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Does Modification 4 at Rasp Mine need a Health Risk Assessment?

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Contents

1. Introduction & Scope

The Rasp Mine is an underground silver/zinc/lead operation located in Broken Hill, NSW. Broken Hill Operations Pty Ltd (BHOP), a wholly owned subsidiary of CBH Resources Ltd (CBH), seeks to modify the Rasp mine approval to:

- install a Concrete Batching Plant (CBP) for the manufacture of fibre-crete and concrete for use at the mine site; and
- extend the life of the Blackwood Pit Tailings Storage Facility (TSF2) by installing embankments and a retaining wall at low points along its perimeter[1].

BHOP engaged Pacific Environment Limited (PEL) to undertake an air quality and greenhouse gas impact assessment for the proposed modification (collectively termed 'Modification 4'). In their assessment [2], PEL performed atmospheric dispersion modelling to predict changes in air concentrations of particulate matter ($PM_{2.5}$ and PM_{10}), total suspended particulates (TSP), and lead (in TSP) potentially resulting from the proposed Modification 4. Also modelled was the incremental predicted dust deposition of lead (Pb) at various locations (receptors) within Broken Hill resulting from the construction and operation of the proposed Modification.

In regard to the potential impact on public health, ToxConsult has been requested by BHOP to provide an opinion whether a formal human health risk assessment (HHRA) is required [3]. From a human health perspective the potential exposures to Pb in Broken Hill occur from Pb in air and soil. Pb deposition to soil by dust fallout is important if it increases soil Pb concentrations, this also affects tracked-in soil and indoor dust. The latter are likely the principal sources of Pb exposure in Broken Hill (Toxikos 2010). Thus if Modification 4 does not materially increase soil Pb concentrations or inhalable Pb in air a formal HHRA will not provide additional information on the potential for health impacts. This approach is consistent with the guidance in enHealth (2012)[4] and WA DoH (2006, 2010)[5].

[1] The proposal is to install 3 embankments and a retaining wall, the latter to protect an old mining residence (BHOP 2016).

[2] PEL letter entitled "Re: Air Quality Assessment for the Rasp Mine Modification 4", dated 27 March 2017.

[3] To provide this opinion, the data and information provided by PEL has been taken on face value. ToxConsult has not checked the assumptions or model predictions.

[4] enHealth (2012, pg. 5) states: "*Risk assessment is inappropriate when it is a ritual rather than a meaningful process and should not be undertaken when….it is clear that the proposal, situation or activity is seen by health and other experts as having few potential risks to health… [or when] risks may be likely, but the evidence is already well documented and it may be possible to develop evidence-based recommendations without the need for a comprehensive assessment.*"

[5] WA DoH (2006, pg. 8) states *"A health risk assessment is not the answer for all situations….Most activities or projects in our society require some type of planning approval. The nature of this approval will often dictate the need for and the level of health risk assessment required."*

Hence in order to consider the potential health impact of the proposed modification:

- the predicted deposition of Pb has been contextualised to existing soil Pb concentrations in Broken Hill as determined from the literature, and
- modelled incremental increases in Pb air concentrations have been compared to existing (i.e. background[6]) measured air Pb concentrations.

2. Receptor locations

Figure 2.1 presents the locations of the proposed CBP and TSF embankments, and modelled receptor locations. The latter include residences, public open spaces, schools, and playgrounds as well as locations where soil Pb concentrations are reported in the literature.

WA DoH (2010, pg. 7) states *"An HIA [health impact assessment] is usually required if the health impacts of a proposal are not considered insignificant, if there is potential for unknown health impacts or if the impacts are not easily controlled using well established management strategies."*

[6] Note that in the context of this assessment 'background' refers to existing or current soil lead concentrations, Pb in dust deposition and air Pb concentrations. That is from all sources but without the construction or operation of Modification 4.

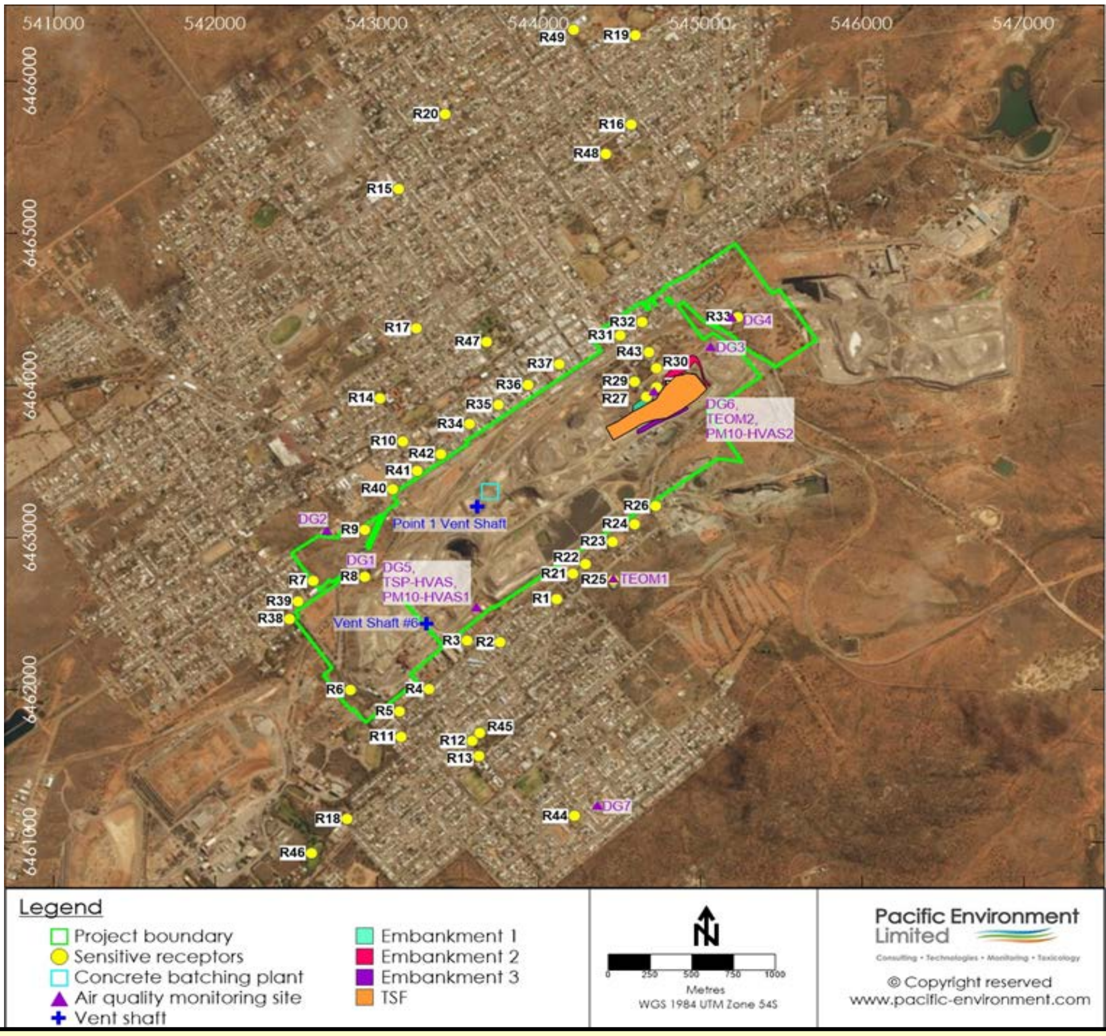

Figure 2.1: Location of proposed Concrete Batching Plant, Tailings Storage Facility Embankments 1-3 and air quality modelling locations (i.e. sensitive receptors).

Receptor	Description	Receptor	Description	Receptor	Description
R1	Piper Street North	R21	Eyre Street North	R41	Silver City Hwy
R2	Piper Street Central	R22	Eyre Street North	R42	Silver City Hwy
R3	Eyre Street North	R23	Eyre Street North	R43	Bowling Green
R4	Eyre Street Central	R24	Eyre Street North	R44 [a]	Duff St Park
R5	Eyre Street South	R25	Water tank, Lawton Street	R45 [a]	Patton park
R6	South Road	R26	Quarry offices	R46 [a]	Zinc Lakes
R7	Carbon Lane	R27	Proprietary Square	R47 [a]	Sturt Park
R8	Old South Road	R28	Proprietary Square	R48 [a]	Queen Elizabeth Park
R9	South Rd	R29	Iodide Street	R49 [a]	North Family Play Centre
R10	Cnr Garnet & Blende Streets	R30	Iodide Street		
R11	Alma Bugldi Preschool	R31	Crystal Street		
R12	Playtime Pre-school	R32	Crystal Street		
R13	Alma Primary School	R33	Brownes Shaft Dwelling		
R14	Broken Hill High School	R34	Crystal Street		
R15	Broken Hill Hospital	R35	Crystal Street		
R16	N. Broken Hill Primary School	R36	Crystal Street		
R17	Broken Hill Public School	R37	Crystal Street		
R18	Rainbow Pre-school	R38	Gypsum Street		
R19	Willyama High School	R39	Gypsum Street		
R20	Morgan Street Primary School	R40	Silver City Hwy		

[a] Recent soil Pb measurements are available for these locations from Taylor et al. (2014). In addition recent area-wide soil Pb concentrations are available from Yang and Cattle (2015).

3. Air Pb

The PEL (2017) report provides predicted incremental (i.e. Modification 4 only) and cumulative (proposed Modification + background[7]) annual average concentrations for Pb in TSP at each of the locations modelled. Depending on the receptor location the Modification potentially contributes 0.04 – 2% to the cumulative annual air Pb (Figure 3.1). These increases are small and only occur during the 14 month construction period (PEL 2017). At every location the predicted cumulative air Pb in TSP is less than half the ambient air quality guideline (AAQG) indicating little potential for the incremental air Pb to cause harm, particularly since this exposure is for a small fraction of the time (14 months) to which the AAQG applies (i.e. a lifetime).

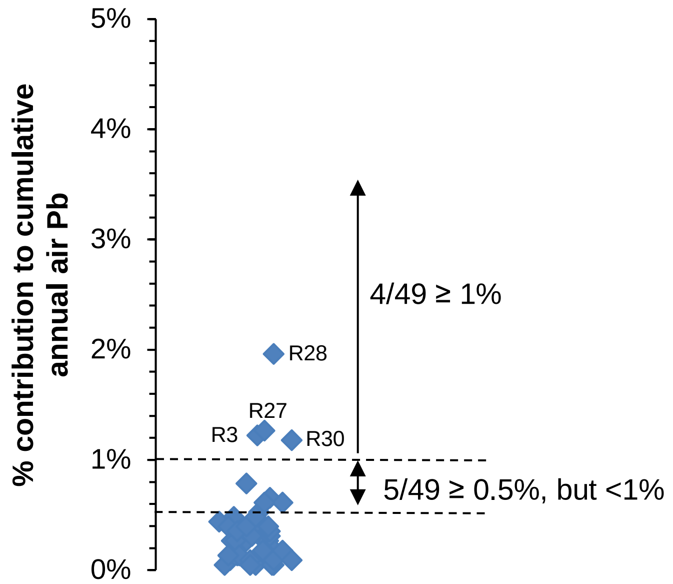

Figure 3.1: Percentage contribution of Modification to cumulative annual air Pb TSP concentration at each modelled receptor.
This is predicted to occur over the 14 month construction period. Most is due to truck movements.

4. Pb deposition

ToxConsult was provided with predicted incremental annual Pb deposition rates at each of the locations modelled for the period of Modification construction[8] (i.e. these deposition rates do not include Pb deposition from 'background'). The data, as provided by PEL, is in Appendix A.

[7] The background concentration was taken from a TSP-HVAS (High Volume Air Sampler) on site (depicted in Figure 2.1), and applied by PEL (2017) to all receptor locations.

[8] Data provided to ToxConsult by PEL in an Excel spreadsheet entitled "21544C_Modelling_Results_Grid_Info_for_HRA_21.03.2017", received via e-mail on 22nd March 2017.

BHOP (2017) considers the construction of the CBP will take approximately 5 weeks, but modifications to the TSF will take up to 14 months. Thus to determine total predicted Pb deposition to soil and other surfaces over the entire period of construction of the TSF modifications, the annual Pb deposition rates provided by PEL were multiplied by a factor of 1.17 (i.e. 14 ÷ 12 months). Since construction of the CBP occurs over less than a year, no change is needed to be made to these Pb deposition rates to determine deposition over the whole construction period. The results are provided in Table 4.1.

Table 4.1: Total predicted incremental Pb deposition from proposed Modification 4 (CBP & TSF) over the entire construction period

	Total modelled incremental Pb deposition from TSP over construction period (i.e. 14 months) (g/m^2)		
Location No.	**Concrete Batching Plant (CBP)**	**Tailings Storage Facility (TSF2) modification [a]**	**Total (TSF2 + CBP = Modification 4) [b]**
R1	0.0004	0.005	0.005
R2	0.0007	0.006	0.007
R3	0.002	0.009	0.01
R4	0.002	0.004	0.006
R5	0.0005	0.002	0.003
R6	0.0002	0.002	0.002
R7	0.0001	0.001	0.001
R8	0.0002	0.002	0.003
R9	0.0002	0.002	0.002
R10	0.0002	0.002	0.003
R11	0.0003	0.002	0.002
R12	0.0002	0.001	0.001
R13	0.0001	0.001	0.001
R14	0.0001	0.001	0.001
R15	0.00004	0.0005	0.0005
R16	0.00004	0.0006	0.0006
R17	0.0001	0.001	0.001
R18	0.00008	0.0007	0.0008
R19	0.00003	0.0004	0.0004
R20	0.00004	0.0004	0.0004
R21	0.0004	0.004	0.005
R22	0.0004	0.004	0.004
R23	0.0003	0.003	0.004
R24	0.0003	0.003	0.004
R25	0.0002	0.002	0.003
R26	0.0002	0.003	0.004
R27	0.0004	0.01	0.01
R28	0.0007	0.02	0.02

	Total modelled incremental Pb deposition from TSP over construction period (i.e. 14 months) (g/m^2)		
Location No.	**Concrete Batching Plant (CBP)**	**Tailings Storage Facility (TSF2) modification [a]**	**Total (TSF2 + CBP = Modification 4) [b]**
R29	0.0003	0.006	0.006
R30	0.0005	0.01	0.01
R31	0.0002	0.003	0.003
R32	0.0002	0.003	0.003
R33	0.0002	0.003	0.003
R34	0.0006	0.003	0.004
R35	0.0005	0.003	0.003
R36	0.0003	0.002	0.003
R37	0.0002	0.002	0.002
R38	0.00008	0.0009	0.0009
R39	0.00008	0.0009	0.001
R40	0.0002	0.003	0.004
R41	0.0003	0.004	0.005
R42	0.0006	0.004	0.005
R43	0.0002	0.006	0.006
R44	0.00006	0.0006	0.0007
R45	0.0002	0.001	0.002
R46	0.00006	0.0005	0.0006
R47	0.0002	0.002	0.002
R48	0.00005	0.0007	0.0007
R49	0.00003	0.0004	0.0004

[a] To determine total predicted Pb deposition from the entire period of construction of the TSF modifications, the annual Pb deposition rates provided by PEL in Appendix A were multiplied by a factor of 1.17 (i.e. 14 ÷ 12 months).
[b] Values are reported to one significant figure.

The proposed modification to the TSF will increase the operational life of the facility by 2 years (BHOP 2016). At the end of its operational life, the TSF will be capped using waste rock. According to PEL (2017),

- The major modelled contribution to deposited Pb during construction is from truck movements on unsealed roads.
- The TSF itself results in very little Pb deposition to wider areas; this is due to hard crusting of the tailings surface preventing wind lift-off of dust.
- The level of dust control afforded by crusting of tailings is equivalent to the proposed final waste rock cover for the TSF.
- For moist surfaces within the TSF, confined air burst chamber (CABC) testing indicates a 100% dust control efficiency (i.e. no dust was produced, and the material was classified as being non-conducive to wind erosion).

- The dust control efficiency of dry, crusted tailings and waste rock was 99.7%.

According to PEL[9], no increase in Pb deposition from the TSF itself is expected over time. A combination of field testing of the waste rock capping layer/chemical dust suppressant, proposed dust management measures and investigation into the composition of the waste rock underpins PEL's confidence that an increase in Pb deposition will not occur after TSF closure (PEL 2017).

Based on the above considerations, it has been assumed the total modelled incremental Pb deposition during the construction period in Table 4.1 represents the total potential deposited Pb due to the proposed Modification 4 over the construction, operation and closure period.

5. Contextualisation & conclusion

From a human health perspective, Pb deposition by dust is important if it increases soil Pb concentrations, as this (together with tracked-in soil and indoor dust) is likely the principal source of Pb exposure in Broken Hill (Toxikos 2010).

In order to contextualise the predicted Pb deposition from the proposed Modification, the concentration of Pb in soil resulting from deposition over the entire construction period was calculated using Equation 5.1 (adapted from Equation 5-1 in US EPA 2005). The deposition rate (Pb_{dep}) was sourced from the third column in Table 4.1 above, values for other parameters in Equation 5.1 are those recommended for untilled (non-agricultural) soil as outlined by US EPA (2005, pg. 5-21). The equation assumes the environmental half-life of Pb at each receptor is infinite, and there is no physical loss from soil due to wind erosion, percolation by rain or water runoff.

C_s (mg/kg) = [Pb_{dep} (g Pb/m^2) x 100] ÷ [∂ (g/cm^3) x D (cm)] …………..**Equation 5.1**

Where:
C_s = Concentration of Pb in soil resulting from Pb deposition originating from proposed Modification 4 (mg Pb/kg soil).
Pb_{dep} = Incremental deposition of Pb from TSP onto residential soil as a result of proposed Modification 4 (g Pb/m^2). This value is receptor specific (see Table 4.1).
100 = Unit conversion factor [(10^6 mg/kg)/(10^4 cm^2/m^2)].
∂ = Soil bulk density, assumed to be 1.5 g/cm^3. This value is the recommended default by the US EPA (2005). US EPA guidance states that literature values for soil bulk density range from 0.93 - 1.84 g/cm^3, depending on soil type. It is not stated what soil type coincides with the value of 1.5 g/cm^3, and the original references

[9] E-mail correspondence with PEL entitled 'Rasp clarification', dated 17/02/2017.

were not available to ToxConsult to verify the value selected. Therefore, the default value used by the US EPA (2005) has been adopted on face value[10].

D = Soil mixing depth, assumed to be just the surface, i.e. 2 cm (US EPA 2005).

The calculated concentrations of Pb in soil arising as a result of dust deposition from the proposed Modification are presented for each modelled location in Table 5.1.

Table 5.1: Predicted concentrations of Pb in soil arising from proposed Modification 4

Location No.	Increment in soil Pb (mg/kg)	Location No.	Increment in soil Pb (mg/kg)
R1	0.2	R26	0.1
R2	0.2	R27	0.4
R3	0.4	R28	0.6
R4	0.2	R29	0.2
R5	0.1	R30	0.4
R6	0.1	R31	0.1
R7	0.04	R32	0.1
R8	0.1	R33	0.1
R9	0.1	R34	0.1
R10	0.1	R35	0.1
R11	0.1	R36	0.1
R12	0.05	R37	0.1
R13	0.04	R38	0.03
R14	0.05	R39	0.03
R15	0.02	R40	0.1
R16	0.02	R41	0.2
R17	0.04	R42	0.2
R18	0.03	R43	0.2
R19	0.01	R44	0.02
R20	0.01	R45	0.1
R21	0.2	R46	0.02
R22	0.1	R47	0.1
R23	0.1	R48	0.02
R24	0.1	R49	0.01
R25	0.1		

To contextualise the predicted increments in Table 5.1 with existing soil Pb concentrations in Broken Hill, recent soil Pb measurements were sourced from publically available literature. More recent data for soil Pb in Broken Hill were not available.

[10] This is consistent with a previous risk assessment for the Rasp mine at Broken Hill (Toxikos 2010). It is noted Yang and Cattle (2017) assumed a bulk density of 1.2 g/cm^3 for soils in Broken Hill.

Taylor et al. (2014, Fig. 2) provide mean soil Pb concentrations at six Broken Hill playgrounds (sampled in September 2013)[11]; these locations coincide with modelled receptors R44-R49.

Yang and Cattle (2015, 2017) provide mean Pb concentrations for soils taken from earthen footpaths, nature strips, parks or vacant land throughout Broken Hill (sampled in May 2013)[12]. These data are presented as mean concentrations for each 'district'[13] of Broken Hill. For this exercise, ToxConsult has assumed the mean soil Pb concentration reported by Yang and Cattle (2015) is representative of the modelled receptors in the corresponding district. Note some PEL modelled locations do not fall within a particular district, thus no recent soil data were available.

The percentage increase in existing soil Pb concentration resulting from modelled dust deposition due to Modification 4 is presented in Table 5.2.

Table 5.2: Predicted percentage increase in existing soil Pb concentration as a result of Pb deposition from Modification 4

Location No.	Current assumed soil Pb (mg/kg) [a]	Increment in soil Pb		Location No.	Current assumed soil Pb (mg/kg) [a]	Increment in soil Pb	
		mg/kg	as % of current soil Pb [d]			mg/kg	as % of current soil Pb [d]
R1	733	0.2	0.024	R26	- [b]	0.1	- [b]
R2	733	0.2	0.033	R27	- [b]	0.4	- [b]
R3	733	0.4	0.051	R28	- [b]	0.6	- [b]
R4	733	0.2	0.026	R29	- [b]	0.2	- [b]
R5	733	0.1	0.012	R30	- [b]	0.4	- [b]
R6	- [b]	0.1	- [b]	R31	- [b]	0.1	- [b]
R7	1,125	0.04	0.003	R32	- [b]	0.1	- [b]
R8	- [b]	0.1	- [b]	R33	- [b]	0.1	- [b]
R9	1,125	0.1	0.007	R34	1,125	0.1	0.012
R10	1,125	0.1	0.008	R35	1,125	0.1	0.01
R11	733	0.1	0.008	R36	1,125	0.1	0.008
R12	733	0.05	0.007	R37	1,125	0.1	0.007
R13	733	0.04	0.006	R38	1,125	0.03	0.003

[11] At least two surface soil (0-2 cm) samples were taken from each playground in accordance with AS 4874-2000 using a plastic trowel that was wiped clean each time prior to sampling using KimWipes™ and deionised water. Soil samples were analysed for Pb by the National Measurement Institute (NMI), Sydney. Further details of analysis were not provided (Taylor et al. 2014).

[12] Surface soils (0.1 m depth) were collected at 53 sampling sites using a stainless steel, hand-held soil auger. For each sample, three adjacent core samples were collected and mixed. All soil samples were air-dried at 40°C, gently crushed, and passed through a 2 mm stainless steel sieve to remove gravel, plant material and other debris. Total Pb concentration was determined by portable X-ray fluorescence (pXRF) analyser with a Pb detection limit of 5 mg/kg (Yang and Cattle 2017).

[13] From previous soil Pb sampling investigations, based on soil lead levels and proximity to the mine, Broken Hill was divided into ten districts. The 'district' concept for organising environmental lead data was retained by various authors over the years (Boreland et al. 2002, Boreland and Lyle 2006, Boreland et al. 2006).

Location No.	Current assumed soil Pb (mg/kg) [a]	Increment in soil Pb		Location No.	Current assumed soil Pb (mg/kg) [a]	Increment in soil Pb	
		mg/kg	as % of current soil Pb [d]			mg/kg	as % of current soil Pb [d]
R14	1,125	0.05	0.004	R39	1,125	0.03	0.003
R15	275	0.02	0.006	R40	1,125	0.1	0.011
R16	275	0.02	0.008	R41	1,125	0.2	0.013
R17	275	0.04	0.014	R42	1,125	0.2	0.015
R18	733	0.03	0.003	R43	- [b]	0.2	- [b]
R19	275	0.01	0.005	R44	700 [c]	0.02	0.003
R20	275	0.01	0.005	R45	700 [c]	0.1	0.008
R21	- [b]	0.2	- [b]	R46	2,450 [c]	0.02	0.001
R22	- [b]	0.1	- [b]	R47	300 [c]	0.1	0.02
R23	- [b]	0.1	- [b]	R48	250 [c]	0.02	0.009
R24	- [b]	0.1	- [b]	R49	80 [c]	0.01	0.016
R25	- [b]	0.1	- [b]				

[a] Current soil Pb assumed to coincide with mean topsoil Pb reported by Yang and Cattle (2015, Table 4) within the relevant 'district' of Broken Hill, unless otherwise indicated.
[b] A '-' in this table indicates the modelled receptor was not within any of the Broken Hill 'districts', therefore current soil Pb concentrations are unknown.
[c] Current assumed soil Pb are approximations for these locations, as they were read off Figure 2c in Taylor et al. (2014).
[d] This is the predicted increase in soil Pb concentration as a result of modelled Pb deposition from Modification 4 (Table 5.1), expressed as a percentage of the current assumed soil Pb at a particular location, i.e. [increment (mg/kg, Table 5.1) ÷ current assumed soil Pb (mg/kg)] x 100.

The predicted incremental increases in soil Pb range from 0.01 – 0.6 mg/kg which represent just 0.001 – 0.05% of existing soil Pb concentrations as measured in 2013. These increases are considered small and insignificant.

Conclusion:

We conclude the small increases in air Pb concentrations over a short period and in soil Pb (assumed to be perpetual) are unlikely to materially influence existing exposures to Pb. It is our opinion that these incremental exposures to Pb, due to the proposed Modification, are so small that a formal HHRA for the proposal is not warranted. Indeed a HHRA will not inform on the potential impact to human health from the proposed Modification any more than is deduced from the analysis provided in this letter report.

We also note that PEL (2017) advises the modelling undertaken over-predicts Pb deposition in dust, thus considerations herein are conservative.

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Appendix A – Pb deposition data provided by PEL

	TSP Lead annual DD - g/m2/year	
Receptor ID	MOD4 (TSF2) construction increment	CBP construction increment
R1	0.00418	0.00041
R2	0.00557	0.00066
R3	0.00797	0.00188
R4	0.00303	0.00209
R5	0.00188	0.00051
R6	0.00163	0.00020
R7	0.00084	0.00010
R8	0.00211	0.00022
R9	0.00196	0.00018
R10	0.00210	0.00022
R11	0.00132	0.00027
R12	0.00111	0.00019
R13	0.00093	0.00014
R14	0.00114	0.00012
R15	0.00040	0.00004
R16	0.00050	0.00004
R17	0.00090	0.00011
R18	0.00058	0.00008
R19	0.00033	0.00003
R20	0.00035	0.00004
R21	0.00362	0.00040
R22	0.00322	0.00036
R23	0.00285	0.00029
R24	0.00281	0.00025
R25	0.00214	0.00022
R26	0.00286	0.00022
R27	0.00948	0.00040
R28	0.01495	0.00070
R29	0.00479	0.00025
R30	0.00983	0.00045
R31	0.00225	0.00015
R32	0.00269	0.00016
R33	0.00269	0.00015
R34	0.00298	0.00060
R35	0.00243	0.00049
R36	0.00202	0.00032
R37	0.00179	0.00021
R38	0.00075	0.00008
R39	0.00077	0.00008

	TSP Lead annual DD - g/m2/year	
Receptor ID	MOD4 (TSF2) construction increment	CBP construction increment
R40	0.00292	0.00023
R41	0.00358	0.00034
R42	0.00381	0.00055
R43	0.00474	0.00024
R44	0.00052	0.00006
R45	0.00123	0.00021
R46	0.00043	0.00006
R47	0.00135	0.00020
R48	0.00056	0.00005
R49	0.00031	0.00003