Human health risk assessment

How can we use HHRA - Case examples

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Example – Change of land use

- Development of former industrial site for residential landuse or more sensitive use such as childcare
- Key issues most commonly relate to site contamination

Data

- Soil – relevance for exposure
- Groundwater or surface water
- Air – soil vapour
- Tier 1 – done correctly

Exposure

- Who exposed and how
- Onsite and/or offsite
- Look for how exposure has been characterised, NEPM has default assumptions
- Bioaccessibility??

Hazard/Dose-response

- Identified quantitative toxicity values for all key chemicals
- Need to use appropriate values, relevant to the exposure (oral, dermal, inhalation)
- Accounted for background intakes

Risk characterisation

- What are the calculated risks?
- What is the margin of safety?
- Do the uncertainties matter for the conclusions?

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Example – New childcare centre

Table 4 Screening Assessment – Soil

Key Chemicals	Maximum Concentration (mg/kg)	Location	Screening Concentration (low density residential) (mg/kg)	Screening Concentration (public open space/park) (mg/kg)	CoPCs (Y/N?)
Arsenic	10	06 (0-0.1 m)	100[N]	300[N]	N
Cadmium	5	09A/08 (0.3 m) and 10A (0.1 m)	20[N]	90[N]	N
Chromium	17	06 (0-0.1 m) and 07/07A (0.3 m)	100[N]	300[N]	N
Copper	20	03 (0-0.1 m)	6000[N]	17000[N]	N
Lead (surface)	510	07/07A (0-0.1 m)	300[N]	600[N]	Y
Lead (depth)	2000	SV1 (base of excavation at 03)			Y
Mercury	0.1	07/07A (0-0.1 m)	40[N]	80[N]	N
Nickel	5	01 (0-0.1 m) and 03 (0-0.1 m)	400[N]	1200[N]	N
Zinc	250	07/07A (0-0.1 m)	7400[N]	30000[N]	N
Benzo[a]pyrene TEQs	2.3	07/07A (0.3 m)	3[N]	3[N]	N
Acenaphthylene	0.4	07/07A (0.3 m)	3 400[RS]	3 400[RS]	N
Anthracene	0.6	07/07A (0.3 m)	17 000[R]	17 000[R]	N
Benzo(a)pyrene	1.5	07/07A (0.3 m)	See BaP TEQs	See BaP TEQs	--
Benzo(a)anthracene	2	07/07A (0.3 m)	See BaP TEQs	See BaP TEQs	--
Benzo(b+k)fluoranthene	2.7	07/07A (0.3 m)	See BaP TEQs	See BaP TEQs	--
Benzo(g,h,i)perylene	0.6	07/07A (0.3 m)	See BaP TEQs	See BaP TEQs	--
Chrysene	1.3	07/07A (0.3 m)	See BaP TEQs	See BaP TEQs	--
Dibenz(a,h)anthracene	0.1	07/07A (0.3 m)	See BaP TEQs	See BaP TEQs	--
Fluoranthene	3.8	07/07A (0.3 m)	2300[R]	2300[R]	N
Fluorene	0.9	03 (0-0.1 m)	2300[R]	2300[R]	N
Indeno(1,2,3-c,d)pyrene	0.9	07/07A (0.3 m)	See BaP TEQs	See BaP TEQs	--
Phenanthrene	2.2	07/07A (0.3 m)	1700[RS]	1700[RS]	N
Pyrene	3.4	07/07A (0.3 m)	1700[R]	1700[R]	N
TRH >C16-C34	190	01A (0-0.1 m) and 04A (0-0.1 m)	2 500 [M]	2 500 [M]	N

Notes:

Refer to **Appendix A** for full analytical results

N = NEPM HIL/HSL for residential soil and recreational soil (NEPC 1999 amended 2013a)

C = CRC CARE HSLs (2011) HSL-A&B and HSL-trench worker/sand/0-1 m (actual values – saturation not considered)

R = USEPA RSL for residential soil as no NEPM HIL (USEPA 2016)

RS = USEPA RSL for residential soil as no NEPM HIL for surrogate compound (acenaphthene for acenaphthylene and pyrene for phenanthrene) (USEPA 2016)

M = NEPM Management Limit for TRH >C16-C34 fraction in coarse soil (NEPC 1999 amended 2013a)

Table 5 Summary and Review of Bioaccessibility Data

Sample ID	Gastric Phase Bioaccessibility [1]	Intestinal Phase Bioaccessibility [1]	Relative Intestinal Phase Bioaccessibility[1]
SV1	85.8	22.1	100
07/07A	67.2	12.4	100

Notes:

1 = Refer to **Appendix B** for further information

The bioaccessibility analysis indicated that:

- Gastric phase bioaccessibility is in the range 70-86%;
- Intestinal phase bioaccessibility is in the range 12-22%;
- Relative intestinal phase bioaccessibility is 100% for both samples; and
- Bioaccessibility values determined for the QC sample run by UniSA (QC1) were within the acceptable range.

Given these results, the HHRA has assumed that the bioaccessibility of lead in soil is 100%. This means the total bioavailability (= bioaccessibility x adsorption) is 50% for children (including teenagers) and 20% for adults (NEPC 1999 amended 2013c).

Table 8 Exposure assumptions and RBC – blood lead model

Parameter	Low Density Residential (HIL-A)	Open Space/ Parkland (HIL-C)	Site-specific – 1	Site-specific – 2
Number of days per year present at the centre (note this cannot be changed in the USEPA model)	365	365	365	240 (calculated by adjusting soil intake to achieve 50 mg/day over 240 days)
Background Exposure (including water and air)	Same values used for all calculations			
Number of years present at the site	The calculation targets young children and assumes they are exposed from 0-6 years			
Ingestion of soil while playing outdoors#	50 mg/day	50 mg/day	50 mg/day	50 mg/day
Ingestion of dust while indoors	50 mg/day	0 mg/day	10 mg/day	10 mg/day
Background Food Level as provided by FSANZ (2011)	Yes	Yes	Yes	Yes
% available in soil for absorption	100%	100%	100%	100%
Guideline	**300 mg/kg**	**600 mg/kg**	**470 mg/kg**	**710 mg/kg**

Notes:

no change has been made to the amount of soil it is assumed the children may consume at the centre even with the discussion above about hand washing. The site-specific guideline still assumes the same amount of outdoor soil is consumed as does the national guideline calculations.

So is remediation required?

- Surface soil: most relevant to exposure – below site-specific guideline
- Soil at depth: unlikely to be relevant to exposure – exceeds site-specific guideline
- Also assess if child digs to depth – lower level of exposure and risks acceptable
- Risk management measure: use marker layer to identify where impacts at depth, and have management plan
- Outcome: no soil excavation and disposal required (significant cost saving) and information available to demonstrate low risk

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Example – Primary school

- Historical fill that includes elevated concentrations of lead and carcinogenic PAHs (as BaP TEQ)

Data

- Sampling from areas accessible by children and adults (teachers and gardeners, construction
- Analysis for relevant chemicals
- Comparison with residential – tier 1 guidelines

Exposure

- Who exposed and how
- What data is relevant to assess exposure
- Bioaccessibility??
- Management measures proposed – if any?

Hazard/Dose-response

- Identified quantitative toxicity values for all key chemicals
- Any additional considerations for children

Risk characterisation

- What are the risks?
- Can these risks be prevented through management?

Primary school

All risks calculated as low and acceptable

Remediation: none required for ongoing use

Table 4: Summary of exposure assumptions

Exposure Parameter	Assumptions adopted for children attending primary school (aged 5-12 years) **Exposure to impacts in fill**
Exposure frequency	200 days per year, assuming children access exposed soil/fill for some time every school day (expected to be conservative)
Exposure duration	7 years (duration of time at primary school)
Body weight	30.5 kg (mean for children aged 5 to 12 years (enHealth 2012a)
Soil concentration	Lead = 338 mg/kg (95% UCL for all fill materials) BaP TEQ = 7.9 mg/kg (95% UCL for all fill materials)
Parameters relevant to soil ingestion	
Soil ingestion rate	50 mg/day (for outdoor soil each day (enHealth 2012a), assuming that impacts in accessible soil outdoors are not tracked indoors as dust – less likely where much of the site is covered with hardstand, which is relevant for Fairfield Public School

Bioaccessibility:
Lead = 30%
BaP = 50%

Heterogeneous fill – so used 95% UCL of data from all depths

Also assessed maximum (lead = 1400 mg/kg and BaP TEQ = 36 mg/kg)

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Example – Mining project

- Projects raise significant concern/anxiety in the community
- Common issues relate to misconceptions on chemicals and risk
- Getting data can also be complex as many communities live in mineralised areas, so the metals of concern are already present

Issues

- What are the metals of concern
- What are the key issues being raised
- Example – Bowdens silver mine in Lue

Exposure

- Who exposed and how
- Exposures via dust inhalation, as well as deposition – and exposure to soil/dust, produce (where the metals accumulate), rainwater tanks etc
- Background exposures

Hazard/Tox

- Have they used appropriate values, relevant to the exposure (oral, dermal, inhalation)
- Do these values address the community, e.g. potential for older adults with impaired kidney function

Risk characterisation

- What are the calculated risks?
- What is the margin of safety?
- Do the uncertainties matter for the conclusions?

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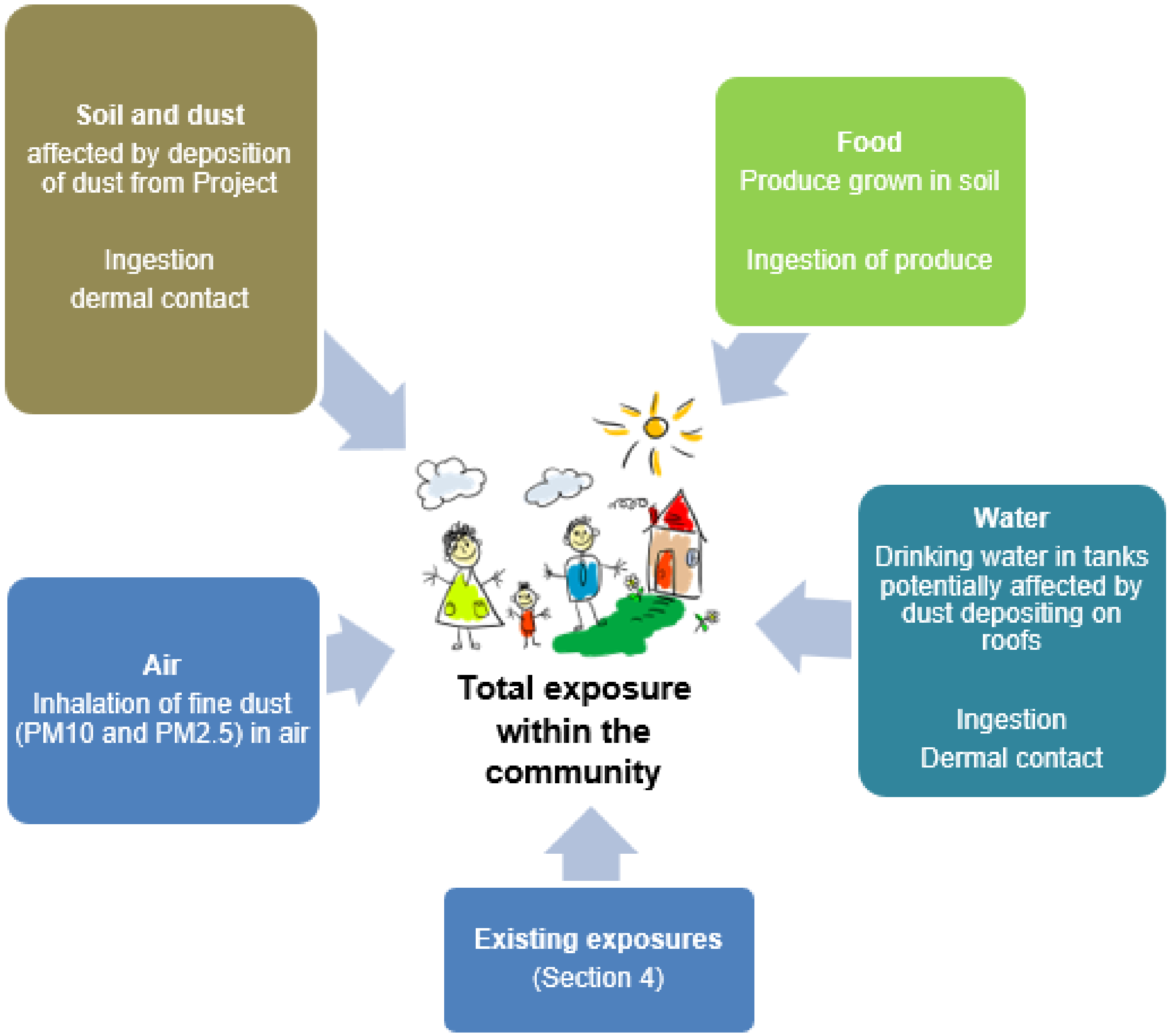
Example – Mining project

Bowdens Silver



- HHRA assessed exposure to lead and all other metals for all pathways of exposure
- Total exposure = existing exposure + exposure from the Project
- Lead – also used data that determines how much lead that is present in soil/dust can get into the body following exposure

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Example – Mining project

Table 5.2
Summary of Chronic Guidelines, Toxicity Reference Values (TRV) (Annual Average) and Dermal Absorption Parameters

Metal	Inhalation TRV (mg/m^3)	Ingestion TRV (mg/kg/day)	Dermal TRV[4] (mg/kg/day)	Dermal Absorption[3] – for contact with Soil (unites)	Dermal Permeability[3] - for contact with Water (cm/hr)
Lead[1]	Children = 0.002 Adults = 0.002	Children = 0.0014 Adults = 0.0006	Children = 0.0007 Adults = 0.0003	Negligible	0.0001
Silver[2]	0.02	0.0057	0.00023	Negligible	0.0006
Arsenic[2]	0.001	0.002	0.002	0.005	0.001
Cadmium[2]	0.000005	0.0008	0.0008	Negligible	0.001
Copper[2]	0.49	0.14	0.14	Negligible	0.001
Manganese[2]	0.00015	0.14	0.14	Negligible	0.001
Zinc[2]	1.75	0.5	0.5	0.001	0.0006
Cobalt[2]	0.0001	0.0014	0.0014	0.001	0.0004
Chromium[2]	0.0001	0.001	0.001	Negligible	0.002
Mercury[2]	0.0002	0.0006	0.00004	0.001	0.001
Lithium[2]	0.007	0.002	0.002	Negligible	0.001
Nickel[2]	0.00002	0.012	0.012	0.005	0.0002

Notes:
1 Refer to **Annexure B** for details in relation to the toxicity reference values adopted for the assessment of lead
2 Refer to **Annexure C** for details in relation to the toxicity reference values adopted for all other metals
3 Dermal parameters available from the Risk Assessment Information System https://rais.ornl.gov/
4 Dermal toxicity reference value adjusted by the gastrointestinal absorption, which is 50% for lead (refer to **Annexure B**), 4% for silver (refer to **Annexure C**) and 7% for inorganic mercury (refer to **Annexure C**)

Table E2
Ingestion and Dermal Exposure Assumptions

Table E2 (Cont'd)
Ingestion and Dermal Exposure Assumptions

Table E2 (Cont'd)
Ingestion and Dermal Exposure Assumptions

Parameter		Value Adopted		Basis
		Young Children	Adults	
CF	Conversion factor			
	Soil	$1x10^{-6}$ to convert mg to kg		Conversion of units relevant to soil ingestion and dermal contact
	Water	0.001 to convert L to cm^3		Conversion for the assessment of dermal exposures to water
	Produce	1		No units conversion required for these calculations
BW	Body weight	70	15	As per enHealth (enHealth 2012a) and ASC NEPM (NEPC 1999 amended 2013e)
EF	Exposure frequency (days/year)	365	365	Assume residents exposed every day
ED	Exposure duration (years)	6 years	29	Duration of residency as per enHealth (enHealth 2012a) and split between young children and adults as per ASC NEPM (NEPC 1999 amended 2013e)
AT	Averaging time (days)	Threshold = ED x 365 days/year Non-threshold = 70 years x 365 days/year		As per enHealth (enHealth 2012b) guidance

t_{event}	Exposure time per event, in water (hours/event)	1	0.58	Reasonable maximum time showering or wet each day (USEPA 2011)
EV	Events per day when wet	1	1	Assumed relevant to the use of rainwater
ABSd	Dermal absorption fraction (unitless)	Chemical specific		Refer to **Table 5.2**
Kp	Dermal permeability through skin (water) (cm/hr)	Chemical specific		Refer to **Table 5.2**

	Eggs	200%	200%	Assume higher intake of home-produced eggs in rural areas (SAHC 1998)

Calculation of Concentrations in Rainwater tank

CW = DM/(VR*Kd*ρ) **(mg/L)**

where:

DM =	Mass of dust deposited on roof each year that enters tank (mg) = DR x Area x 1 year
DR =	Deposition rate from model for TSP (mg/m²/year)
Area =	Area of roof (m²)
VR =	Volume of water collected from roof over year (L) = (R x Area x Rc x 1000)/1000
R =	Rainfall each year (mm)
ρ =	Soil bulk-density (g/cm³)
Rc =	Runoff coefficient (unitless)
Kd =	Soil-water partition coefficient (cm³/g)
1000 =	Conversion from mm to m; and conversion from m³ to L

Bowdens Silver

General Parameters			
Average rainfaill	mm	663.2	mean for all years (1994 - 2019) for Mudgee airport
Roof area	m²	200	4 bedroom australian home
Runoff coefficient	-	0.7	assumes 30% loss in capture into tank
Volume of rainwater	L	92848	
Bulk density of deposited dust	g/cm³	0.5	assumed for loose deposited dust on roof (similar to upper end measured for powders)

Chemical-specific Inputs and calculations - maximum private residences

Chemical	Deposited dust entering tank: Deposition Rate TSP (DR)	Deposited dust entering tank: Mass deposited each year into tank (DM)	Kd	Particulate Concentration in water	Dissolved Concentration in water
	mg/m²/year	mg	(cm3/g)	mg/L	mg/L
Silver (Ag)	0.0215	4.3	8.3	4.6E-05	1.1E-05
Lead (Pb)	0.7667	153.3	900	1.7E-03	3.7E-06
Arsenic (As)	0.1191	23.8	29	2.6E-04	1.8E-05
Cadmium (Cd)	0.0052	1.0	75	1.1E-05	3.0E-07
Copper (Cu)	0.0152	3.0	35	3.3E-05	1.9E-06
Manganese (Mn)	3.8710	774.2	65	8.3E-03	2.6E-04
Zinc (Zn)	1.0394	207.9	62	2.2E-03	7.2E-05
Cobalt (Co)	0.0045	0.9	45	9.8E-06	4.3E-07
Chromium (Cr)	0.0241	4.8	19	5.2E-05	5.5E-06
Mercury (Hg)	0.0039	0.8	52	8.4E-06	3.2E-07
Lithium (Li)	0.0392	7.8	300	8.4E-05	5.6E-07
Nickel (Ni)	0.0058	1.2	65	1.3E-05	3.9E-07

Drinin king water guideline	Proportion of DWG: Particulate	Proportion of DWG: Dissolved
mg/L		
0.1	0%	0.011%
0.01	17%	0.037%
0.01	3%	0.18%
0.002	1%	0.015%
2	0%	0.000093%
0.5	2%	0.051313%
6	0%	0.0012%
0.006	0%	0.0072%
0.05	0%	0.011%
0.001	1%	0.032%
0.04	0%	0.00141%
0.02	0%	0.00194%

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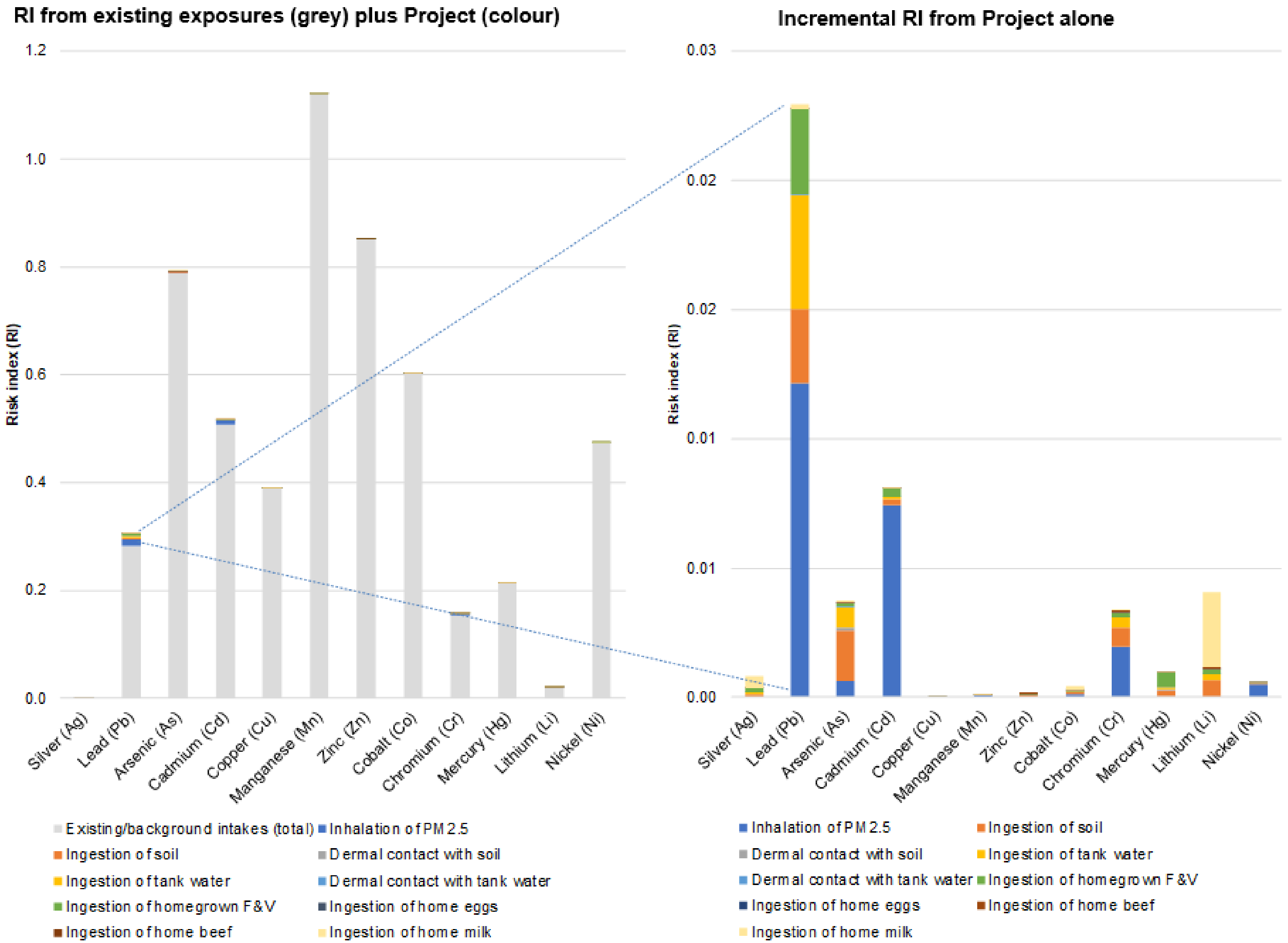
Figure 5.4 Calculated RI for Existing and Project Exposures (Scenario 3 – Year 8) – Young Children



Questions ?