Statement of Andrew G. Helps
Delegated toxic metal expert to the UNEP Minamata Convention on Mercury

I have had an involvement with the Lindenow community for the past 4 years. My role with the community has been to conduct baseline water testing of drinking water tanks and farm dams in the area. Over time, my role has increased to advice on the toxicology of various metals and the pollution of drinking water, the air and groundwater.

On the 28^{th} of January 2018 in the company of one of the local farmers, I took baseline samples from 24 domestic drinking water tanks in the Lindenow area. I also took a single sample from a farm dam as a control sample.

These samples were conveyed under a chain of custody in a refrigerated container to Envirolab in Knox. All of the samples were quite pristine but the farm dam water was in excess of the Australian Drinking Water Guidelines (ADWGL) for Antimony which was not an unexpected result for an area with toxic metal ore bodies.

Over the next two years, I carried out two public briefing sessions for the Lindenow communities.

The first of these was at the Lindenow public hall and the attending crowd was larger than the hall capacity. Some of the farmers were very rightly very concerned about the impact that dust containing carcinogenic heavy metals would have on their export vegetable crops.

This meeting ran for about an hour over time and at the finish there was an overwhelming request for a further public meeting where more detailed toxicology data could be provided. A number of the Lindenow vegetable farmers came up to me and asked if I could provide much more detailed toxicology data for them. These farmers had grave concerns that toxic dust from the potential KALBAR mine would contaminate their vegetable crops for both the Australian and Asian export markets.

A number of farmers expressed concern to me that toxic metal pollution of their crops by dust from the proposed KALBAR mine would not only impact their ability to sell vegetable crops into the local and export markets, but damage the "clean and green" image of all Australian vegetable farmers.

A number of the farmers were concerned that if the KALBAR proposal was approved then their farming enterprises, some of which had been in the families for nearly 80 years would be destroyed and the clean green image of the are would be trashed.

I agreed to set up a further meeting and then worked to develop the toxicology data in a format that lay persons could understand.

A second meeting was held in Bairnsdale at the quite large church hall. Again the crowd was standing in the aisles and in the doorway. I was unable to provide the human health risk toxicology answers that the community wanted due to a lack of data on the quantum of various toxic metals in the ore body.

Not long after this meeting, KALBAR released some data from analysis work on sludge and soils carried out by Envirolab (Analysis 217289-B). As this data came from Envirolab it was, as far as I was concerned, high credibility data as I am also a frequent user of Envirolab services.

I plugged this data into my Rare Earth/Toxic Element/Compound calculation template that I originally developed in my role as a delegated toxic metal expert to the UNEP Minamata Convention on Mercury in 2013.

A copy of this spreadsheet is attached as file 8310 Revision 29. The functionality of this spreadsheet allows the assessment of risk using the Hazard Index approach as developed by Nordberg/Fowler in their two volume work "Handbook on the Toxicology of Metals" (HBTOM) fourth edition.

Page 231 Table 1 of the above reference details Potential Health Effects caused by some metals found in human body fluids. A copy of page 231 is attached. All the metals in Table 1 with the single exception of Silver are contained in the KALBAR ore body.

Table 1 is of fundamental importance to the whole KALBAR EES and should have been included and discussed as an absolute priority in the KALBAR Human Health Risk Assessment.

Some of the metals identified in Table 1 can cause more than 1 bodily health function risk:

Arsenic	All 6 health functions impacted.
Cadmium	3 health functions impacted.
Chromium	3 health functions impacted.
Copper	3 health functions impacted.
Lead	4 health functions impacted.
Thallium	3 health functions impacted
Thorium	Liver dysfunction
Uranium	Renal dysfunction

The American ATSDR (Agency for Toxic Substances and Disease Registry) publishes a Substance Priority List (SPL) which ranks all metals in order of their toxicity.

This ATSDR list gives data based on the nominal 70kg fit healthy young adult male.
This nominal fit healthy 70kg male would inhale 50.4 m^3 of air per day.

All my various State level clients in Asia would have mandated a detailed exploration of this toxic dust inhalation issue as matter of routine. All these clients use ATSDR and USEPA substance priority lists as a general operational procedure.

<u>This is an important issue that should have been explored by KALBAR's consultants.</u>

The list provides data on Water GMMC, (Gross Mean Maximum Concentration) for water at mg/L level, Soil at mg/kg, Air at mg/m^3 and TDD (Total Daily Dose) (mg/day) again for a fit healthy 70kg male.

In October 2020, at the request of a concerned Lindenow farmer, I carried out further testing in the Lindenow area.

A truncated ATSDR list of the applicable KALBAR ore body metals is attached. Using Envirolab Report # 22941, I have highlighted the metals that we know are in the Kalbar ore body.

There are a number of metals in the KALBAR ore body that have verified toxicology data - for instance Cerium, Strontium and Titanium dioxide.

Cerium (CAS # 7440-45-1) is a metal of particular concern at Lindenow because of the relatively high levels in the water samples - 14 and 66 ug/L. Cerium is radioactive and is a listed carcinogen with a US ATSDR chronic limit of 1 mSv/yr and an ATSDR air carcinogenic target air risk of 0.094 ug/m^3.

The US EPA publishes a Toxicological Review of Cerium Oxide and Cerium compounds. This is a document that was released in 2009. Section 5.2 of this document deals with Inhalation Reference Concentrations (RfC).

Section 5.2.1 is very relevant to the proposed KALBAR mine.

Exposure to Cerium compounds in the environment is most likely through Cerium (Ceric) oxide. There are numerous case reports of workers who developed pneumoconiosis or interstitial lung disease associated with the accumulation of cerium particles in the lungs after occupational exposure to cerium fumes or dust."

<u>Cerium is most dangerous in the working environment due to the fact that damps and gases can be inhaled with air.</u>

Strontium (CAS # 7440-24-6) is another metal within the KALBAR ore body that does not have significant verified toxicology data. The Envirolab analysis indicates that in the private dam water at Lindenow it is at between 28 and 69 ug/L. The ATSDR Regional Screening Level (RSL) for residential tap water is at 1200 ug/L.

Strontium in drinking water is a known causal agent for rickets in Children with poor nutrition. This is because Strontium acts as an imperfect surrogate for calcium in the body which interferes with bone mineralization in the developing skeleton.

There have been no known developmental or reproductive studies involving exposure to stable strontium during gestation.

However, Strontium Chromate is a genotoxic human carcinogen by the inhalation route but the hazard is caused by the hexavalent chromium. Chromium is ubiquitous in the KALBAR ore body.

Titanium (CAS 7440-32-6) is in the KALBAR ore body ranging between 6 and 61 mg/kg and in the water between 76 and 110 ug/L. Titanium is an inhalation risk to children at 0.00008 mg/m^3 in the air . This figure demonstrates that the risk to the Woodglen primary school some 4km from the proposed mine site and the Lindenow primary school is very high.

Next on the toxicity list at Lindenow is Lanthanum which runs between 9 and 27 mg/kg. Lanthanum is an air toxicant at 0.00018 mg/m^3. The Theoretical Daily Dose (TDD) for a fit healthy 70kg male is 0.00268 mg/day. If you adopt an average level of 18 mg/kg in the soil at Lindenow then the level is 6,716 times the safe limit (Reference HBTOM page 907). My primary concerns would be children engaging in Pica events. There is no effective therapeutic chelator to remove Lanthanum from the human body.

The KALBAR ore body contains Gallium (CAS 7440-55-3) at between 2 and 12 mg/kg. Gallium is highly toxic and a suspected carcinogen, has an air toxic level of 0.00001mg/m^3 and a Theoretical daily dose of 0.00011 mg/day. If you presume an average level of 7 mg/kg (the average of our 2 samples) in the dust blowing out of the mine then you have Gallium at 700,000 times the safe limit.

The KALBAR ore body contains Lead (CAS 7439-92-1) at between 4 and 29 mg/kg. Lead is highly toxic and has an air toxic level of 0.00243 mg/m^3 and a Theoretical daily dose of 0.33152 mg/day. If you presume an average of 16.5 mg/kg (the average of our 2 samples) in the dust blowing out of the mine then you have lead at 6,790 time the safe limit.

The KALBAR ore body contains Sulphur (CAS 7704-34-9) (US speak Sulfur) at between 31 and 5700 mg/kg. Sulphur is toxic and has an air toxic level of 0.00122 mg/m^3 and a Theoretical daily dose of 0.01829 mg/day.

If you presume an average for Sulphur of 1510 mg/kg (the average of our 4 samples) then you have sulphur in the dust blowing out of the mine at 1.23 million times the safe limit.

The KALBAR ore body contains RADNUCS (Radionuclides) the most obvious of which are Thorium, Uranium and Yttrium.

Thorium is at an average of 5 mg/kg. At this time we have not speciated the Thorium but it is likely to be the CAS 744029-1 variant. There is no safe level of Thorium in the environment.

Uranium is at an average of a little over 1 mg/kg and it is likely to be the CAS 740-61-1 variant. This figure is a normal background level for Uranium in this part of Gippsland.

Yttrium (CAS 7440-65-5) is in the ore body and average of 8.8 mg/kg. Yttrium has an Air GMMC of 0.00001 mg/m^3 and a TDD of 0.0012 mg/day. Yttrium is also in the water at an average of 19.85 ug/L. Yttrium has a Zero water GMMC and an Air GMMC at 0.00002 mg/m^3.

Experience in Asia with similar ore bodies indicates that these levels will increase with mine pit depth and quantum.

The key ATSDR Substance Priority List (SPL) toxicity data should be used as baseline data if this mine proposal is eventually approved.

RARE EARTH ELEMENTS.

We have a list of 16 Rare Earth Elements that are contained in the KALBAR ore body. Cerium, Lanthanum and Yttrium are line items in this list. Whilst the list quotes "% at Fingerboards" we do know the base number for calculating the percentage. This is important risk management data if it could be made available.

COMMENTS AND RECOMMENDATIONS.

1. This mine proposal, in its current format with dangerously incomplete, misleading and non existent technical reports should not be approved under any circumstances.

2. These deficiencies are such that it would take a significant amount of effort and money and require KALBAR to hire a report writing team that is more up to date with metals toxicology to bring the proposal data pack up to Worlds best practice standard (which it should be).

3. I would be happy to provide advice to the Panel on the necessary extra reports and investigations that need to be completed before this proposal could be regarded as both complete and technically complete.

4. The seriously deficient due-diligence process for mining licence applications and rehabilitation bonds in Victoria is in urgent need of upgrading to modern standards and this task needs to be completed before the KALBAR Lindenow project is permitted to proceed.

It is interesting to note that in several Asian countries these days this type of report is generated by a University from a distant province and not by the conflicted proponents!

5. Should this proposal be approved then the rehabilitation bond applied to the project would need to be in the region of $A240 to $A280 million to provide an adequate buffer for the vast range of remediation issues that will be required.

Thank you for giving me the opportunity to provide comment on the toxic metal issues with this proposal.

Andrew G. Helps

UNEP Global Mercury Partnership

Partnership Areas: Mercury in Gold Mining, Mercury Supply and Storage,
Mercury Air Transport and Fate, Mercury in Products.

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KALBAR Resources Lindenow (Vic) Project

DATA FROM ENVIROLAB ANALYSIS 217289-B

? Aquatic Toxicity **TABLE #1**

Conversion Factors

To Convert concentrations in air(at 25^{0}C) from PPM to mg/m^3 = **7/10/2020**

(ppm) x (molecular weight of the compound) / (24.45) e.g for Antimony 1 ppm = 4.97 mg/m^3.)

DEFAULT HAZARD INDEX IS ZERO

$$HI = \frac{QTY\ Chemical}{TDD} + \frac{QTY\ Chemical}{TDD} + \frac{QTY\ Chemical}{TDD}$$

QTY Chemical in mg/kg
TDD in mg/day

Note*
A Hazard Index in excess of 10 requires investigation and or remediation
PDRV - Prioritised Dose Response Value

Rare Earth/Toxic Element/Compound Calculation Template
File 8310 Revision 29
10th October 2020

Rare Earths in Italics

	CHEMICAL ELEMENTS/COMPOUNDS: mg/kg - ug/kg	Specific Gravity	Metal Group	Formula Weight (Molecular Weight)	California Rated as Carcinogen	ATSDR Rank	HBTOM* Ref Pages	Ignition Temperature (Dust ^{0}C)	Solubility in 100 parts Cold Water Formular Dependent D= Dissolves	ATSDR MRL's Chronic mg/kg/day	USEPA Residential Soil mg/kg	Australia Residential Soil mg/kg (HIL A)	ATSDR & USEPA Resident Air Carcinogenic Target Risk ug/m^3	ATSDR & USEPA Resident Tapwater mg/L	Australia Resident Tapwater ug/L	Vic EPA SEPP 240 Air ug/m^3	PEM M+E Vic EPA SEPP AQM Pub 1191 ug/m^3	ATSDR SPL THEORETICAL Daily Dose TDD (mg/day) (Fit 70kg male)	USEPA PDRV* Non Cancer	CHRONIC INHALATION Data Source	USEPA PDRV* Cancer	USEPA PDRV* Cancer (micrograms)	KALBAR DATA Leach FT Sludge mg/kg	Leach CT Soil mg/kg	Leach HM Soil mg/kg	Hazard Index Leach FT Sludge (TDD)	Hazard Index Leach CT Soil (TDD)	Hazard Index Leach HM Soil (TDD)
1	Aluminium (Al)	2.70 g/cm^3	Group 13	26.97	Carcinogen	183	549-560	650	i	1	7700		0.52	2000				10.323	Neurological	ATSDR			4500	260	260	435.9	25.2	25.2
2	Antimony (Sb)	6.69 g/cm^3	Group 15	121.76	Carcinogen	232	565-572	420	i	0.0003	3.1		0.021	0.78	3	17		0.103992	0.2ug/m^3	IRIS IARC 2B	0.2ug/m^3	0.2	<0.5	<0.5	0.50			4.81
3	Arsenic (see note 1)	5.73 g/cm^3	Group 15	299.64	Carcinogen	1	582-610	815	i	0.0003	0.68	100	0.00065	0.052	10	71.278	0.003	0.071278	0.015ug/m^3	Cal IARC 1	0.015ug/m^3	0043ug/r	35	4.40	11.00	491.0	61.70	154.30
4	Arsine (gaseous AsH3)	2.769 g/cm^3	Group 15	77.93	Carcinogen	1	615	285	20cc		0.027		0.005	0.007					0.05 ug/m^3	IARC 1	0.0043ug/m^3	0.0043						
5	Barium	3.51 g/cm^3	Group 2	137.36		134	625-633	725	D	0.2	1500		0.00108	0.51499		17		0.61652					28.00	5.80	32	45.4	9.4	51.9
6	Beryllium (glucinum)	1.85 g/cm^3	Group 4	9.02	Carcinogen	43	636-651	1278	i	0.002	2.64	60	0.00000	2.50	60.0	0.007		0.0078	0.01 ug/m^3	IRIS IARC 1	0.0024ug/m^3	0.0024	<0.5	<0.5	<1			
7	Bismuth (Bi)	9.72 g/cm^3	Group 4	209.00			655-663	271.3	i														<1	<1	<1			
8	Cadmium (Cd)	8.65 g/cm^3	Group 12	112.41	Carcinogen	7	668-708	1040	i	0.0005	7.1	20	0.00001	0.92	2	0.033		0.045127	0.01 ug/m3	ATSDR	0.0018ug/m^3	0.0018	<0.1	<01.	<0.1			
9	Calcium(Ca)	1.55 g/cm^3	Group 2	40.08				842	D				5.892442	103.777				195.6125					380	44	170	1.94	0.22	0.87
10	*Ceric Oxide (Cerium)$Ce0_2$*	6.71 g/cm^3	Group 3	172.13	Suspected	570	101-102	3500	i	1 mSv/yr			0.094															
11	Chromium compounds (Cr)	7.19 g/cm^3	Group 6	52.01	Carcinogen	66	717-739	580	i	0.0009			0.00001			17		0.00263					81	10	58	30798	3802	22053
14	Cobalt (Co)	8.85 g/cm^3	Group 9	58.94	Carcinogen	52	743-759	760	i	1 mSv/yr	2.3	100	0.000031	0.6				0.67523	0.1 ug/m^3	ATSDR			1.7	<0.5	<1	2.52		
15	Copper (Cu)	8.94 g/m^3	Group 11	63.57		125	765-782	900	i	0.01	310	6000		80	2000	33		0.47242					17.00	1.80	12	36	4	25
16	*Dysprosium $Dy20_3$*	8.53 g/m^3	Group 3	162.5	Suspected			2567	i																			
17	*Erbium $Er20_3$*	9.04 g/m^3	Group 12	167.26	Suspected			1529	i																			
18	*Europium $Eu0_3$*	5.25 g/cm^3	Group 3	151.96	Suspected	575		1800	i																			
19	*Gadollinium $Gd2p0_3$*	7.87 g/cm^3	Group 3	157.25	Suspected			3545	i																			
20	*Gallium Bromide ($GaBr_3$)*	5.92 g/cm^3	Group 13	309.47	Carcinogen		787-795	302	i				0.000007					0.00011					*6.60*	*1.10*	*23*	60000	10000	209091
21	*Germanium*	5.32 g/cm^3	Group 14	72.63			800-813		i																			
22	*Holmium $Ho20_3$*	8.80 g/m^3	Group 12	164.93	Suspected			1474	i																			
23	Iron	7.87 g/cm^3	Group 8	55.85			878-902	420	i		32919		0.01626	11.29				18.07					12000.00	1300.00	5000	664.08	71.94	276.7
24	*Lanthanum -138*	6.17 g/m^3	Group 3	138.92	Suspected	711	903-908	920	i				0.00018	0.00027				0.002682					*49.00*	*11.00*	*300*	18270	4101	111857
25	Lead - not 210 (Pb)	11.34 g/cm^3	Group 14	430.42	Carcinogen	2	129-131	710	i		400	300		15	10	3		0.330938	0.15 ug/m^3	OAQPS			10	1.9	18	30	6	54
26	*Lithium Oxide Li_2O*	0.53 g/cm^3	Group 1	29.88	Suspected	344	969-974	2600	to Li0H		104.51			0.3835				0.404424		ATSDR			*2.00*	*1.00*	*1.00*	5	2	2
27	*Lutetium -176*	9.84 g/cm^3	Group 3	174.99	Suspected			1936	i																			
28	Magnesium	3.58 g/cm^3	Group 2	24.32				520	i		6317.87		0.0907	33.3369				35.96134										
29	Manganese	7.47 g/cm^3	Group 6	54.93		140	975-1005	1246	D	0.3 ug/m3	180	3800	0.05	43	500			1.61855	0.03 ug/m^3	ATSDR			23	6	44	14	4	27
30	Mercury	13.55 g/cm^3	Group 12	200.61	Suspected	3	1014-106	o gas @10^0(	i	0.0002 mg/m3	0.94	40		0.063	1	3.3		0.051981	0.3ug/m^3	IRIS			0.02	0.01	<0.01	0.4	0.19	
31	Methyl Mercury	215.63g/mol	Group 12	417.22	Suspected	120	448-450	ithin organic	i	0.0003	0.78			0.2					0.1 ug/m^3	IRIS	0.1 ug/m^3	0.1						
32	Molybdenum	10.22 g/cm^3	Group 6	95.95		326	1077-110	720	i	0.00004 mg/m^3	39			10	50			0.2412	0.2ug/m^3	IARC 2B			1.2	0.50	1	5	2.1	5.0
33	Nickel	8.90 g/cm^3	Group 10	58.69	Carcinogen	57	1091-110	950+	i	0.00009 mg/m^3	84	400		20	20	0.33		0.38969	0.09 ug/m^3	ATSDR/CAL	0.00024 ug/m	0.00024	4	0.7	3.1	10.3	1.8	8
34	*Neodymium 144*	7.00 g/cm^3	Group 3	144.27	Suspected			1021	D																			
35	*Palladium*	12.99 g/cm^3	Group 10	106.7	Suspected	173	1113-112	2963	i				0.012000					0.00018										
36	*Platinum*	21.45 g/cm^3	Group 10	195.23			1125-1138		i																			
37	*Praseodymium Pro_6*	6.78 g/cm^3	Group 3	140.92	Suspected			3512	D																			
38	*Radium 222 , 226 or 228*	5.5 g/cm^3	Group 2	226.05	Carcinogen			1500	i				5pCi total combined per litre of water															
40	*Radium Bromide*	5.79 g/cm^3	Group 2	385.88																								
41	*Rhodium*	8.85 g/cm^3	Group 9	102.91			1143-1171		i																			
42	*Rubidium*	1.63 g/cm^3	Group1	85.48	Suspected	711			D				0.00001					0.000091										
43	*Samarium 147 (Chloride)*	7.54 g/cm^3	Group 3	150.43	Suspected				NK	EPA Doc EPA/690/R-09/050F																		
44	*Scandium $Sc2O_3$*	2.99 g/cm^3	Group 3	45.1	Suspected	584			NK																			
45	Selenium	4.50 g/cm^3	Group 16	631.68	Suspected	146	1176-120	950+	i	0.005 mh/kg/day	5.36	200	0.00002	0.03657	10			0.03778	20 ug/m^3	CAL			0.3	<0.1	0.4	7.94		10.59
46	Silica $PM_{2.5}$ Faction)	2.33 g/cm^3	Group 14	60.06	Carcinogen		102	780	i		430000			0.31			3	Annual av										
47	Sulphur (%)	2.067 g/cm^3	Group 16	32.06				392	i				0.00122					0.01829										
48	Strontium SrO (Stable)	2.64 g/cm^3	Group 2	87.63	Carcinogen		455	768.85	D	2 mg/kg/day													8	1	4			
49	*Tellurium*	6.24 g/cm^3	Group 16	127.61	Carcinogen		1218-122	449.51	i				0.00003					0.00039										
50	*Terbium $Tb40_7$*	8.27 g/cm^3	Group 3	159.2	Suspected			1356	NK																			
51	*Thallium*	11.86 g/cm^3	Group 13	204.39	Suspected	279	1229-123	303	i		6.0646		0.00007	0.01355				0.01579					<0.5	<0.5	<0.5			
52	*Thorium 229*	11.73 g/cm^3	Group 3	232.12	Carcinogen	227		270	i											IARC I	.000185 pCi/m^3		9.8	1.0	120			
54	*Thulium $Tm2O_3$*	9.33 g/cm^3	Group 12	169.4	Suspected			1950	i																			
55	Titanium	4.54 g/cm^3	Group 4	47.9	Carcinogen	310	1287-129	460	i	0.0001 mg/m3	14000			0.021				2.271688	0.01 ug/m^3	ATSDR	Respiratory		230	100	350	101.25	44.02	154.07
56	Tin	7.29 g/cm^3	Group 14	118.7		307	1242-127	630	i	0.3 mg/kg/day	4700			1200	1200			0.09981					1.7	<0.5	1.7	17.03		17.03
57	Tungsten	19.25 g/cm^3	Group 6	183.92			1297-130	950	i														<1	<1	<1			
58	Uranium 234	19.05 g/cm^3	Group 7	238.07	Carcinogen	97	1308-133	20	i	0.00004 mg/m3													3	0.4	9			
59	Vanadium (86%)	6.10 g/cm^3	Group 5	50.95	Carcinogen	200	1348-136	500	i	0.0001 mg/m3	39			8.6				0.123043		CAL		0.00034	130	17	83	1056.54	138.16	674.56
60	*Ytterbium $Yb2O_3$*	6.95 g/cm^3	Group 3	173.04	Suspected	581			NK																			
61	*Yttrium $Y2O_3$*	4.47 g/cm^3	Group 3	88.92	Suspected	711			D		0.104881		0.0000006					0.000118										
62	Zinc	7.14 g/cm^3	Group 12	65.38		75	1369-138	600	i	0.3 mg/kg/day	2300	7400		600		33		1.96084					16	2.3	11	8.16	1.17	5.61
63	Zirconium	6.51 g/cm^3	Group 4	91.22	Carcinogen	701		20	i		0.63			0.16	0.000022			0.00032					14	2.0	2.0	43750.0	6250.00	6250.00
64	Hydrogen Cyanide	0.69g/cm^3		179.16	Reproductive	35			NK		0.27	250		0.15	80	170	9*	1.3058										
65	PM10								Particle	ICPMS Analysis							50ug/m^3	24 hour av										
66	PM2.5				Carcinogen				Particle	ICPMS Analysis							25ug/m^3	24 hour av	Annual Average									
67	Radionuclides (Uranium)	18.7 g/cm^3	Group 3	238.03	Carcinogen	102	1307-1345		i								>00001ug/m^3				0.000185 pCi/m^3				Totals	155751	24525	350749
																	(As low as reasonably achievable ???)				Total REE Packa	Mg/kg	89.40	17.10	450.00			
																						Mg/ton	89400	17100	450000			
																						Gm/ton	89.40	17.10	450.00			
																				REE Package Price ($US Kg)		$21.10						
																					$US Gm	$0.0211	$1.89	$0.36	$9.50			

Note 1 USEPA Residential level Average fit healthy 70 kg male inhales 50.4 m3 a day

HBTOM - Handbook of the toxicology of Metals - Nordberg et al Fourth Edition
ATSDR Minimum Risk Levels (MRLs December 2019

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CERTIFICATE OF ANALYSIS 22941

Client Details

Client	Andrew Helps
Attention	Andrew Helps
Address	VIC

Sample Details

Your Reference	**F01-11 Lindenow**
Number of Samples	2 Water, 3 Sand, 1 Sludge
Date samples received	14/10/2020
Date completed instructions received	14/10/2020

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	16/10/2020
Date of Issue	20/10/2020
Reissue Details	This report supersedes 22941_R00 due to addition of Sulphur on all samples.

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Results Approved By
Chris De Luca, Operations Manager

Authorised By

P. Adams

Pamela Adams, Laboratory Manager

Acid Extractable metals in soil					
Our Reference		22941-2	22941-3	22941-5	22941-6
Your Reference	UNITS	L-26	L-27	L-29	L-30
Date Sampled		13/10/2020	13/10/2020	13/10/2020	13/10/2020
Type of sample		Sand	Sand	Sludge	Sand
Date digested	-	14/10/2020	14/10/2020	14/10/2020	14/10/2020
Date analysed	-	15/10/2020	15/10/2020	15/10/2020	15/10/2020
Silver	mg/kg	<1	<1	<1	<1
Aluminium	mg/kg	13,000	4,700	28,000	14,000
Antimony	mg/kg	<7	<7	<7	<7
Arsenic	mg/kg	5	<4	8	4
Boron	mg/kg	<3	<3	15	<3
Barium	mg/kg	18	15	58	22
Beryllium	mg/kg	<1	<1	<1	<1
Bismuth	mg/kg	<1	<1	<1	<1
Cadmium	mg/kg	<0.4	<0.4	<0.8	<0.4
Cobalt	mg/kg	2	1	8	3
Chromium	mg/kg	19	8	34	20
Copper	mg/kg	<1	<1	570	<1
Caesium*	mg/kg	<1	<1	<1	<1
Gallium	mg/kg	4	2	13	6
Gold*	mg/kg	<1	<1	<1	<1
Iron	mg/kg	30,000	12,000	37,000	26,000
Lanthanum*	mg/kg	16	9	27	15
Lead	mg/kg	10	4	29	11
Lithium	mg/kg	4	1	11	5
Manganese	mg/kg	33	10	190	31
Mercury	mg/kg	<0.1	<0.1	<0.1	<0.1
Molybdenum	mg/kg	<1	<1	<1	<1
Nickel	mg/kg	4	1	15	4
Selenium	mg/kg	<2	<2	<2	<2
Strontium	mg/kg	5	2	31	4
Sulphur	mg/kg	150	31	5,700	160
Tellurium	mg/kg	<1	<1	<1	<1
Thallium	mg/kg	<2	<2	<2	<2
Tin	mg/kg	<1	<1	2	<1
Titanium	mg/kg	7	9	61	6
Thorium	mg/kg	6	3	5	6
Uranium	mg/kg	<1	<1	2	1
Vanadium	mg/kg	50	28	62	54
Yttrium*	mg/kg	7.6	4.8	15	7.8

Acid Extractable metals in soil					
Our Reference	UNITS	22941-2	22941-3	22941-5	22941-6
Your Reference		L-26	L-27	L-29	L-30
Date Sampled		13/10/2020	13/10/2020	13/10/2020	13/10/2020
Type of sample		Sand	Sand	Sludge	Sand
Zinc	mg/kg	4	1	280	3

Moisture					
Our Reference		22941-2	22941-3	22941-5	22941-6
Your Reference	UNITS	L-26	L-27	L-29	L-30
Date Sampled		13/10/2020	13/10/2020	13/10/2020	13/10/2020
Type of sample		Sand	Sand	Sludge	Sand
Date prepared	-	14/10/2020	14/10/2020	14/10/2020	14/10/2020
Date analysed	-	15/10/2020	15/10/2020	15/10/2020	15/10/2020
Moisture	%	2.9	14	88	7.3

All metals in water - total			
Our Reference		22941-1	22941-4
Your Reference	UNITS	L-25	L-28
Date Sampled		13/10/2020	13/10/2020
Type of sample		Water	Water
Date prepared	-	14/10/2020	14/10/2020
Date analysed	-	14/10/2020	14/10/2020
Silver-Total	µg/L	<1	<1
Aluminium-Total	µg/L	12,000	43,000
Arsenic-Total	µg/L	3	4
Boron-Total	µg/L	30	60
Barium-Total	µg/L	37	150
Beryllium-Total	µg/L	<0.5	3
Bismuth-Total	µg/L	<1	<1
Cadmium-Total	µg/L	<0.2	<0.2
Cerium-Total*	µg/L	14	66
Cobalt-Total	µg/L	1	6
Chromium-Total	µg/L	11	48
Copper-Total	µg/L	<2	5
Caesium-Total*	µg/L	<1	2
Gallium-Total	µg/L	3	15
Mercury-Total	µg/L	<0.05	<0.05
Iron-Total	µg/L	8,100	30,000
Lanthanum-Total	µg/L	9	43
Lithium-Total	µg/L	3	15
Manganese-Total	µg/L	120	93
Molybdenum-Total	µg/L	<1	<1
Niobium-Total*	µg/L	2.7	2.4
Nickel-Total	µg/L	4	12
Lead-Total	µg/L	6	30
Rubidium-Total*	µg/L	8	31
Rhenium-Total*	µg/L	<1	<1
Antimony-Total	µg/L	<1	<1
Scandium-Total*	µg/L	<1	8
Selenium-Total	µg/L	<1	2
Tin-Total	µg/L	2	<1
Strontium-Total	µg/L	28	69
Tantalum-Total*	µg/L	<1	<1
Tellurium-Total*	µg/L	<0.5	<0.5
Thorium-Total	µg/L	1	5.0
Thallium-Total	µg/L	<1	<1

All metals in water - total			
Our Reference		22941-1	22941-4
Your Reference	UNITS	L-25	L-28
Date Sampled		13/10/2020	13/10/2020
Type of sample		Water	Water
Titanium-Total	µg/L	110	76
Uranium-Total	µg/L	0.6	3.5
Vanadium-Total	µg/L	13	53
Tungsten-Total	µg/L	<1	<1
Yttrium-Total*	µg/L	6.7	33
Zinc-Total	µg/L	9	25

Metals in Waters - Total			
Our Reference		22941-1	22941-4
Your Reference	UNITS	L-25	L-28
Date Sampled		13/10/2020	13/10/2020
Type of sample		Water	Water
Date prepared	-	20/10/2020	20/10/2020
Date analysed	-	20/10/2020	20/10/2020
Sulfur -Total	mg/L	2.0	3.6

Method ID	Methodology Summary
Inorg-008	Moisture content determined by heating at 105 deg C for a minimum of 12 hours.
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Metals-021 CV-AAS	Determination of Mercury by Cold Vapour AAS.
Metals-021 CV-AAS	Determination of Mercury by Cold Vapour AAS.
Metals-022 ICP-MS	Determination of various metals by ICP-MS.

QUALITY CONTROL: Acid Extractable metals in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date digested	-			14/10/2020	3	14/10/2020	14/10/2020		14/10/2020	[NT]
Date analysed	-			15/10/2020	3	15/10/2020	15/10/2020		15/10/2020	[NT]
Silver	mg/kg	1	Metals-020 ICP-AES	<1	3	<1	<1	0	98	[NT]
Aluminium	mg/kg	10	Metals-020 ICP-AES	<10	3	4700	3600	27	98	[NT]
Antimony	mg/kg	7	Metals-020 ICP-AES	<7	3	<7	<7	0	102	[NT]
Arsenic	mg/kg	4	Metals-020 ICP-AES	<4	3	<4	<4	0	108	[NT]
Boron	mg/kg	3	Metals-020 ICP-AES	<3	3	<3	<3	0	89	[NT]
Barium	mg/kg	1	Metals-020 ICP-AES	<1	3	15	11	31	104	[NT]
Beryllium	mg/kg	1	Metals-020 ICP-AES	<1	3	<1	<1	0	109	[NT]
Bismuth	mg/kg	1	Metals-020 ICP-AES	<1	3	<1	<1	0	91	[NT]
Cadmium	mg/kg	0.4	Metals-020 ICP-AES	<0.4	3	<0.4	<0.4	0	104	[NT]
Cobalt	mg/kg	1	Metals-020 ICP-AES	<1	3	1	1	0	103	[NT]
Chromium	mg/kg	1	Metals-020 ICP-AES	<1	3	8	7	13	103	[NT]
Copper	mg/kg	1	Metals-020 ICP-AES	<1	3	<1	<1	0	101	[NT]
Caesium*	mg/kg	1	Metals-020 ICP-AES	<1	3	<1	<1	0	100	[NT]
Gallium	mg/kg	1	Metals-020 ICP-AES	<1	3	2	2	0	115	[NT]
Gold*	mg/kg	1	Metals-020 ICP-AES	<1	3	<1	<1	0	99	[NT]
Iron	mg/kg	10	Metals-020 ICP-AES	<10	3	12000	13000	8	99	[NT]
Lanthanum*	mg/kg	1	Metals-020 ICP-AES	<1	3	9	8	12	111	[NT]
Lead	mg/kg	1	Metals-020 ICP-AES	<1	3	4	4	0	98	[NT]
Lithium	mg/kg	1	Metals-020 ICP-AES	<1	3	1	1	0	90	[NT]

QUALITY CONTROL: Acid Extractable metals in soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Manganese	mg/kg	1	Metals-020 ICP-AES	<1	3	10	12	18	105	[NT]
Mercury	mg/kg	0.1	Metals-021 CV-AAS	<0.1	3	<0.1	<0.1	0	110	[NT]
Molybdenum	mg/kg	1	Metals-020 ICP-AES	<1	3	<1	<1	0	100	[NT]
Nickel	mg/kg	1	Metals-020 ICP-AES	<1	3	1	1	0	99	[NT]
Selenium	mg/kg	2	Metals-020 ICP-AES	<2	3	<2	<2	0	100	[NT]
Strontium	mg/kg	1	Metals-020 ICP-AES	<1	3	2	2	0	107	[NT]
Sulphur	mg/kg	10	Metals-020 ICP-AES	<10	3	31	33	6	105	[NT]
Tellurium	mg/kg	1	Metals-020 ICP-AES	<1	3	<1	<1	0	98	[NT]
Thallium	mg/kg	2	Metals-020 ICP-AES	<2	3	<2	<2	0	97	[NT]
Tin	mg/kg	1	Metals-020 ICP-AES	<1	3	<1	<1	0	99	[NT]
Titanium	mg/kg	1	Metals-020 ICP-AES	<1	3	9	9	0	108	[NT]
Thorium	mg/kg	2	Metals-022 ICP-MS	<2	3	3	2	40	106	[NT]
Uranium	mg/kg	1	Metals-022 ICP-MS	<1	3	<1	<1	0	107	[NT]
Vanadium	mg/kg	1	Metals-020 ICP-AES	<1	3	28	31	10	102	[NT]
Yttrium*	mg/kg	1	Metals-020 ICP-AES	<1	3	4.8	4.5	6	98	[NT]
Zinc	mg/kg	1	Metals-020 ICP-AES	<1	3	1	<1	0	102	[NT]

QUALITY CONTROL: All metals in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			16/10/2020	[NT]	[NT]	[NT]	[NT]	16/10/2020	[NT]
Date analysed	-			16/10/2020	[NT]	[NT]	[NT]	[NT]	16/10/2020	[NT]
Silver-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Aluminium-Total	µg/L	10	Metals-022 ICP-MS	<10	[NT]	[NT]	[NT]	[NT]	106	[NT]
Arsenic-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Boron-Total	µg/L	20	Metals-022 ICP-MS	<20	[NT]	[NT]	[NT]	[NT]	107	[NT]
Barium-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Beryllium-Total	µg/L	0.5	Metals-022 ICP-MS	<0.5	[NT]	[NT]	[NT]	[NT]	103	[NT]
Bismuth-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	119	[NT]
Cadmium-Total	µg/L	0.1	Metals-022 ICP-MS	<0.1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Cerium-Total*	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	102	[NT]
Cobalt-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Chromium-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	102	[NT]
Copper-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Caesium-Total*	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Gallium-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	103	[NT]
Mercury-Total	µg/L	0.05	Metals-021 CV-AAS	<0.05	[NT]	[NT]	[NT]	[NT]	85	[NT]
Iron-Total	µg/L	10	Metals-022 ICP-MS	<10	[NT]	[NT]	[NT]	[NT]	103	[NT]
Lanthanum-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
Lithium-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Manganese-Total	µg/L	5	Metals-022 ICP-MS	<5	[NT]	[NT]	[NT]	[NT]	105	[NT]

QUALITY CONTROL: All metals in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Molybdenum-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Niobium-Total*	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	111	[NT]
Nickel-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Lead-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Rubidium-Total*	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	105	[NT]
Rhenium-Total*	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	108	[NT]
Antimony-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	110	[NT]
Scandium-Total*	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	108	[NT]
Selenium-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Tin-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]
Strontium-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	103	[NT]
Tantalum-Total*	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	102	[NT]
Tellurium-Total*	µg/L	0.5	Metals-022 ICP-MS	<0.5	[NT]	[NT]	[NT]	[NT]	102	[NT]
Thorium-Total	µg/L	0.5	Metals-022 ICP-MS	<0.5	[NT]	[NT]	[NT]	[NT]	95	[NT]
Thallium-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	104	[NT]
Titanium-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	103	[NT]
Uranium-Total	µg/L	0.5	Metals-022 ICP-MS	<0.5	[NT]	[NT]	[NT]	[NT]	101	[NT]
Vanadium-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	102	[NT]
Tungsten-Total	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	107	[NT]
Yttrium-Total*	µg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]

QUALITY CONTROL: All metals in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Zinc-Total	μg/L	1	Metals-022 ICP-MS	<1	[NT]	[NT]	[NT]	[NT]	106	[NT]

QUALITY CONTROL: Metals in Waters - Total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			20/10/2020	[NT]	[NT]	[NT]	[NT]	20/10/2020	[NT]
Date analysed	-			20/10/2020	[NT]	[NT]	[NT]	[NT]	20/10/2020	[NT]
Sulfur -Total	mg/L	0.5	Metals-020 ICP-AES	<0.5	[NT]	[NT]	[NT]	[NT]	110	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

METALS: The PQL has been raised for Cadmium & Copper due to the sample matrix requiring dilution.

PQL has been raised for Cadmium due to the high moisture content in the sample, resulting in a high dilution factor.

UNEP Global Mercury Partnership

Partnership Areas: Mercury in Gold Mining, Mercury Supply and Storage, Mercury Air Transport and Fate, Mercury in Products.

DATA From Envirolab Analysis #22941 dated 16/10/2020

HI = +QTY Chemical / TDD

Author: Andrew Helps [redacted]

Conversion Factors

To Convert concentrations in air(at 25^{0}C) from PPM to mg/m^3 = **6/12/2020**

(ppm) x (molecular weight of the compound) / (24.45) e.g for Antimony 1 ppm = 4.97 mg/m^3.)

KALBAR Resources Lindenow (Vic) Project

Note*
A Hazard Index in excess of 10 requires investigation and or remediation

PDRV - Prioritised Dose Response Value

Rare Earth/Toxic Element/Compound Calculation Template   Lindenow Testing on 13/10/2020

Revision 33   *Rare Earths in Italics*
6th February 2021

#	CHEMICAL ELEMENTS/COMPOUNDS: mg/kg - ug/kg	Specific Gravity	Metal Group	Formula Weight (Molecular Weight)	California Rated as Carcinogen	ATSDR Rank	HBTOM* Ref Pages	Ignition Temperature (Dust ^{0}C)	Solubility in 100 parts Cold Water Formular Dependent D= Dissolves	ATSDR MRL's Chronic mg/kg/day	Australia Residential Soil mg/kg (HIL A)	ATSDR & USEPA Resident Air Carcinogenic Target Risk ug/m^3	ATSDR & USEPA Resident Tapwater mg/L	Australia Resident Tapwater ug/L	ATSDR SPL THEORETICAL Daily Dose TDD (mg/day) (Fit 70kg male)	USEPA PDRV* Non Cancer	CHRONIC INHALATION Data Source	USEPA PDRV* Cancer	USEPA PDRV* Cancer micrograms	13/10/2020 Water L-25 ug/L	Exceedence USEPA Tapwater	13/10/2020 Water L-28 ug/L	Exceedence USEPA Tapwater	13/10/2020 Sand L26 mg/kg	13/10/2020 Sand L27 mg/kg	13/10/2020 Sand L29 mg/kg	13/10/2020 Sand L30 mg/kg
1	Aluminium (Al)	2.70 g/cm^3	Group 13	26.97	Carcinogen	183	549-560	650	i	1		0.52	2000		10.323	Neurological	ATSDR			12000	6	43000		13000	4700	28000	14000
2	Antimony (Sb)	6.69 g/cm^3	Group 15	121.76	Carcinogen	232	565-572	420	i	0.0003		0.021	0.78	3	0.103992	0.2ug/m^3	IRIS IARC 2B	0.2ug/m^3	0.2	<1		<1		<7	<7	<7	<7
3	Arsenic (see note 1)	5.73 g/cm^3	Group 15	299.64	Carcinogen	1	582-610	815	i	0.0003	100	0.00065	0.052	10	0.071278	0.015ug/m^3	Cal IARC 1	0.015ug/m^3	0.0043ug/m^3	3	57.69	4.00		5.00	<4	8.00	4.00
4	Boron	2.47 g/cm^3	Group 13									2.1	400							30	0.08	60.00		<3	<3	15.00	<3
5	Arsine (gaseous AsH3)	2.769 g/cm^3	Group 15	77.93	Carcinogen	1	615	285	20cc			0.005	0.007			0.05 ug/m^3	IARC 1	0.0043ug/m^3	0.0043					?	?	?	?
6	Barium	3.51 g/cm^3	Group 2	137.36		134	625-633	725	D	0.2		0.00108	0.51499		0.61652					37.00	71.85	150.00		18	15.0	58.0	22.0
7	Beryllium (glucinum)	1.85 g/cm^3	Group 4	9.02	Carcinogen	43	636-651	1278	i	0.002	60	0.00000	2.50	60.0	0.0078	0.01 ug/m^3	IRIS IARC 1	0.0024ug/m^3	0.0024	<0.5		3.00		<1	<1	<1	<1
8	Bismuth (Bi)	9.72 g/cm^3	Group 4	209.00			655-663	271.3	i											<1		<1		<1	<1	<1	<1
9	Cadmium (Cd)	8.65 g/cm^3	Group 12	112.41	Carcinogen	7	668-708	1040	i	0.0005	20	0.00001	0.92	2	0.045127	0.01 ug/m3	ATSDR	0.0018ug/m^3	0.0018	<0.2		<0.2		<0.4	<0.4	<0.8	<0.4
11	Ceric Oxide (Cerium)$Ce0_2$	6.71 g/cm^3	Group 3	172.13	Suspected	570	101-102	3500	i	1 mSv/yr		0.094								14.00		66.00					
14	Chromium compounds (Cr)	7.19 g/cm^3	Group 6	52.01	Carcinogen	66	717-739	580	i	0.0009		0.00001			0.00263					11		48					
15	Cobalt (Co)	8.85 g/cm^3	Group 9	58.94	Carcinogen	52	743-759	760	i	1 mSv/yr	100	0.000031	0.6		0.67523	0.1 ug/m^3	ATSDR			1.0	1.67	6.00		2.00	1.00	8.00	3
	Caesium																			<1		2.00		1.00	1.00	1.00	1.00
16	Copper (Cu)	8.94 g/m^3	Group 11	63.57		125	765-782	900	i	0.01	6000		80	2000	0.47242					<2		5.00		<1	<1	570	<1
17	*Dysprosium $Dy20_3$*	8.53 g/m^3	Group 3	162.5	Suspected			2567	i																		
18	*Erbium $Er20_3$*	9.04 g/m^3	Group 12	167.26	Suspected			1529	i																		
19	*Europium $Eu0_3$*	5.25 g/cm^3	Group 3	151.96	Suspected	575		1800	i																		
20	*Gadolinium $Gd2p0_3$*	7.87 g/cm^3	Group 3	157.25	Suspected			3545	i																		
21	*Gallium*	5.91 g/cm^3	Group 13	69.72	Carcinogen		787-797	29.78				0.00001			0.00011									4.00	2	13	6.00
22	*Germanium*	5.32 g/cm^3	Group 14	72.63			800-813		i																		
23	*Holmium $Ho20_3$*	8.80 g/m^3	Group 12	164.93	Suspected			1474	i																		
24	Iron	7.87 g/cm^3	Group 8	55.85			878-902	420	i			0.01626	11.29		18.07					8100.00	717.45	30000.00		30000	12000	37000	26000
25	*Lanthanum -138*	6.17 g/m^3	Group 3	138.92	Suspected	711	903-908	920	i			0.00018	0.00268		0.02188					9.00	3358.21	43.00	**16044.78**	16	9	27	15
26	Lead - not 210 (Pb)	11.34 g/cm^3	Group 14	430.42	Carcinogen	2	129-131	710	i		300		15	10	0.330938	0.15 ug/m^3	OAQPS			6	0.40	30.0		10	4	29	11
27	*Lithium Oxide Li_2O*	0.53 g/cm^3	Group 1	29.88	Suspected	335	969-974	2600	to Li0H	0.404424			0.3835		0.404424		ATSDR			3.00	7.82	15.00		4	1	11	5
28	*Lutetium -176*	9.84 g/cm^3	Group 3	174.99	Suspected			1936	i																		
29	Magnesium	3.58 g/cm^3	Group 2	24.32				520	i			0.0907	33.3369		35.96134												
30	Manganese	7.47 g/cm^3	Group 6	54.93		140	975-1005	1246	D	0.3 ug/m3	3800	0.05	43	500	1.61855	0.03 ug/m^3	ATSDR			120	2.79	93		33	10	190	31
31	Mercury	13.55 g/cm^3	Group 12	200.61	Suspected	3	1014-1064	to gas @10^{0}C	i	0.0002 mg/m3	40		0.063	1	0.051981	0.3ug/m^3	IRIS			<0.05		<0.05		<0.1	<0.1	<0.1	<0.1
32	Methyl Mercury	215.63g/mol	Group 12	417.22	Suspected	120	448-450	within organics	i	0.0003			0.2			0.1 ug/m^3	IRIS	0.1 ug/m^3	0.1		0.00						
33	Molybdenum	10.22 g/cm^3	Group 6	95.95		326	1077-1107	720	i	0.00004 mg/m^3			10	50	0.2412	0.2ug/m^3	IARC 2B			<1		<1		<1	<1	<1	<1
34	Nickel	8.90 g/cm^3	Group 10	58.69	Carcinogen	57	1091-1107	950+	i	0.00009 mg/m^3	400		20	20	0.38969	0.09 ug/m^3	ATSDR/CAL	0.00024 ug/m^3	0.00024	4	0.20	12.0		4.0	1	15	4
35	*Neodymium 144*	7.00 g/cm^3	Group 3	144.27	Suspected			1021	D											2.70		2.40					
36	*Palladium*	12.99 g/cm^3	Group 10	106.7	Suspected	173	1113-1121	2963	i			0.012000			0.00018												
37	*Platinum*	21.45 g/cm^3	Group 10	195.23			1125-1138		i																		
38	*Praseodymium Pro_6*	6.78 g/cm^3	Group 3	140.92	Suspected			3512	D																		
40	*Radium 222 , 226 or 228*	5.5 g/cm^3	Group 2	226.05	Carcinogen			1500	i			5pCi total combined per litre of water															
41	*Radium Bromide*	5.79 g/cm^3	Group 2	385.88																							
42	*Rhodium*	8.85 g/cm^3	Group 9	102.91			1143-1171		i																		
43	*Rubidium*	1.63 g/cm^3	Group1	85.48	Suspected	711			D			0.00001			0.000091					8.00		31.00					
44	*Samarium 147 (Chloride)*	7.54 g/cm^3	Group 3	150.43	Suspected				NK	:PA Doc EPA/690/R-09/050F																	
45	*Scandium $Sc2O_3$*	2.99 g/cm^3	Group 3	45.1	Suspected	584			NK											<1		8.00					
46	Selenium	4.50 g/cm^3	Group 16	631.68	Suspected	146	1176-1203	950+	i	0.005 mh/kg/day	200	0.00002	0.03657	10	0.03778	20 ug/m^3	CAL			<1		5.00		<2	<2	<2	<2
47	Silica $PM_{2.5}$ Faction)	2.33 g/cm^3	Group 14	60.06	Carcinogen		102	780	i				0.31000		Annual av												
48	Sulphur (%)	2.067 g/cm^3	Group 16	32.06				392	i			0.00122			0.01829												
49	Strontium SrO (Stable)	2.64 g/cm^3	Group 2	87.63	Carcinogen		455	768.85	D	2 mg/kg/day										28		69		5	2	31	4
50	*Tellurium*	6.24 g/cm^3	Group 16	127.61	Carcinogen		1218-1226	449.51	i			0.00003			0.00039					<0.5		<0.5		<1	<1	<1	<1
51	*Terbium $Tb40_7$*	8.27 g/cm^3	Group 3	159.2	Suspected			1356	NK																		
52	*Thallium*	11.86 g/cm^3	Group 13	204.39	Suspected	279	1229-1238	303	i			0.00007	0.01355		0.01579					<1		<1		<2	<2	<2	<2
54	*Thorium 229*	11.73 g/cm^3	Group 3	232.12	Carcinogen	227		270	i								IARC I	0.000185 pCi/m^3		1.0		5.0		6	3	5	6
55	*Thulium $Tm2O_3$*	9.33 g/cm^3	Group 12	169.4	Suspected			1950	i																		
56	Titanium	4.54 g/cm^3	Group 4	47.9	Carcinogen	310	1287-1294	460	i	0.0001 mg/m3			0.021		2.271688	0.01 ug/m^3	ATSDR	Respiratory		110		76					
57	Tin	7.29 g/cm^3	Group 14	118.7		307	1242-1276	630	i	0.3 mg/kg/day			1200	1200	0.09981					2.0		<1					
58	Tungsten	19.25 g/cm^3	Group 6	183.92			1297-1305	950	i											<1		<1					
59	Uranium 234	19.05 g/cm^3	Group 7	238.07	Carcinogen	97	1308-1338	20	i	0.00004 mg/m3										0.6		3.5		<1	<1	2	1
60	Vanadium (86%)	6.10 g/cm^3	Group 5	50.95	Carcinogen	200	1348-1364	500	i	0.0001 mg/m3			8.6		0.123043		CAL		0.00034	13		53		50	28	62	54
61	*Ytterbium $Yb2O_3$*	6.95 g/cm^3	Group 3	173.04	Suspected	581			NK																		
62	*Yttrium $Y2O_3$*	4.47 g/cm^3	Group 3	88.92	Suspected	711			D			0.0000006			0.000118					6.70		33.00		7.60	4.8	15	7.8
63	Zinc	7.14 g/cm^3	Group 12	65.38		75	1369-1382	600	i	0.3 mg/kg/day	7400		600		1.96084					9		25.0		4	1	280	3
64	Zirconium	6.51 g/cm^3	Group 4	91.22	Carcinogen	701		20	i				0.16	0.000022	0.00032												
65	Hydrogen Cyanide	0.69g/cm^3		179.16	Reproductive	35			NK		250		0.15	80	1.3058												
66	PM10								Particle	ICPMS Analysis					24 hour av												
67	PM2.5				Carcinogen				Particle	ICPMS Analysis					24 hour av	Annual Average											
	Radionuclides (Uranium)	18.7 g/cm^3	Group 3	238.03	Carcinogen	102	1307-1345		i									0.000185 pCi/m^3									

Note 1 **USEPA Residential level Average fit healthy 70 kg male inhales 50.4 m3 a day**

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TABLE 1 Potential Health Effects Caused by Some Metals Found in Human Body Fluids

	Cancer	Reproductive disorders	Immune function	Renal dysfunction	Liver dysfunction	Neurotoxic disorders
Aluminum						°
Arsenic	°	°	°	°	°	°
Barium				°		
Beryllium			°			
Cadmium	°	°		°		
Chromium	°			°	°	
Cobalt			°			
Copper			°	°	°	
Lead		°	°	°		°
Manganese						°
Mercury		°	°	°		°
Nickel	°		°			
Silver			°			
Thallium				°	°	°
Thorium					°	
Uranium				°		

emissions. However, a minimum amount of information should be available to enable a mixture to be classified as sufficiently similar to the mixture of concern. For example, if a risk assessment is needed for gasoline contamination of groundwater and information is available on the chronic toxic effects of gasoline, then it may be possible to use the available information to assess risks from the contaminated groundwater. However, there are no set criteria to help decide when a mixture is sufficiently similar. Hence, the health assessor is left to determine whether the two chemical mixtures are sufficiently similar and whether this similarity justifies use of surrogate risk or toxicity data. The first two approaches, "mixture of concern" and "similar mixture," are used for those mixtures that have been experimentally tested as a whole to some extent.

5.2.3 *Hazard Index Approach*

The third approach, the "hazard index" (HI) approach, is the method used most often. This approach integrates the exposure level and the related toxicity into a single value by the use of a potency-weighted dose or response addition. The goal of the HI approach is to approximate the toxicity index that would have been determined had the mixture itself been tested (Mumtaz et al., 2002). Initially, the potential health hazard from exposure to each chemical is estimated by calculating its individual hazard quotient (HQ). The HQ is derived by dividing a chemical's actual exposure level through an environmental medium by its acceptable/allowable exposure level (AE), such as an MRL or a reference dose (RfD). The HI of the mixture is then calculated by adding together all the component HQs, as illustrated below for three chemicals in a mixture:

$$HI = \frac{Chem.\,exposure_1}{AE1} + \frac{Chem.\,exposure_2}{AE2} + \frac{Chem.\,exposure_3}{AE3}$$

In a manner analogous to the HI approach for noncarcinogens, a HI for carcinogens can be estimated by dividing chemical exposure levels by the doses associated with a set level of cancer risk (EPA, 1986,2000):

$$HI = \frac{Chem.\,Exposure_1}{DR_1} + \frac{Chem.\,Exposure_2}{DR_2} + \frac{Chem.\,Exposure_3}{DR_3}$$

In terms of estimating risk, the HI values obtained using the HI approach should be interpreted carefully. For example, if chemical mixture "X" yields an HI value of 4, it need not be interpreted as being twice as toxic as mixture "Y" that yields a value of 2. However, it can be said that mixture "X" is more toxic than mixture "Y". Thus, the HI approach can be used for priority setting of mixtures. As the value of the HI increases toward unity, the potential hazard of a mixture increases. The potential health effects of a mixture are further analyzed and investigated if the HI value is equal to or greater than 1, since it is based on the concept of dose additivity (Teuschler and Hertzberg; 1995; U.S EPA, 2000). For carcinogens, the preceding equation assumes that each carcinogen has a linear dose-response curve and that each carcinogen is acting independently (EPA, 1986).

5.2.4 *Target-Organ Toxicity Dose*

In terms of estimating risk, it is important that the estimates are realistic. The use of acceptable exposure

Year	Rank	Substance Name	CAS Registry Number	Toxicity	Water GMMC (mg/L)	Soil GMMC (mg/kg)	Air GMMC (mg/m3)	Theoretical Daily Dose (TDD) (mg/day)
2019	1	ARSENIC	7440-38-2	1	0.06030	48.63636	0.00007	0.07113
2019	2	LEAD	7439-92-1	10	0.11817	884.79106	0.00243	0.33153
2019	3	MERCURY	7439-97-6	1	0.00350	2.71690	0.00314	0.05109
2019	7	CADMIUM	7440-43-9	10	0.03876	19.40584	0.00012	0.04444
2019	17	CHROMIUM, HEXAVALENT	18540-29-9	1	0.81491	46.31430	0.00000	0.82422
2019	35	CYANIDE	57-12-5	10	0.23628	27.02039	0.07093	1.30565
2019	52	COBALT	7440-48-4	10	0.06399	17.07890	0.00003	0.06780
2019	58	NICKEL	7440-02-0	100	0.30382	90.24526	0.00462	0.39114
2019	66	CHROMIUM(VI) TRIOXIDE	1333-82-0	1	0.15211	2.13689		0.15254
2019	69	METHANE	74-82-8	10	0.48000		529.80386	7947.53787
2019	75	ZINC	7440-66-6	1000	1.68153	1400.12252	0.00260	2.00056
2019	78	CHROMIUM	7440-47-3	5000	0.20702	198.07556	0.00059	0.25551
2019	95	RADIUM-226	13982-63-3	1				
2019	97	URANIUM	7440-61-1	1				
2019	101	RADIUM	7440-14-4	1				
2019	102	THORIUM	7440-29-1	1				
2019	106	RADON	10043-92-2	1				
2019	108	RADIUM-228	15262-20-1	1				
2019	109	THORIUM-230	14269-63-7	1				
2019	110	URANIUM-235	15117-96-1	1				
2019	111	THORIUM-228	14274-82-9	1				
2019	112	RADON-222	14859-67-7	1				
2019	113	URANIUM-234	13966-29-5	1				
2019	118	PLUTONIUM-239	15117-48-3	1				
2019	119	POLONIUM-210	13981-52-7	1				
2019	120	COPPER	7440-50-8	5000	0.37123	431.11606	0.00091	0.47117
2019	121	PLUTONIUM-238	13981-16-3	1				
2019	122	LEAD-210	14255-04-0	1				
2019	123	AMOSITE ASBESTOS	12172-73-5	1				
2019	123	PLUTONIUM	7440-07-5	1				
2019	123	STRONTIUM-90	10098-97-2	1				
2019	126	RADON-220	22481-48-7	1				
2019	136	BARIUM	7440-39-3	1000	0.51499	426.64488	0.00108	0.61652
2019	140	MANGANESE	7439-96-5	5000	1.36531	1219.24985	0.00102	1.62443
2019	147	SELENIUM	7782-49-2	100	0.03657	5.36217	0.00002	0.03795
2019	201	VANADIUM	7440-62-2	1000	0.10855	57.46577	0.00020	0.12304
2019	217	CESIUM-137	10045-97-3	10				
2019	217	Chromic Acid	7738-94-5	10				
2019	219	POTASSIUM-40	13966-00-2	10				
2019	225	THORIUM-227	15623-47-9	10				
2019	226	NITRATE	14797-55-8	1000	21.42883	103.78191	0.02715	21.85683
2019	227	ARSENIC ACID	7778-39-4	1				
2019	228	ARSENIC TRIOXIDE	1327-53-3	1				
2019	229	SILVER	7440-22-4	1000	0.02696	8.25419	0.00003	0.02901
2019	235	ARSINE	7784-42-1	1				
2019	239	MERCURIC CHLORIDE	7487-94-7	1				
2019	239	SODIUM ARSENITE	7784-46-5	1				
2019	239	URANIUM-233	13968-55-3	1				
2019	244	ANTIMONY	7440-36-0	5000	0.08579	75.25725	0.00012	0.10261
2019	279	THALLIUM	7440-28-0	1000	0.01358	6.04104	0.00007	0.01582
2019	311	TIN	7440-31-5	1000	0.07865	96.69555	0.00012	0.09981
2019	312	ANTHRACENE	120-12-7	5000	0.07213	19.11067	0.00002	0.07630
2019	313	TITANIUM	7440-32-6	1000	2.25872	58.79488	0.00008	2.27169
2019	334	MOLYBDENUM	7439-98-7	1000	0.22919	56.17243	0.00005	0.24120
2019	337	BORON	7440-42-8	5000	1.64915	181.03419		1.68535
2019	344	LITHIUM	7439-93-2	1000	0.38352	104.50714		0.40442
2019	351	CHROMIUM, TRIVALENT	16065-83-1	1000	0.10818	299.78167		0.16814
2019	356	CYANIDE, SODIUM	143-33-9	10				
2019	356	LEAD OXIDE	1317-36-8	10				
2019	375	ALUMINUM CHLORIDE	7446-70-0	10				
2019	375	ZINC OXIDE	1314-13-2	10				
2019	399	SULFIDE	18496-25-8	5000	3.09101	396.33319		3.17028
2019	439	SULFUR	7704-34-9	5000			0.00122	0.01829
2019	448	INDIUM	7440-74-6	1000			0.00002	0.00027
2019	453	LEAD-212	15092-94-1	100				
2019	470	TRITIUM	10028-17-8	1000				
2019	478	TUNGSTEN	7440-33-7	1000				
2019	479	GERMANIUM	7440-56-4	1000			0.00000	0.00002
2019	496	TELLURIUM	13494-80-9	1000			0.00003	0.00039
2019	500	COBALT-60	10198-40-0	100				
2019	570	CERIUM	7440-45-1	5000				
2019	573	NEODYMIUM	7440-00-8	5000				
2019	575	DYSPROSIUM	7429-91-6	5000				
2019	575	EUROPIUM	7440-53-1	5000				

Year	Rank	Substance Name	CAS Registry Number	Toxicity	Water GMMC (mg/L)	Soil GMMC (mg/kg)	Air GMMC (mg/m3)	Theoretical Daily Dose (TDD) (mg/day)
2019	575	PRASEODYMIUM	7440-10-0	5000				
2019	575	SAMARIUM	7440-19-9	5000				
2019	581	YTTERBIUM	7440-64-4	5000				
2019	583	GALLIUM	7440-55-3	5000			0.00001	0.00011
2019	584	SCANDIUM	7440-20-2	5000				
2019	585	INDAN	496-11-7	1000	0.00002	0.46900		0.00012
2019	612	ANTIMONY TRIOXIDE	1309-64-4	1000				
2019	711	CESIUM	7440-46-2	50000				
2019	711	IRON	7439-89-6	50000	11.29038	33072.13825	0.01626	18.14875
2019	711	LANTHANUM	7439-91-0	50000			0.00018	0.00268
2019	711	MAGNESIUM	7439-95-4	50000	33.33691	6317.86906	0.09072	35.96134
2019	711	NITROGEN	7727-37-9	50000	14.77943			14.77943
2019	711	NITROGEN OXIDE	10024-97-2	50000				
2019	711	POTASSIUM	7440-09-7	50000	13.30819	1379.44670	0.37635	19.22941
2019	711	RUBIDIUM	7440-17-7	50000			0.00001	0.00009
2019	711	SILICON	7440-21-3	50000	55.34264		0.32500	60.21764
2019	711	SODIUM	7440-23-5	50000	136.06748	819.01805	0.99375	151.13748
2019	711	SULFATE	14808-79-8	50000	737.54456	4588.94808	0.12563	740.34675
2019	711	YTTRIUM	7440-65-5	50000		0.10488	0.00001	0.00012
2019	711	ZIRCONIUM	7440-67-7	50000			0.00002	0.00032