Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

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Broken Hill Operations Pty Ltd

RE: Proposed upcast ventilation Shaft #6 – Air Quality aspects

1 INTRODUCTION

Broken Hill Operations Pty Ltd (BHOP) is seeking to modify the Project Approval 07_0018 for the Rasp Mine in Broken Hill to extend its underground mining to the south-western boundary to include Block 7 and the Zinc Lodes.

The current operations has the main ventilation shaft located on the north-western side of the CML7 lease (referred to as 'Point 1' in the site's Environmental Protection Licence) and has been operating within the relevant licence limits (for in-stack concentration) since its installation.

The proposed modification will not require any changes to the life of the mine or tonnages of material mined. The extension of the underground mining will however require the installation of an additional ventilation system which is proposed to be located at the current (disused) Vent Shaft #6 site (see **Figure 1**).

Pacific Environment has been asked by BHOP to provide an evaluation of the potential air quality impacts associated with the proposed additional ventilation shaft at the Rasp underground mine. The purpose of this letter is to provide an assessment of the impacts of an additional ventilation system at the Vent Shaft #6 site.

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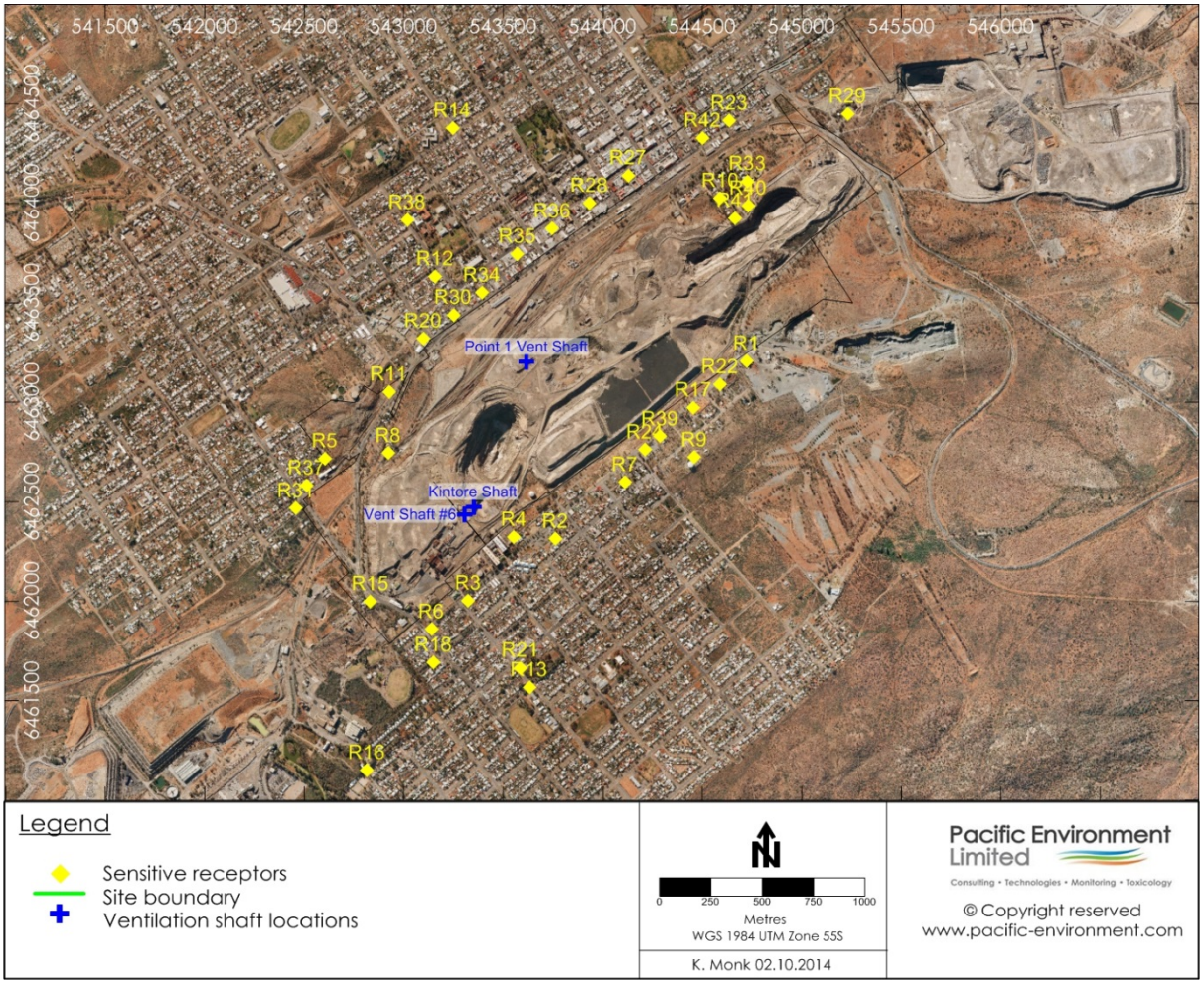

Figure 1: Locations of Kintore Shaft, Point 1 Shaft, Vent Shaft #6 and sensitive receptors

2 REGULATORY REQUIREMENTS

BHOP is currently required by their Environmental Protection Licence (EPL 12559) to conduct monitoring from its existing ventilation shaft (Point 1). The EPL specifies the minimum performance in-stack concentration criteria relevant to the point source emissions within NSW as per the NSW *Protection of the Environment Operations (Clean Air) Regulation* (2010; the POEO (Clean Air) Regulation).

Table 1 summarises the maximum in-stack concentration limits for PM and other air quality parameters relevant to air emissions from Rasp mine operations within the POEO (Clean Air) Regulation Schedule 4. The release of air emissions from the mine must operate within these limits.

Table 1: Maximum In-Stack Concentration Limits for Point 1 (Ventilation Shaft) as contained in Condition L2.1 of EPL 12559

Air quality parameter	In-stack concentration limits [1] (mg/m^3)
Total Solid Particles	20
Nitrogen Oxides (NO_x)	350
Type 1 and Type 2 substances in aggregate [2]	1
Volatile organic compounds as n-propane equivalent	40

Notes 1: Reference conditions: Dry, 273 K, 101.3 kPa. Source: POEO (Clean Air) Regulation – Schedule 5.
2: Type 1 substance means the elements antimony, arsenic, cadmium, lead or mercury or any compound containing one or more of those elements. Type 2 substances means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium or any compound containing one or more of those elements.

Additionally, **Table 2** summarises the ambient air quality criteria relevant to air emissions from Rasp mine operations, as contained within the NSW EPA's 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW'.

Table 2: Ambient air quality criteria relevant to Rasp mine air emissions

Air Quality Parameter	EPA Criterion (µg/m³)	Averaging Period
PM_{10}	50	24-Hour
	30	Annual
NO_2	246	1-Hour
	62	Annual
VOCs	N/A	1-Hour
SO_2	570	1-Hour
	228	24-Hour
	60	Annual
PAH	0.4 [1]	1-Hour
CO	30,000	1-Hour
	10,000	8-Hour
$PM_{2.5}$	25	24-Hour
	8	Annual
Pb	0.5	Annual

Note 1: Expressed as Benzo[a]pyrene equivalent.

The above criteria should be compared to predictions of ambient air quality provided in **Table 4** and **Table 5**.

3 AIR QUALITY IMPACTS

The original air quality assessment (AQA) for the Environmental Assessment (**ENVIRON, 2010**) modelled the proposed main ventilation shaft located at the Kintore Shaft, located in Little Kintore Pit (see **Figure** 1). This proposed location collapsed due to heavy rains and could no longer be utilised, prompting the relocation of the stack to north-western side of the CML7 lease (i.e. the existing Point 1 site).

This alternative (now existing) location was assessed in an AQA as part of a modification (**PAEHolmes, 2011**). A comparison of these modelled ventilation shaft parameters, along with those anticipated for the currently proposed Vent Shaft #6 are presented in **Table 3**.

Table 3: Comparison of modelled stack parameters with the proposed ventilation Shaft #6

Scenario	Kintore Shaft (modelled 2010)	Point 1 Vent Shaft (modelled 2011)	Vent Shaft #6 (proposed 2013)
Stack height (m)	0	0	8
Vent cross-sectional area (m^2)	30	30	4
Stack diameter (estimated m equivalent)	6.18	6.18	2
Gas volumetric flow (m^3/s)	300	400	96
Gas exit velocity (m/s)	10	13	24
Gas exit temperature (K)	293	293	293
Emission Source Type	Horizontal Point	Horizontal Point	Vertical Point
Easting	543350	543618	543304
Northing	6462472	6463202	6462437

The current steel evase at Vent Shaft #6 may be utilised as the exit point, with two 110kW ventilation fans proposed to be placed 134m below the surface. A nominal cross sectional area for the evase / vent shaft exit point has thus been based on a 2m X 2m evase, and a release height of approximately 8m.

It is noted that the current evase is vertically orientated, and if utilised, would result in improved dispersion compared to the horizontal release points that were modelled in the previous modification.

The location of the proposed new ventilation shaft at Vent Shaft #6 will be within ~75m of the original proposed ventilation shaft location at the Kintore Shaft (see **Figure 1**). Due to its location and comparable (or, in the case of volumetric flow, significantly lower) exit parameters, the predicted ground level concentrations from the Kintore Shaft are anticipated to give a conservative indication of the potential impacts from proposed operations at Vent Shaft #6. Accordingly, predictions of ground level impacts associated with modelling of the Kintore Shaft have been taken as a (conservative) surrogate for modelling of emissions from Vent Shaft #6.

The results from the 2011 modification (modelling of Kintore Shaft impacts) are presented in **Table 4**. The highest predicted concentrations for PM_{10} and NO_2 for the Vent Shaft #6 (under previously modelled stack parameters) are all well below their respective assessment criterion for all averaging periods.

As noted above, Vent Shaft #6 is proposed to be operated in addition to the current main (Point 1) ventilation shaft on the northwestern side of the mine. To provide an indication of the potential cumulative impact of both vent shafts operating, the annual average predictions can be added for the Kintore Shaft and Point 1 locations.

The highest predicted annual average PM_{10} concentration for both ventilation shafts combined is 0.2 µg/m^3 at receptor R3, which is significantly below the assessment criterion of 30 µg/m^3. The highest predicted annual average NO_2 concentration (both ventilation shafts combined) is 2.9 µg/m^3 at receptor R3, which is also well below the assessment criterion of 62 µg/m^3.

The maximum 24 hour average PM_{10} concentrations represent a potential level reached on a particular day. Given the geographical separation between the two ventilation shafts, the maximum prediction at a given receptor will in all likelihood occur on a different day dependent on the source. It is therefore not appropriate to add the Kintore Shaft and Point 1 Shaft predictions together to capture the potential (short-term) operational impacts. However, for conservatism, if the short-term PM_{10} predictions were added together the highest possible concentration would be 5.9 µg/m^3 (24-hour average) at receptor R41, which is well below the assessment criterion of 50 µg/m^3.

In the case of NO_2, it is additionally inappropriate to add maximum short-term incremental impacts from the two locations, since peaks in NO_2 emissions will be generated by a single underground blast. Associated emissions and off-site impacts from this activity would thus not be duplicated across the two emission points.

Table 4: Modelling predictions comparison (source: PAEHolmes, 2011) – PM_{10} and NO_2

Receptor	24-Hour Average PM_{10} Predictions (µg/m³)		Annual Average PM_{10} Predictions (µg/m³)		1-Hour Average NO_2 Predictions (µg/m³)		Annual Average NO_2 Predictions (µg/m³)	
	Kintore Shaft	Point 1 Shaft	Kintore Shaft	Point 1 Shaft	Kintore Shaft	Point 1 Shaft	Kintore Shaft	Point 1 Shaft
Assessment criteria	**50**		**30**		**246**		**62**	
R1	0.7	0.9	0	0	99	108	0.4	0.5
R2	3.5	0.7	0.1	0	195	109	1	0.5
R3	4.1	1.2	0.2	0	171	114	2.3	0.6
R4	3.2	0.7	0.1	0	164	104	1.5	0.4
R5	2.4	0.8	0.1	0	144	104	1.1	0.4
R6	2.8	0.4	0.1	0	151	95	0.9	0.4
R7	3.4	0.7	0.1	0	196	110	0.6	0.3
R8	3.1	1.4	0.1	0	159	122	1.4	0.6
R9	1	1.1	0.1	0	116	122	1.1	0.5
R10	0.9	1.8	0	0.1	112	130	0.5	1
R11	1.2	0.5	0.1	0	117	98	0.7	0.3
R12	1.7	0.6	0	0	117	100	0.5	0.3
R13	1.5	0.6	0	0	111	98	0.4	0.3
R14	0.5	0.4	0	0	97	95	0.4	0.6
R15	0.3	0.2	0	0	96	53	0.1	0.2
R16	0.1	0.1	0	0	21	20	0.1	0.1
R17	0.5	0.7	0	0	100	104	0.2	0.5
R18	0.9	0.5	0	0	114	100	0.4	0.2
R19	0.1	0.1	0	0	15	15	0.1	0.1
R20	0.1	0.3	0	0	24	96	0.1	0.1
R21	0.8	0.5	0	0	109	95	0.3	0.4
R22	0.6	1.3	0	0	104	109	0.3	0.4
R23	0.4	1.5	0	0	97	138	0.2	0.4
R24	0.4	0.7	0	0	99	102	0.2	0.3
R25	0.5	1	0	0	101	103	0.3	0.3
R26	0.5	0.4	0	0	101	96	0.2	0.2
R27	0.2	0.6	0	0	55	103	0.1	0.2
R28	0.2	0.6	0	0	57	103	0.1	0.2
R29	0.2	1	0	0	61	104	0.1	0.2
R30	0.1	0.9	0	0	24	105	0.1	0.2
R31	0.2	0.3	0	0	45	95	0.2	0.2
R32	0.2	0.1	0	0	47	36	0.1	0.2
R33	0.2	0.5	0	0	59	99	0.1	0.1
R34	0.4	3.5	0	0.1	97	197	0.4	1.5
R35	0.3	0.9	0	0.1	70	114	0.3	1
R36	0.2	0.4	0	0	27	71	0.2	0.6
R37	0.2	0.7	0	0	55	108	0.2	0.4
R38	1	0.7	0	0	116	104	0.4	0.3
R39	0.5	0.6	0	0	102	106	0.4	0.3
R40	1.4	1.8	0.1	0.1	123	141	0.9	0.9
R41	2.1	3.5	0.1	0.1	153	165	0.7	1.7
R42	0.6	2.5	0	0.2	105	146	0.6	2.2

The highest incremental concentrations of a number of other modelled pollutants from the 2011 modification are presented in **Table 5**. There are no concentrations predicted at the Kintore Shaft location that would exceed any assessment criterion.

Table 5: Maximum predictions comparison (source: PAEHolmes, 2011) – other air quality parameters

Air Quality Parameter	Maximum Predicted Concentration across all Receptors (µg/m³)		Averaging Period	EPA Criterion (µg/m³)
	Kintore Shaft	Point 1 Shaft		
VOCs	74	75	1-Hour	N/A
SO_2	23	23	1-Hour	570
	1	1	24-Hour	228
	0.1	<0.1	Annual	60
PAH	0.029	0.029	1-Hour	0.4 [1]
CO	1	1	1-Hour	30,000
	0.2	0.2	8-Hour	10,000
$PM_{2.5}$	1	1	24-Hour	25
	0.1	<0.1	Annual	8
Pb	0.01	0.01	Annual	0.5

Note 1: Expressed as Benzo[a]pyrene equivalent.

4 QUARTERLY STACK TESTING

Consistent with their the requirements of Condition M2.3 of EPL 12559, Broken Hill Operations Pty Ltd has commissioned Pacific Environment to monitor emissions from their Point 1 vent shaft at the Broken Hill Facility at quarterly intervals. A summary of the concentrations recorded at this point is presented in **Table 6**. The monitoring campaigns show that the in-stack concentrations have not exceeded the EPL limits shown in **Table 1**.

Table 6: Quarterly stack testing from Point 1 vent shaft – in-stack concentrations

Licence Parameter	Units	Licence limit	2013			2014	
			Q1	Q3	Q4	Q1	Q3
PM concentration	mg/Nm³	20	8.37	7.15	6.58	2.02	6.62
Total heavy metals[a] concentration	mg/Nm³	1	13.69 [c]	0.24	0.47	0.10	0.09
Oxides of Nitrogen (as NO_2)[b]	mg/Nm³	350	7.85	6.72	2.44	36.54	2.61
Volatile organic compounds	mg/Nm³	40	4.88	1.15	2.68	1.16	0.04

[a] Where appropriate results is an average of 2 sample runs
[b] Total heavy metals are the sum of As, Be, Cd, Co, Cr, Mn, Ni, Pb Sb, Se, Sn, V & Hg. Non detect figures are not included.
[c] It is understood that this elevated result was considered anomalous and due to a sample contamination issue.

Finally, **Table 7** presents a comparison between the current in-stack concentration limits, values adopted in previous dispersion modelling, and those measured during operations. While measured parameters are greater than those assumed within modelling, they do not represent concentrations anticipated to cause off-site exceedances of air quality criteria, and are in any event, well below EPL in-stack concentrations limits.

Table 7: Comparison of in-stack concentrations (modelled and monitored) against EPL criteria

Air quality parameter	In-stack concentration limits (mg/m³)	Kintore Shaft (modelled 2010)	Point 1 Vent Shaft (modelled 2011)	Point 1 Vent Shaft (average of measured) [a]
Total Solid Particles	20	0.41	0.31	6.15
Nitrogen Oxides (NOx)	350	4.64	3.48	11.23
Type 1 and Type 2 substances in aggregate	1	0.02	0.01	0.23
Volatile organic compounds as n-propane equivalent	40	0.31	0.23	1.98

[a] Excludes results where sample contamination was present.

5 CONCLUSION

Pacific Environment has assessed the potential air quality impacts from the installation of an additional ventilation shaft (located at Vent Shaft #6) at the BHOP Rasp underground mine.

The original Environmental Assessment modelling for the site's main ventilation shaft (located at a similar location to the proposed ventilation shaft) predicted ground level concentrations at sensitive receptors well below the relevant air quality assessment criteria.

Given that it is anticipated that the stack and fan system will operate under more favourable conditions for dispersion (lower volumetric flows, potentially vertically orientated, elevated release point), it is not anticipated that this additional ventilation system will not result in any additional adverse (or indeed measureable) impacts at sensitive receptors surrounding the mine.

I trust that the above provides sufficient detail and explanation for the required purpose. Please do not hesitate to contact the undersigned should you wish for clarification of any aspect of the above.

Yours sincerely

Damon Roddis
Principal / General Manager (NSW)
Pacific Environment Limited

6 REFERENCES

Department of Environment and Conservation (DEC) 2005, "Approved methods for the modelling and assessment of air pollutants in NSW" New South Wales EPA 59-61 Goulburn Street, Sydney, NSW August 2005.

ENVIRON, 2010. Air quality assessment in support of the Development Application for the Rasp Underground Mine Project (ENVIRON report reference 1150_BHOP Rasp Air_Final_19Mar10, dated 19 March 2010.

Pacific Environment 2011, Air Quality Assessment for Rasp Mine Revised Ventilation shaft Location, prepared for CBH Resources, October 2011

Protection of the Environment and Operations Regulation (2010) – Schedule