source of metals in the tank water is likely to be dust deposited on roofs being washed into the tank (as outlined in the Appendix C). Other potential sources include metals used in roofing or guttering products, such as lead flashing or aluminium-zinc coated steel.

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[4] Refer to Appendix D2 for details on the selection of COPC.

The presence of antimony within the tank water in the Dome, and much lower concentrations outside the Dome is consistent with the soil data. This suggests that the antimony sources is most likely dust deposited antimony local origin (i.e. dust from within the Dome) and that dust containing antimony is not widely dispersed beyond the area of its geological origin.

The presence of lead both inside and outside the Dome is also consistent with the soil results. Whilst there is some lead of local geological origin, there is also likely to be other anthropogenic sources of lead in the Costerfield environment.

An assessment of the tank water (pre-cleaning) data was undertaken comparing the results of the samples from within the Costerfield Dome to the following data sets:

- Golder sampling conducted at seven properties outside the Dome (refer Appendix D2).
- Golder sampling of five tanks within the Heathcote area (refer attachment Table I.2).
- A regional set compiled by Chapmen et al. (2006) of tank water testing of six tanks in each of Adelaide, Brisbane, Canberra, Broken Hill, Sydney and Wollongong, and two in Melbourne.

The range of results data set is shown in Table 7. The results show a similar pattern as the soil regional comparison: for antimony and arsenic, the concentrations are higher within the Dome. For lead, the concentrations are similar to that of the environment outside the Dome and in other parts of Australia.

Table 7: Tank Water Data Comparison

Analyte	**Costerfield within the Dome – concentration range (mg/L)**	**Costerfield outside the Dome – concentration range (mg/L)**	**Heathcote – concentration range (mg/L)**	**Chapmen et al. (2006) – concentration range (mg/L)**
Antimony	<0.001-0.11	<0.001-0.003	<0.001-0.002	Not detected
Arsenic	<0.001-0.009	<0.001-0.002	<0.001-0.005	<0.001-0.001
Lead	<0.001-0.024	<0.001-0.062	<0.001-0.09	<0.0003-0.013

8.0 SUMMARY AND CONCLUSIONS

The consideration of the potential sources of metals concentration in the Costerfield environment including the contribution of the current mining activities has considered a number of lines of evidence as outlined in the above sections. The assessment findings are summarised below.

Antimony and Arsenic

The soil concentrations of antimony and arsenic within the Dome show a strong positive correlation, therefore these two metals have been considered together. Antimony and arsenic are known components of the local geology; specifically the mineralised zones of sulphide minerals such as stibnite and adjacent altered host rocks of the Costerfield Formation (refer Appendix A).

As noted in the Desktop Review (Appendix A), the extensive distribution of mine wastes (particularly tailings) within Costerfield is likely to be a significant source of antimony and associated arsenic in the environment. This is supported by the soil data which indicates that the antimony and arsenic concentrations are closely correlated in the Dome, and their presence is consistent with the geology of the area.

The consideration of the concentrations of antimony and arsenic by depth show that within the Dome, there are generally higher concentrations in the surface samples than the deeper samples. This suggests that there are activities or processes that have impact on surface soils, for example, the spreading of tailings or dust deposition.

The assessment of air quality data in the Dome indicates that significant dust impacts are limited to a few hundred meters (<500 m) from current mining activities. The estimated increase in PM_{10} concentrations above background levels due to current mining activities is up to 15%. It was estimated that the current operations may contribute in the range of 9% to 22% increase in surface soil antimony concentrations.

Antimony and arsenic concentrations in tank water show a similar patter to those in soil, with higher concentrations within the Dome than outside the Dome.

In summary, the soil concentrations of antimony and arsenic are naturally occurring in the geology of the Costerfield Dome, with an increase in the soil concentration of up to 15% due to mining related dust contributions. Therefore there remains a need for dust monitoring and reactive dust management at the current mining operations.

Farming and residential development within the Costerfield area is unlikely to have significantly contributed to the antimony load within the local environment.

Lead

Whilst lead is also a naturally occurring metal in the Costerfield formation, the concentrations found in soil within the Dome are higher than expected if the lead was all due to the local geology, therefore it is likely that there are other anthropogenic (man made) sources of lead in the Costerfield environment. This is supported by the following:

- Although lead is present in the ore at concentrations in the range of 14-31 mg/kg, concentrations in soil within the Dome range from <5 mg/kg to 3760 mg/kg. Lead is known to be used in the current mining process as added lead nitrate and it is present in the waste tailings (224 mg/kg) and the processed ore (concentrate) (1100 mg/kg to 2000 mg/kg). Lead may also have been used in historical mining works and may be present in the tailings and mullocks heaps within the Costerfield area.
- The distribution plot show that the concentrations of lead in the ore, are similar to the concentrations of lead in the deeper samples, but the concentrations of lead in surface soil are generally higher, with the outlier being significantly higher.
- The correlation plots indicated that whilst at low concentrations, the antimony, arsenic and lead were relatively positively correlated as expected as there three metals are naturally occurring in the ore, however at higher lead concentrations the correlation is no longer significant.
- Review of regional data suggests that the concentrations of lead within the Dome are higher than sample collected form Heathcote and outside the Dome, and appear to follow a similar distribution to an established urban environment with a similarly low impact from vehicle traffic.
- The results suggest that the lead in soil is most likely a mixture of anthropogenic sources and unlikely to be solely from the Costerfield ore. The isotope analysis does not allow additional characterisation of the anthropogenic source (i.e. it is not possible to distinguish between common sources of lead and lead nitrate used in mining).
- Lead concentrations in tank water are not significantly different inside the Dome compared to outside the Dome.

In summary, there is a naturally occurring source of lead in the soil environment in the range of 14-31 mg/kg (as described by the analysis of the Costerfield Ore). The investigations conducted to date suggest that the higher concentrations of lead are likely to be due to a mixture of anthropogenic sources and/or activities.

9.0 REFERENCES

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APPENDIX I

Sources of Metals in the Costerfield Environment

Attachments – **Table I.1 Heathcote Soil Data**

Table 1.2 Heathcote Tank Water Data

Table I.1: Heathcote Soil Analytical Results

				Unknown	Exchangable Cations				Heavy Metals					Other	Sample Quality Parameters			
				PH_CACL2	Exchangeable Calcium	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Aluminium	Antimony	Arsenic	Iron	Manganese	CEC	Electrical Conductivity @ 25°C	Sulphate (as SO4)	Total Organic Carbon	Moisture
				pH Unit	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/kg	uS/cm	mg/kg	mg/kg	%
EQL				0.1	0.1	0.1	0.1	0.1	50	5	5	50	5	1	1	50	200	1
NEPM HIL A										200	100		1500					
Sample ID	**Sample Point**	**Date**	**Soil Description**															
DC001/4001_20140710	Surface	10/07/2014	Sandy CLAY	5.8	27.6	18.8	2.9	0.2	6360	28	6	10,700	518	495	232	50	240,000	11.2
DC001/4002_20140710	Surface	10/07/2014	SAND	5.5	-	-	-	-	1140	<5	<5	3230	54	-	7	-	-	11
DC001/4003_20140710	Surface	10/07/2014	SAND	4.3	-	-	-	-	1210	<5	<5	10,600	65	-	15	-	-	5.6
DC001/4004_20140710	Surface	10/07/2014	Silty CLAY	5.8	-	-	-	-	4240	<5	<5	9880	442	-	51	-	-	14.8
DC001/4005_20140710	Surface	10/07/2014	silty CLAY / tan bark	5.9	-	-	-	-	7180	<5	10	14,200	553	-	57	-	-	9.4
DC001/4006_20140710	Surface	10/07/2014	SAND	5.3	-	-	-	-	770	<5	<5	2200	27	-	7	-	-	8.5
DC001/4007_20140710	Surface	10/07/2014	Sandy CLAY	6.2	-	-	-	-	3550	<5	<5	6260	26	-	34	-	-	15.3
DC001/4008_20140710	Surface	10/07/2014	Sandy CLAY	6.5	-	-	-	-	3580	<5	7	8910	193	-	34	-	-	18.4
DC001/4009_20140710	Surface	10/07/2014	Sandy CLAY	5.9	-	-	-	-	5840	212	20	11,400	189	-	65	-	-	33
DC001/4010_20140710	Surface	10/07/2014	Silty CLAY	5.7	-	-	-	-	5350	53	41	22,200	300	-	50	-	-	25.5
DC002/4001_20140710	Surface	10/07/2014	Sandy CLAY	6.2	-	-	-	-	4330	34	12	29,500	172	-	32	-	-	9.4
DC002/4002_20140710	Surface	10/07/2014	Sandy CLAY	5.5	1.8	1.5	0.4	<0.1	8480	41	14	22,200	36	37	16	<50	4700	18.6
DC002/4003_20140710	Surface	10/07/2014	Clayey SAND	5.8	-	-	-	-	3380	<5	<5	7570	209	-	26	-	-	20.3
DC002/4004_20140710	Surface	10/07/2014	Clayey SAND	5.1	-	-	-	-	4140	<5	<5	9000	277	-	18	-	-	13.4
DC002/4005_20140710	Surface	10/07/2014	Clayey SAND	6.1	-	-	-	-	2600	<5	<5	5360	220	-	46	-	-	20.7
DC002/4006_20140710	Surface	10/07/2014	Clayey SAND	4.8	-	-	-	-	4370	<5	<5	9380	310	-	5	-	-	13.2
DC002/4007_20140710	Surface	10/07/2014	Clayey SAND	5.3	-	-	-	-	5700	<5	<5	11,600	294	-	15	-	-	14.4
DC002/4008_20140710	Surface	10/07/2014	Silty SAND	6.9	-	-	-	-	7380	<5	9	9770	238	-	97	-	-	33.5
DC002/4009_20140710	Surface	10/07/2014	Silty SAND	7.1	-	-	-	-	3720	<5	7	6430	103	-	54	-	-	24.6
DC002/4010_20140710	Surface	10/07/2014	Silty SAND	6.8	-	-	-	-	4000	21	5	6720	179	-	71	-	-	29.3
DC002/4011_20140710	Surface	10/07/2014	Sandy CLAY	4.8	-	-	-	-	880	<5	<5	8220	65	-	6	-	-	13.3
DC002/4012_20140710	Surface	10/07/2014	SAND	4.8	-	-	-	-	820	24	<5	6480	54	-	7	-	-	10.2
DC002/4013_20140710	Surface	10/07/2014	SAND	4.7	-	-	-	-	670	5	<5	2890	48	-	34	-	-	1.4
DC002/4014_20140710	Surface	10/07/2014	Gravelly SAND	3.9	-	-	-	-	1610	6	<5	4370	46	-	27	-	-	6.4
DC002/4015_20140710	Surface	10/07/2014	Gravelly SAND	3.7	-	-	-	-	1100	<5	<5	3460	56	-	21	-	-	6.7
DC003/4001_20140710	Surface	10/07/2014	Silty SAND	6.1	7.2	3.1	0.4	<0.1	2650	<5	10	5360	98	107	32	<50	93,400	39.4
DC003/4002_20140710	Surface	10/07/2014	SAND	6	-	-	-	-	280	<5	<5	190	<5	-	9	-	-	3.2
DC003/4003_20140710	Surface	10/07/2014	SAND	6.1	-	-	-	-	260	<5	<5	120	<5	-	7	-	-	3.3
DC003/4004_20140710	Surface	10/07/2014	Organics, trace sand	6.7	-	-	-	-	3910	<5	9	8070	125	-	77	-	-	18
DC003/4005_20140710	Surface	10/07/2014	Sandy CLAY	4.3	-	-	-	-	1740	<5	<5	3940	94	-	90	-	-	46.5
DC003/4006_20140710	Surface	10/07/2014	Organics, trace sand	3.8	-	-	-	-	1540	<5	<5	3110	68	-	16	-	-	8.2
DC003/4007_20140710	Surface	10/07/2014	Sandy CLAY	4.5	-	-	-	-	1900	<5	6	4680	88	-	33	-	-	30.9
DC003/4008_20140710	Surface	10/07/2014	Clayey SAND	6.5	-	-	-	-	3230	<5	42	8830	126	-	70	-	-	26
DC003/4009_20140710	Surface	10/07/2014	Clayey SAND	6.6	-	-	-	-	4130	<5	54	13,600	243	-	196	-	-	21.3
DC003/4010_20140710	Surface	10/07/2014	Organics, trace sand	3.5	-	-	-	-	1260	<5	<5	2670	68	-	37	-	-	9.3
DC004/4001_20140729	Surface	29/07/2014	Silty SAND	4.9	-	-	-	-	1470	8	22	5040	85	-	19	-	-	40.4
DC004/4002_20140729	Surface	29/07/2014	Silty SAND	4.8	-	-	-	-	1880	6	11	8000	175	-	14	-	-	49.4
DC004/4003_20140729	Surface	29/07/2014	Silty SAND	4.4	-	-	-	-	1460	7	29	5170	153	-	15	-	-	42.3
DC004/4004_20140729	Surface	29/07/2014	Silty SAND	5.3	-	-	-	-	1680	7	25	4880	135	-	22	-	-	46.7
DC004/4005_20140729	Surface	29/07/2014	SAND	4.6	-	-	-	-	240	<5	6	1260	16	-	4	<50	-	6.4
DC004/4006_20140729	Surface	29/07/2014	Silty sandy GRAVEL	4.8	-	-	-	-	1320	<5	10	4590	73	-	8	-	-	11.7
DC004/4007_20140729	Surface	29/07/2014	Silty sandy GRAVEL	5.3	-	-	-	-	1370	<5	<5	4120	124	-	15	-	-	29.4
DC004/4008_20140729	Surface	29/07/2014	Silty SAND	4.8	-	-	-	-	1850	37	17	5080	102	-	14	-	-	44.2
DC004/4009_20140729	Surface	29/07/2014	Silty SAND	4.7	-	-	-	-	1750	20	17	5380	148	-	13	-	-	44.6
DC004/4010_20140729	Surface	29/07/2014	Silty SAND	5.8	-	-	-	-	5870	9	11	10,200	277	-	25	-	-	34.9
DC005/4001_20140729	Surface	29/07/2014	Sandy CLAY	5	-	-	-	-	4300	<5	8	13,900	102	-	20	-	-	5.9
DC005/4002_20140729	Surface	29/07/2014	Sandy GRAVEL	6.6	-	-	-	-	6000	24	10	21,900	204	-	20	<50	-	7.4
DC005/4003_20140729	Surface	29/07/2014	Sandy GRAVEL	6.6	-	-	-	-	5180	16	5	19,100	181	-	33	-	-	14.9
DC005/4004_20140729	Surface	29/07/2014	Gravelly SAND	6.5	-	-	-	-	3220	14	<5	17,100	157	-	15	-	-	6.2
DC005/4005_20140729	Surface	29/07/2014	Gravelly SAND	6.7	-	-	-	-	3860	34	<5	19,500	226	-	17	-	-	7.5
DC005/4006_20140729	Surface	29/07/2014	Gravelly SAND	6.7	-	-	-	-	5310	88	19	31,500	448	-	23	-	-	8.3
DC006/4001_20140729	Surface	29/07/2014	Silty SAND	6.4	-	-	-	-	4450	<5	<5	9510	214	-	36	-	-	11.2
DC006/4002_20140729	Surface	29/07/2014	Clayey SAND	6.3	-	-	-	-	5130	43	<5	9050	219	-	53	-	-	30.4
DC006/4003_20140729	Surface	29/07/2014	Silty CLAY	6.9	-	-	-	-	7020	<5	<5	7330	234	-	208	-	-	44.3
DC006/4004_20140729	Surface	29/07/2014	Silty SAND	6.5	-	-	-	-	3470	<5	<5	7130	205	-	55	-	-	26.7
DC006/4005_20140729	Surface	29/07/2014	Silty CLAY	6.3	-	-	-	-	10,100	<5	<5	29,300	634	-	54	-	-	32.8
DC006/4007_20140731	Surface	31/07/2014	Sandy CLAY	6.7	-	-	-	-	6370	<5	<5	15,500	215	-	85	<50	-	26.2
DC006/4009_20140731	Surface	31/07/2014	Sandy CLAY	5.9	-	-	-	-	6000	8	5	12,400	298	-	2840	<50	-	22.7
DC006/4010_20140731	Surface	31/07/2014	Clayey gravelly SAND	5.2	-	-	-	-	8810	<5	7	11,100	99	-	10	<50	-	14.1
DC006/4011_20140731	Surface	31/07/2014	Clayey gravelly SAND	6	-	-	-	-	3400	<5	<5	9580	215	-	44	<50	-	21.6
DC007/4001_20140729	Surface	29/07/2014	Clayey SAND	7.1	-	-	-	-	5040	<5	10	24,800	63	-	59	-	-	6.4
DC007/4002_20140729	Surface	29/07/2014	Clayey SAND	6.4	-	-	-	-	6240	<5	9	23,500	72	-	22	-	-	4.4

Statistical Summary

Number of Results	84	6	6	6	6	84	84	84	84	84	6	84	13	6	84
Number of Detects	84	6	6	5	1	84	27	49	84	82	6	84	1	6	84
Minimum Concentration	3.5	0.2	0.2	<0.1	<0.1	240	<5	<5	120	<5	4	3	<50	2400	1.4
Minimum Detect	3.5	0.2	0.2	0.2	0.2	240	5	5	120	16	4	3	50	2400	1.4
Maximum Concentration	7.4	27.6	18.8	2.9	0.2	23400	212	54	62400	887	495	2840	50	240000	49.4
Maximum Detect	7.4	27.6	18.8	2.9	0.2	23400	212	54	62400	887	495	2840	50	240000	49.4
Average Concentration	5.8	7.9	5.4	0.73	0.075	4538	12	9.3	12246	195	140	74	27	61750	18
Median Concentration	5.9	5.15	2.8	0.4	0.05	3925	2.5	6	9245	141.5	87.5	27.5	25	15000	14.15
Standard Deviation	0.96	10	6.9	1.1	0.061	3865	26	10	10174	180	180	308	6.9	93743	12
Number of Guideline Exceedances	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Table I.2: Heathcote Tank Water Analytical Results

Sample ID	Sample Point	Tank Location Description	Date	Heavy Metals																Sample Quality Parameters			
				Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)	Sulphur (as S) (Filtered)
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH Units	mg/L	mg/L	mg/L
EQL				0.001	0.001	0.001	0.001	0.0001	0.0001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.001	0.005	0.005	0.01	10	1	1
ADWG 2011 Aesthetic										1	1	0.3	0.3					3	3	6.5-8.5	600	250	
ADWG 2011 Health				0.003	0.003	0.01	0.01	0.002	0.002	2	2			0.01	0.01	0.02	0.02					500	
WHO Guidelines for Drinking Water Quality (2011)				0.02	0.02	0.01	0.01	0.003	0.003	2	2			0.01	0.01	0.07	0.07	3	3				
DC001/5001_20140710	Within tank	On building	10/07/2014	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.012	0.01	<0.05	<0.05	<0.001	<0.001	0.002	0.002	0.038	0.038	4.6	15	<1	-
DC002/5001_20140710	Within tank	Corner of main building	10/07/2014	<0.001	<0.001	0.005	0.005	<0.0001	<0.0001	0.003	0.004	0.08	<0.05	<0.001	<0.001	0.002	0.002	0.254	0.213	7.53	141	7	-
DC002/5002_20140710	Within tank	Northernmost tank west of car park	10/07/2014	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.002	0.003	<0.05	<0.05	0.001	<0.001	<0.001	<0.001	0.25	0.088	6.54	13	<1	-
DC003/5001_20140710	Within tank	On building	10/07/2014	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.002	0.003	<0.05	<0.05	0.001	<0.001	<0.001	<0.001	3.22	2.53	6.75	33	<1	-
DC003/5002_20140710	Tank tap	On building	10/07/2014	<0.001	<0.001	0.001	<0.001	<0.0001	<0.0001	0.066	0.042	<0.05	<0.05	0.006	0.002	<0.001	0.001	3.47	2.67	6.8	39	<1	-
DC008/5001_20140731	Within tank	Western tank	31/07/2014	0.002	0.002	0.002	<0.001	0.0002	<0.0001	0.363	0.118	1.1	<0.05	0.09	0.009	0.005	0.002	0.482	0.301	6.94	49	<1	<1
DC009/5001_20140731	Tank tap	Behind portable office	31/07/2014	<0.001	<0.001	<0.001	<0.001	0.0002	0.0002	0.003	0.25	<0.05	<0.05	**0.096**	0.021	<0.001	0.006	4.48	5.44	7.06	<10	<1	<1

Statistical Summary

	Antimony	Antimony (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	pH (Lab)	Total Dissolved Solids @180°C	Sulphate (as SO4) (Filtered)	Sulphur (as S) (Filtered)
Number of Results	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	2
Number of Detects	1	1	3	1	2	1	7	7	2	0	5	3	3	5	7	7	7	6	1	0
Minimum Concentration	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	0.002	0.003	<0.05	<0.05	<0.001	<0.001	<0.001	<0.001	0.038	0.038	4.6	<10	<1	<1
Minimum Detect	0.002	0.002	0.001	0.005	0.0002	0.0002	0.002	0.003	0.08	ND	0.001	0.002	0.002	0.001	0.038	0.038	4.6	13	7	ND
Maximum Concentration	0.002	0.002	0.005	0.005	0.0002	0.0002	0.363	0.25	1.1	<0.05	0.096	0.021	0.005	0.006	4.48	5.44	7.53	141	7	<1
Maximum Detect	0.002	0.002	0.005	0.005	0.0002	0.0002	0.363	0.25	1.1	ND	0.096	0.021	0.005	0.006	4.48	5.44	7.53	141	7	ND
Average Concentration	0.00071	0.00071	0.0014	0.0011	0.000093	0.000071	0.064	0.061	0.19	0.025	0.028	0.0049	0.0016	0.002	1.7	1.6	6.6	42	1.4	
Median Concentration	0.0005	0.0005	0.0005	0.0005	0.00005	0.00005	0.003	0.01	0.025	0.025	0.001	0.0005	0.0005	0.002	0.482	0.301	6.8	33	0.5	0.5
Standard Deviation	0.00057	0.00057	0.0017	0.0017	0.000073	0.000057	0.13	0.093	0.4	0	0.045	0.0078	0.0017	0.0019	1.9	2	0.94	46	2.5	
Number of Guideline Exceedances	0	0	0	0	0	0	0	0	1	0	2	1	0	0	3	1	1	0	0	0
Number of Guideline Exceedances(Detects Only)	0	0	0	0	0	0	0	0	1	0	2	1	0	0	3	1	1	0	0	0

Values in bold are those adoped from the duplicate results as a conservative measure. This was done where the primary or secondary duplicate result was greater than the results from the primary sample as well as greater than the adopted guideline.

APPENDIX J

Important Information Relating to this Report

IMPORTANT INFORMATION RELATING TO THIS REPORT

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

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