4 October 2011

Gwen Wilson
CBH Resources

Dear Gwen

Re: Air Quality Assessment for Rasp Mine Revised Ventilation Stack Location

1 INTRODUCTION

Broken Hill Operations Pty Ltd (BHOP) was granted approval in early 2011 to undertake underground lead-zinc mining within the boundaries of the CML7 mining lease ("the Rasp underground mine") at a maximum rate of 750,000t ore / annum.

The location of the ventilation stack associated with the Rasp underground mine proposed within the project Environmental Assessment (EA) and Preferred Project Report (PPR) is now proposed to be altered.

This is since the original ventilation shaft location in Little Kintore pit has collapsed due to heavy rains in the area and can no longer be utilised.

It is proposed to relocate the stack and associated fans to the north-western side of the CML7 lease.

PAEHolmes have been asked by CBH Resources to provide a brief air quality assessment associated with the proposed relocation of the Rasp underground mine ventilation stack.

It is understood that the relocation of the ventilation stack, which was included in the original air modelling undertaken within the EA and PPR, will require a variation to the Rasp mine Project Approval.

The following provides a summary of the air quality assessment for the proposed relocation, and is intended to inform any future variation to the Rasp underground mine Project Approval.

2 SCOPE OF WORK

The following scope of work has been completed as part of the subject Air Quality Assessment:

- Process site representative meteorology consistent with the methodology undertaken within the EA and PPR to obtain a minimum one year of meteorological inputs suitable for use within an atmospheric dispersion model (AERMOD);

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- Undertake atmospheric dispersion modelling of the stack source in both its original and proposed locations; and

- Present the differences in predicted air quality impacts (principally 24-hour and annual average PM_{10}) within a letter report suitable for submission to the relevant authorities (DPI and OEH).

3 DISPERSION MODEL SET-UP

3.1 Emissions Inventory

Table 3.1 provides a summary of the emissions inventory used for the ventilation shaft in the EA and PPR modelling ("Original"), compared with that adopted for the current assessment ("Revised").

Table 3.1: Emissions Inventory for Original and Revised Ventilation Shafts

Scenario	Original	Revised
Stack height (m)	0	0
Vent area (m^2)	30	30
Stack diameter (estimated m equivalent)	6.18	6.18
Gas volumetric flow (m^3/s)	300	400
Gas exit velocity (m/s)	10.0	13.3
Gas exit temperature (K)	293	293
Emission Source Type	Horizontal Point	Horizontal Point
Easting	543350	543618
Northing	6462472	6463202
NO_X (g/s)	1.392	1.392
VOCs (g/s)	0.092	0.092
SO_2 (g/s)	0.029	0.029
PAH (g/s)	3.6-05	3.6-05
CO (g/s)	1.284	1.284
TPM (g/s)	0.122	0.122
PM_{10} (g/s)	0.092	0.092
$PM_{2.5}$ (g/s)	0.029	0.029
Pb (g/s)	0.006	0.006

It is noted that the specification provided for the revised ventilation shaft includes a volumetric flow of $400m^3/s$ as opposed to $300m^3/s$ originally modelled. This has marginally increased the exit velocity used within the modelling.

All pollutant mass emission rates remain equivalent to those used within the original assessment, given they were based on emission estimates associated with underground mine activities, which are unchanged.

3.2 Model Selection

For consistency with the EA and PPR modelling, the current assessment has used the US-EPA regulatory model, AERMOD.

A detailed account of the model selection and modelling methodology is presented in the air assessment (ENVIRON, 2010).

3.3 Sensitive Receptors

A number of occupied buildings used for a variety of purposes located near to the Project Area were selected within the EA and PPR to represent sensitive receptors. These receptors are non-Project related and are illustrated in subsequent Figures.

These comprise a selection of nearby residences and other sensitive receptors, consistent with the OEH definition of sensitive receptors (DECCW, 2005) as:

A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area.

Receptor numbers R1 to R10 and R21 to R42 comprise individual residences or commercial offices located in the vicinity of the Project Area. Receptor R26 represents the offices of the quarry located to the south of the relocated processing plant. Receptors R27, R28 and R33 are located on the mining lease (CML7). Receptors R27 and R28 represent unoccupied structures owned by the Line of Lode Association which is in receivership and is currently negotiating a transfer of these buildings to the Broken Hill City Council. These structures are of heritage significance; R27 is a previous mine manager's house dating to the early part of the 20th Century and R28 was constructed in the 1930s as part of offices for the Broken Hill Proprietary Company (BHP). Receptor R33 is a mine manager's house dated to 1910 and is currently occupied by a caretaker on behalf of BHOP.

Receptors R29 and R30 are located on a surface mining lease owned by Perilya Broken Hill Operations Pty Ltd.

Receptor numbers R11 to R20 represent schools, pre-schools and hospitals in the broader area. These localities represent places of greater community exposure potentials and are therefore of specific relevance to the Health Risk Assessment conducted as part of the EA.

3.4 Modelling of NO_X Emissions

Consistent with the approach adopted within the EA (ENVIRON, 2010) NO_X emissions from the ventilation shaft were specifically modelled using the Ozone Limiting Method within AERMOD. No site specific ozone concentrations are available for the study area. Reference was however made to measurements of background continental ozone levels in the rural US southwest desert, where such levels were observed to be in the range of 19 ppb to 44 ppb with the diurnal pattern exhibiting marked repeatability. Ozone concentrations of a similar magnitude are anticipated to be experienced in the region of Broken Hill given the local setting and land uses.

4 AIR QUALITY IMPACT ASSESSMENT

Incremental Project-related concentrations and deposition rates occurring due to operation of the ventilation shaft were modelled (termed 'vent-shaft incremental').

It is both instructive and appropriate to model the ventilation shaft in isolation (i.e. without the inclusion of other emission sources on site). This is since several of the parameters of interest (e.g. nitrogen dioxide (NO_2), volatile organic compounds (VOCs), sulphur dioxide (SO_2), carbon monoxide (CO) and polycyclic aromatic hydrocarbons (PAH)) were modelled as being exclusively attributable to this source in the EA and PPR modelling. The above air quality parameters are associated with fossil fuel combustion of underground plant and equipment, as well as emissions associated with blasting. In the case of the particulate size fractions (TPM, PM_{10} and $PM_{2.5}$) and lead, the vent shaft incremental concentrations form a relatively minor contribution to total site impacts, and as such it is instructive to evaluate changes associated with the vent shaft relocation in isolation. Particulate and lead are expected to be generated as a result of source material dust generation from mechanical processes associated with underground mining and blasting.

Model results are expressed as the maximum predicted concentration for each averaging period at the sensitive receptors over a twelve month period (calendar year 2009).

Contour plots presented in the report Appendices do not represent the dispersion pattern on any individual day, but rather illustrate the maximum concentration that was simulated to be possible at each gridded receptor point across the modelling domain given the range of meteorological conditions occurring over the period modelled.

4.1 Changes in Impact Profile

The difference between the modelling of the Original and Revised vent shaft location is illustrated in **Figure 4.1**, **Figure 4.2**, **Figure 4.3**, **Figure 4.4**, **Figure 4.5** and **Figure 4.6**.

These figures additionally inform as to changes in incremental impacts of the key air pollutant parameters at Project receptors compared to the modelling of the original ventilation shaft location.

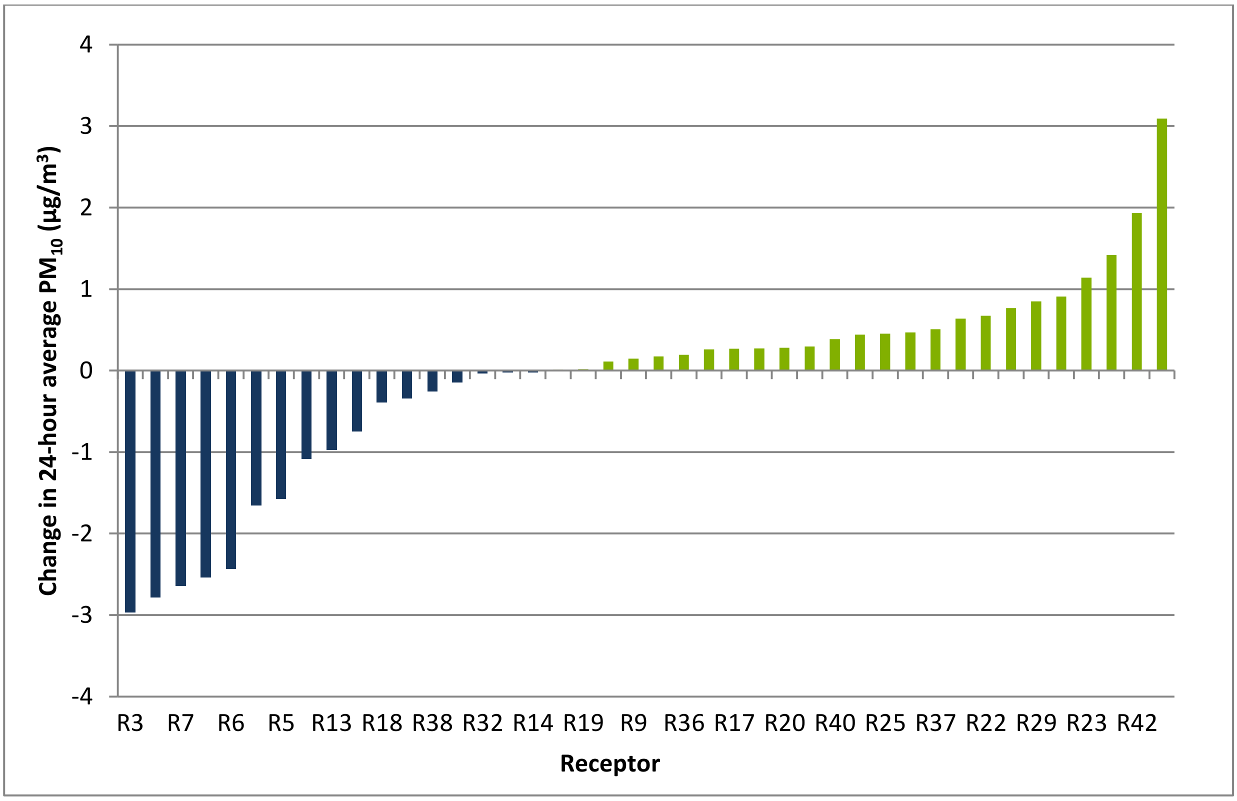

Figure 4.1: Change in Predicted 24-hour Average PM_{10} Concentrations from Original Ventilation Shaft Modelling

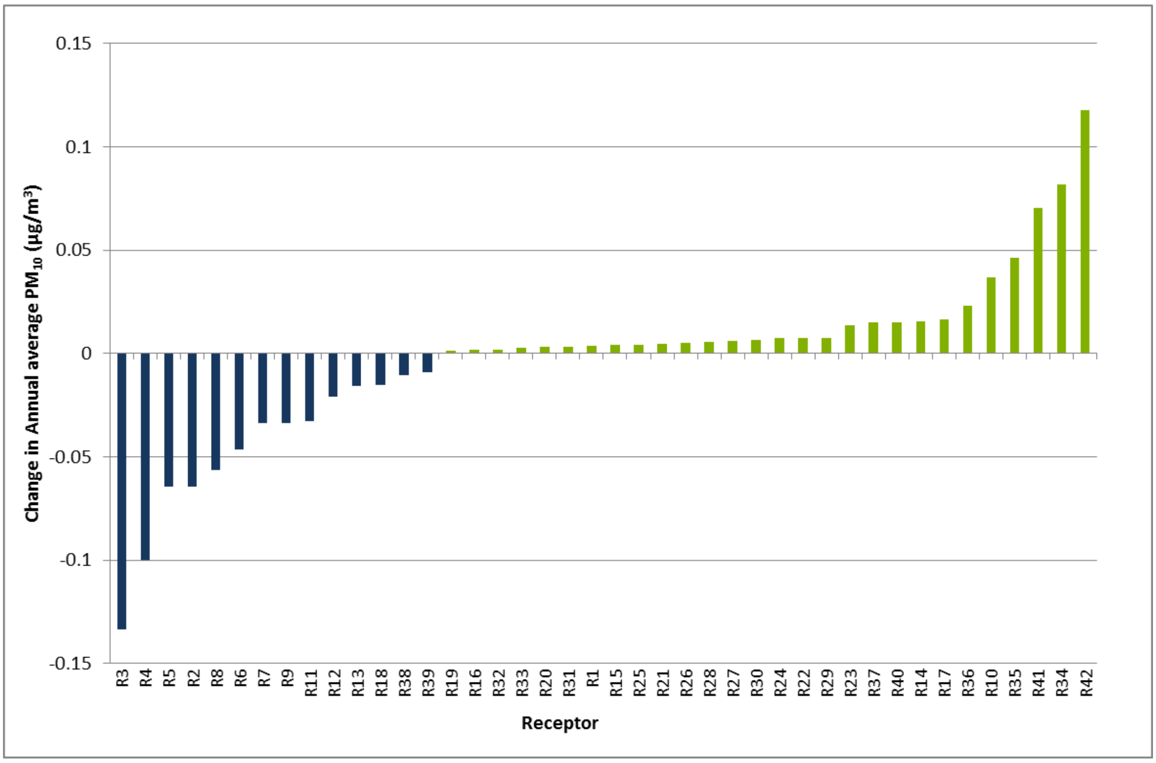

Figure 4.2: Change in Predicted Annual Average PM_{10} Concentrations from Original Ventilation Shaft Modelling

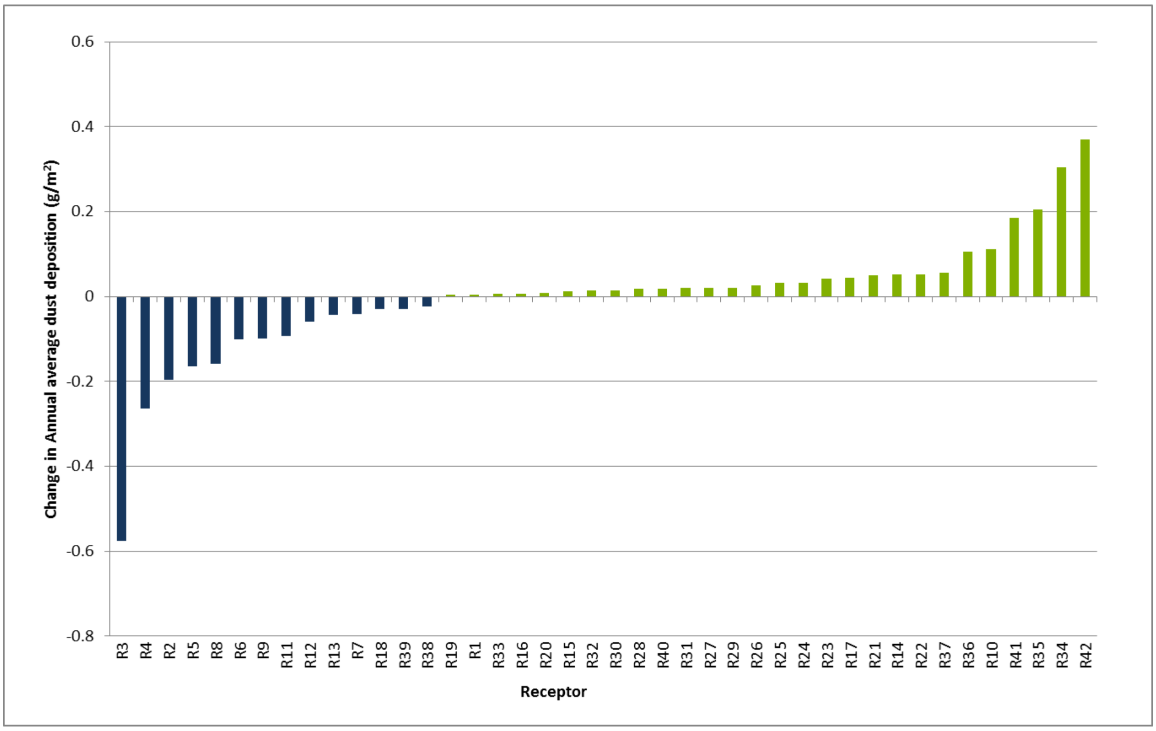

Figure 4.3: Change in Predicted Annual Average Dust Deposition from Original Ventilation Shaft Modelling

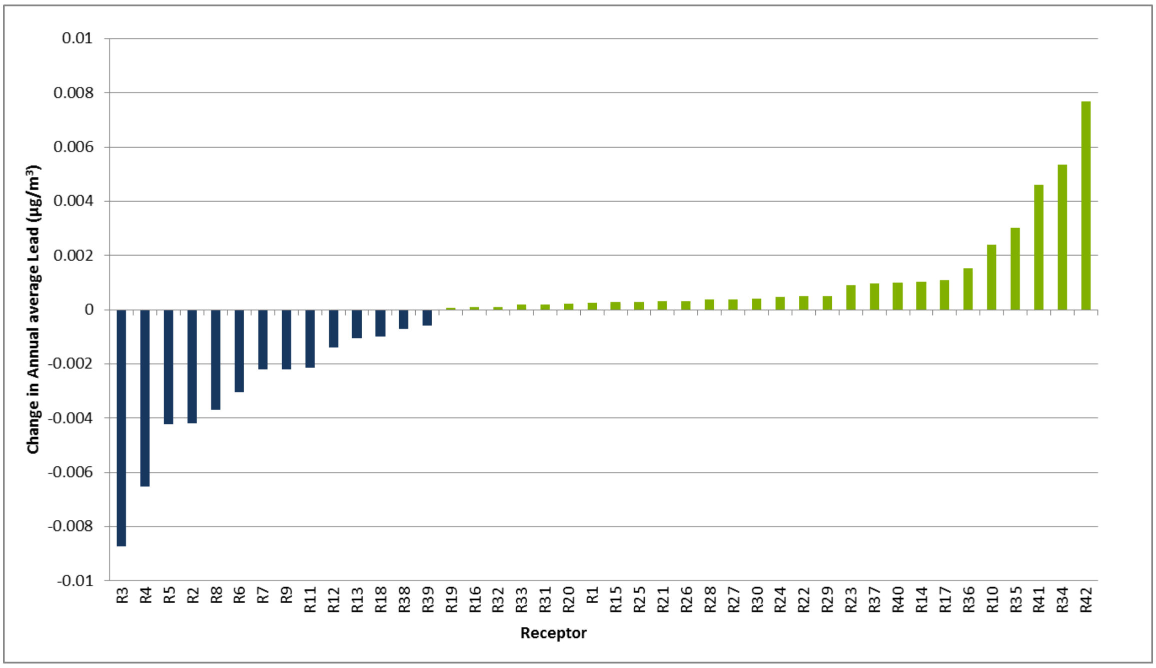

Figure 4.4: Change in Predicted Annual Average Lead Concentration from Original Ventilation Shaft Modelling

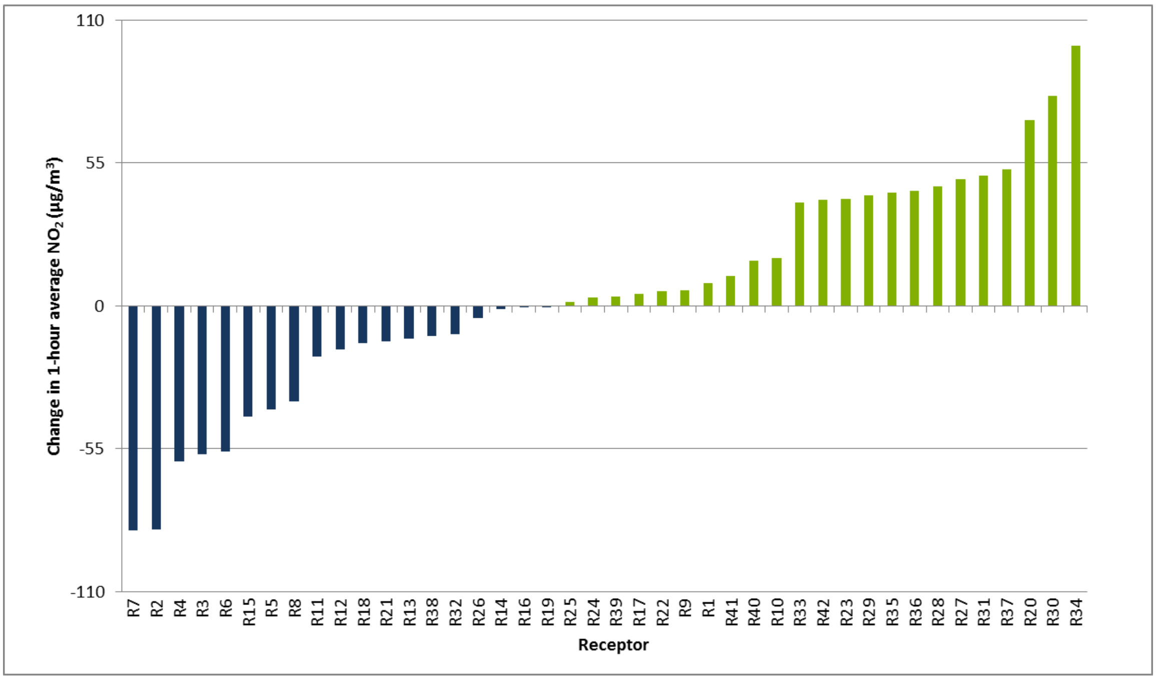

Figure 4.5: Change in Predicted 1-hour Average NO_2 Concentrations from Original Ventilation Shaft Modelling

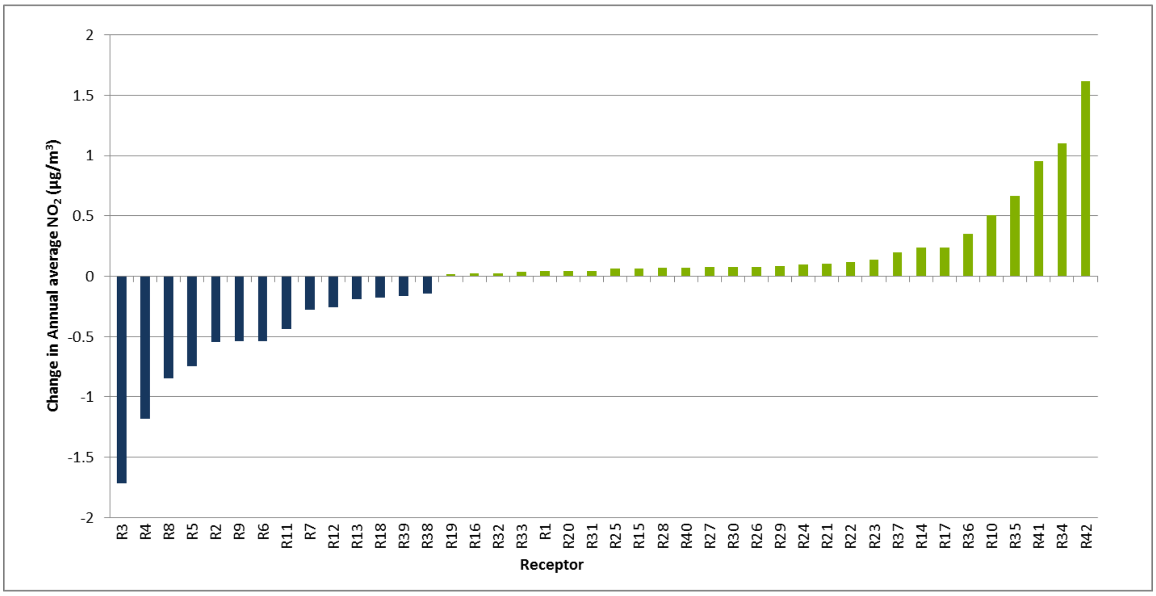

Figure 4.6: Change in Predicted Annual Average NO_2 Concentrations from Original Ventilation Shaft Modelling

Examination of **Figure 4.1**, **Figure 4.2**, **Figure 4.3**, **Figure 4.4**, **Figure 4.5** and **Figure 4.6** illustrates that overall incremental impacts are predicted to reduce at receptor locations representative of groups of receptors. Broadly, incremental impacts are predicted to increase relative to the air assessment predictions at locations representative of single dwellings / commercial properties.

Additionally, locations with the highest predicted increases occur relative to the air assessment predictions represent single commercial properties (receptors R34, R35 and R42).

4.2 24-Hour and Annual Average PM_{10}

The incremental highest 24-hour and annual average PM_{10} concentrations predicted to occur at nearby receptor locations due to operations at maximum production levels for the modelled year 2009 are summarised in **Table 4.1**.

Predicted concentrations are presented spatially as contours in **Appendix A**.

Under normal operations, the revised vent-shaft incremental concentration of PM_{10} is predicted to contribute up to 7% of the OEH criterion of 50µg/m³ for the worst case 24-hour period across all receptors. Original modelling predicts incremental contributions of up to 8% of the OEH criterion.

The maximum predicted vent-shaft increment in annual PM_{10} concentrations across all receptors is 0.2µg/m³, or 0.5% of the OEH criterion of 30µg/m³. Original modelling predicts vent-shaft increments of equivalent magnitude.

Table 4.1: Predicted 24-hour and Annual Average PM_{10} – Original and Revised Ventilation Shaft Modelling

Receptor	24-Hour Average Predictions ($\mu g/m^3$)		Annual Average Predictions ($\mu g/m^3$)	
	Original	Revised	Original	Revised
R1	0.7	0.9	0.0	0.0
R2	3.5	0.7	0.1	0.0
R3	4.1	1.2	0.2	0.0
R4	3.2	0.7	0.1	0.0
R5	2.4	0.8	0.1	0.0
R6	2.8	0.4	0.1	0.0
R7	3.4	0.7	0.1	0.0
R8	3.1	1.4	0.1	0.0
R9	1.0	1.1	0.1	0.0
R10	0.9	1.8	0.0	0.1
R11	1.2	0.5	0.1	0.0
R12	1.7	0.6	0.0	0.0
R13	1.5	0.6	0.0	0.0
R14	0.5	0.4	0.0	0.0
R15	0.3	0.2	0.0	0.0
R16	0.1	0.1	0.0	0.0
R17	0.5	0.7	0.0	0.0
R18	0.9	0.5	0.0	0.0
R19	0.1	0.1	0.0	0.0
R20	0.1	0.3	0.0	0.0
R21	0.8	0.5	0.0	0.0
R22	0.6	1.3	0.0	0.0
R23	0.4	1.5	0.0	0.0
R24	0.4	0.7	0.0	0.0
R25	0.5	1.0	0.0	0.0
R26	0.5	0.4	0.0	0.0
R27	0.2	0.6	0.0	0.0
R28	0.2	0.6	0.0	0.0
R29	0.2	1.0	0.0	0.0
R30	0.1	0.9	0.0	0.0
R31	0.2	0.3	0.0	0.0
R32	0.2	0.1	0.0	0.0
R33	0.2	0.5	0.0	0.0
R34	0.4	3.5	0.0	0.1
R35	0.3	0.9	0.0	0.1
R36	0.2	0.4	0.0	0.0
R37	0.2	0.7	0.0	0.0
R38	1.0	0.7	0.0	0.0
R39	0.5	0.6	0.0	0.0
R40	1.4	1.8	0.1	0.1
R41	2.1	3.5	0.1	0.1
R42	0.6	2.5	0.0	0.2

4.3 1-Hour and Annual Average NO_2

The incremental highest 1-hour and annual average NO_2 concentrations predicted to occur at nearby receptor locations due to operations at maximum production levels for the modelled year 2009 are summarised in **Table 4.2**.

Predicted concentrations are presented spatially as contours in **Appendix A**.

Under normal operations, the revised vent-shaft incremental concentration of NO_2 is predicted to contribute up to 80% of the OEH criterion of 246µg/m³ for the worst case 1-hour period across all receptors. Original modelling predicts equivalent incremental contributions.

The maximum predicted vent-shaft increment in annual NO_2 concentrations across all receptors is 2.2µg/m³, or 3% of the OEH criterion of 62µg/m³. Original modelling predicts vent-shaft increments of equivalent magnitude.

Table 4.2: Predicted 1-hour and Annual Average NO_2 – Original and Revised Ventilation Shaft Modelling

Receptor	1-Hour Average Predictions (µg/m³)		Annual Average Predictions (µg/m³)	
	Original	Revised	Original	Revised
R1	99	108	0.4	0.5
R2	195	109	1.0	0.5
R3	171	114	2.3	0.6
R4	164	104	1.5	0.4
R5	144	104	1.1	0.4
R6	151	95	0.9	0.4
R7	196	110	0.6	0.3
R8	159	122	1.4	0.6
R9	116	122	1.1	0.5
R10	112	130	0.5	1.0
R11	117	98	0.7	0.3
R12	117	100	0.5	0.3
R13	111	98	0.4	0.3
R14	97	95	0.4	0.6
R15	96	53	0.1	0.2
R16	21	20	0.1	0.1
R17	100	104	0.2	0.5
R18	114	100	0.4	0.2
R19	15	15	0.1	0.1
R20	24	96	0.1	0.1
R21	109	95	0.3	0.4
R22	104	109	0.3	0.4
R23	97	138	0.2	0.4
R24	99	102	0.2	0.3
R25	101	103	0.3	0.3
R26	101	96	0.2	0.2
R27	55	103	0.1	0.2
R28	57	103	0.1	0.2
R29	61	104	0.1	0.2
R30	24	105	0.1	0.2
R31	45	95	0.2	0.2
R32	47	36	0.1	0.2
R33	59	99	0.1	0.1
R34	97	197	0.4	1.5
R35	70	114	0.3	1.0
R36	27	71	0.2	0.6
R37	55	108	0.2	0.4
R38	116	104	0.4	0.3
R39	102	106	0.4	0.3
R40	123	141	0.9	0.9
R41	153	165	0.7	1.7
R42	105	146	0.6	2.2

4.4 Other Air Quality Parameters

The incremental highest concentrations of other air quality parameters predicted to occur at nearby receptor locations due to operations at maximum production levels for the modelled year 2009 are summarised in **Table 4.3**.

Only the maximum predicted concentration across all receptors has been reported, as the remaining parameters are predicted to constitute a relatively minor percentage of their relevant OEH criterion.

Table 4.3: Maximum Predicted Concentrations of Other Air Quality Parameters – Original and Revised Ventilation Shaft Modelling

Air Quality Parameter	Maximum Predicted Concentration across all Receptors (µg/m^3)		Averaging Period	OEH Criterion (µg/m^3)
	Original	Revised		
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.

Table 4.3 indicates that in terms of maximum impact at nearby sensitive receptors, there is no significant change between the original and revised (relocated) ventilation shaft scenarios.

Additionally, there is no significant contribution to cumulative concentrations of these parameters relative to OEH criteria. The largest vent-shaft increment as a percentage of the corresponding OEH criterion is 7%, associated with maximum 1-hour average concentrations of PAH.

4.5 Comparison between Original and Modelling and Proposed Relocation

As a final illustration of the impact of the relocation of the processing plant on nearby receptors, the top three maximum increments at receptor sites have been compared for different air quality indicators under the air assessment and Scenario 2 conditions, as shown in **Figure 4.7**, **Figure 4.8**, **Figure 4.9**, **Figure 4.10** and **Figure 4.11**.

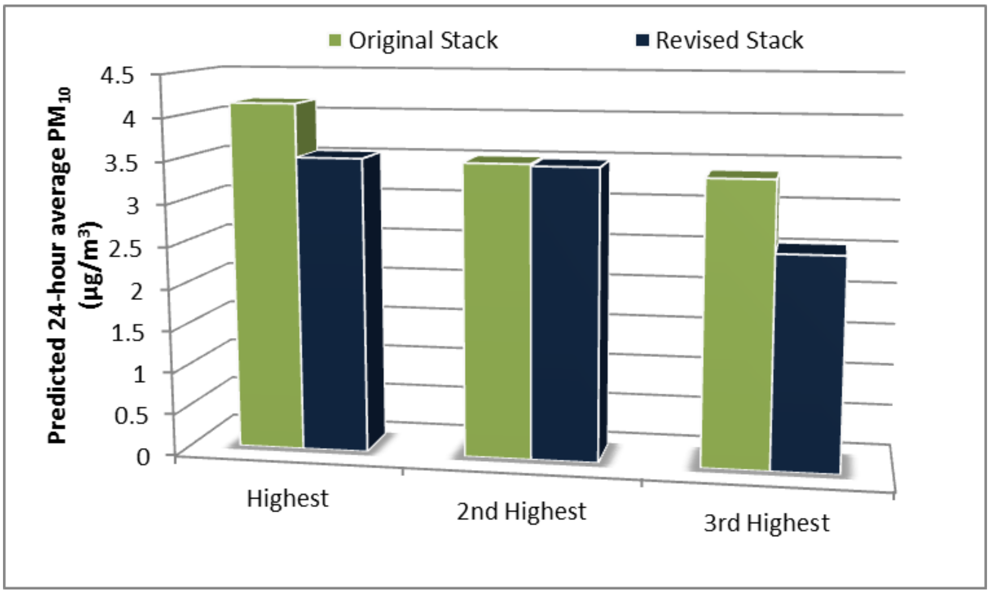

Figure 4.7: Comparison of Top Three Maximum Predicted Receptor Increments for 24-hour PM_{10} – Original vs. Revised Modelling

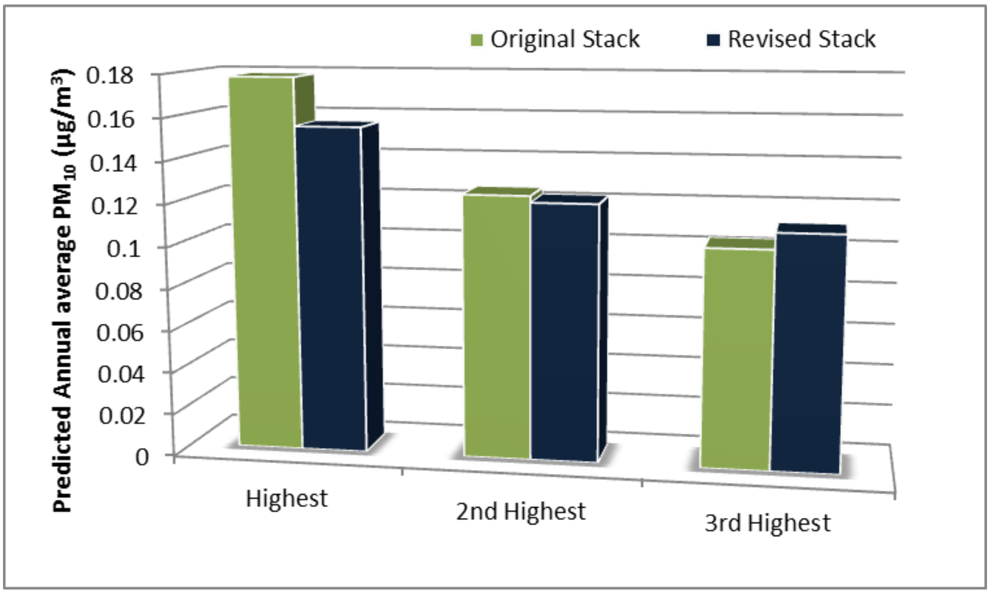

Figure 4.8: Comparison of Top Three Maximum Predicted Receptor Increments for Annual Average PM_{10} – Original vs. Revised Modelling

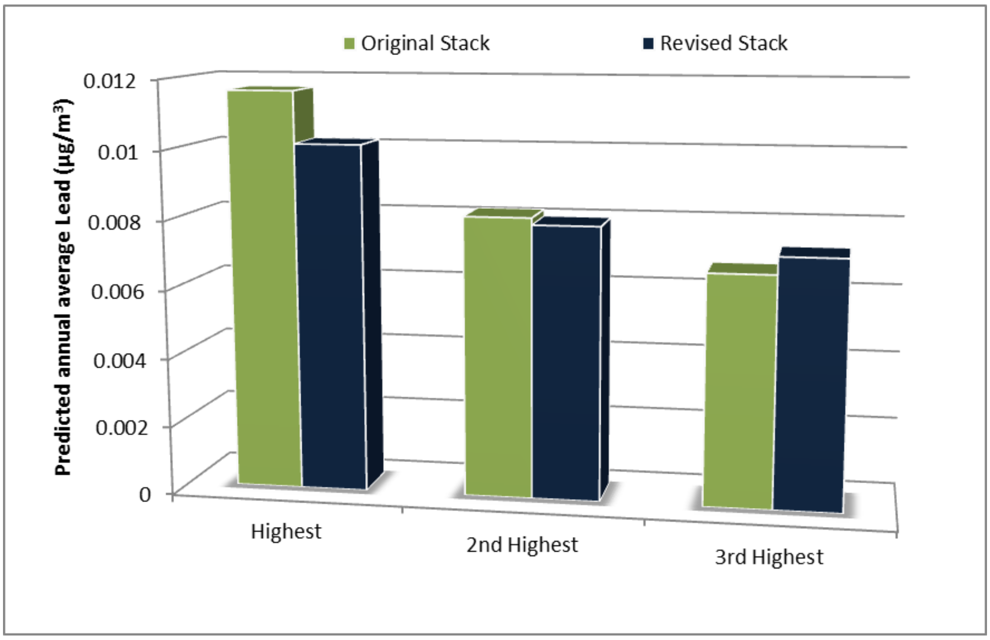

Figure 4.9: Comparison of Top Three Maximum Predicted Receptor Increments for Annual Lead Concentration – Original vs. Revised Modelling

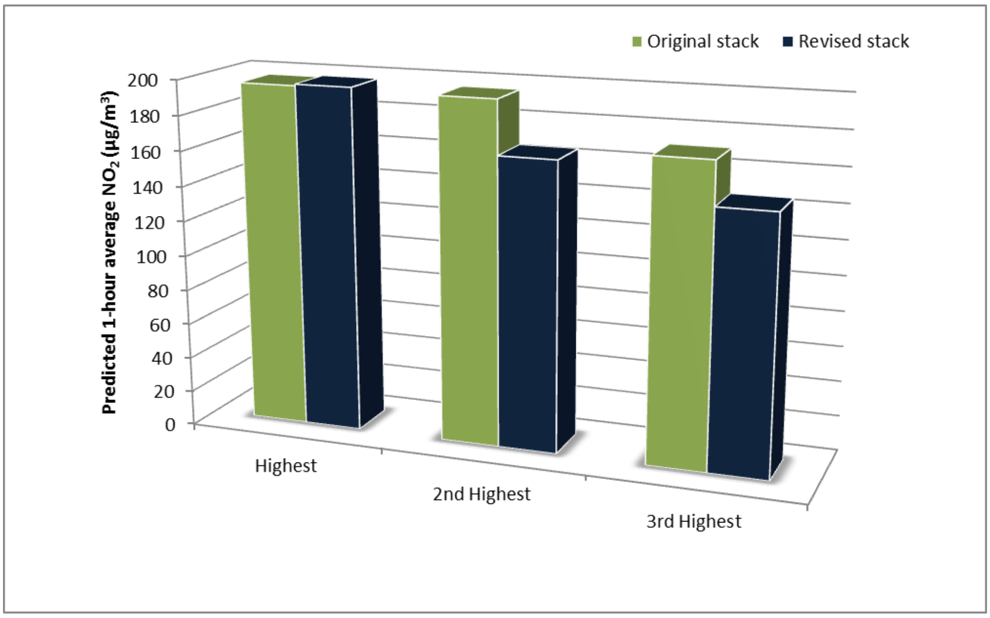

Figure 4.10: Comparison of Top Three Maximum Predicted Receptor Increments for 1-Hour Average Nitrogen Dioxide – Original vs. Revised Modelling

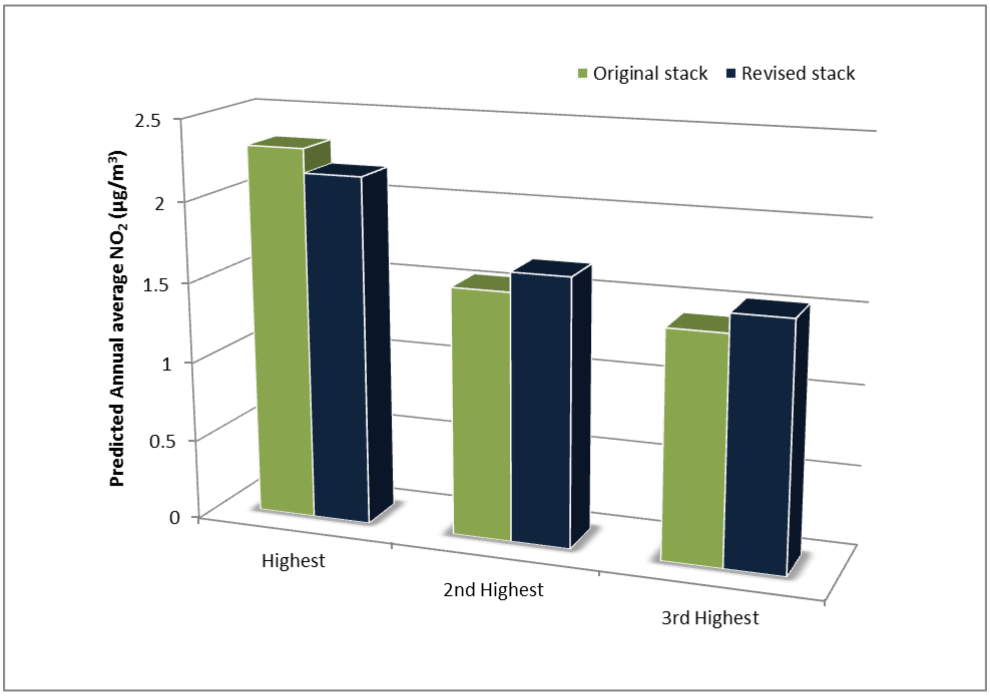

Figure 4.11: Comparison of Top Three Maximum Predicted Receptor Increments for Annual Average Nitrogen Dioxide – Original vs. Revised Modelling

Figure 4.7, **Figure 4.8**, **Figure 4.9**, **Figure 4.10** and **Figure 4.11** illustrate visually that compared to the original vent-shaft increment predictions, the maximum incremental increases for the revised location, for all key air quality indicators, are in the main either equivalent or are marginally reduced.

5 CONCLUSION

While the location of the most affected sensitive receptors changes under the proposed relocation of the ventilation shaft, the maximum impact at nearby sensitive receptors does not change significantly between the original and revised (relocated) ventilation shaft scenarios.

Overall, incremental impacts are predicted to reduce at receptor locations representative of groups of receptors. Broadly, incremental impacts are predicted to increase relative to the air assessment predictions at locations representative of single dwellings / commercial properties.

Additionally, locations with the highest predicted increases occur relative to the air assessment predictions represent single commercial properties (receptors R34, R35 and R42).

In view of the above, it is anticipated that the proposed relocation of the Rasp underground mine ventilation shaft will not cause any significant change to the conclusions made within either the EA or PPR.

It is anticipated that the ventilation shaft may be operated to ensure that there are no adverse air quality impacts associated with either the shaft in isolation, or in the context of the mine as a whole (i.e. cumulative air quality impacts).

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
General Manager (NSW)
PAEHolmes

6 REFERENCES

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.

DECCW, 2005. Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, NSW Department of Environment and Conservation.

APPENDIX A

Incremental Contour Plots for PM_{10} and Nitrogen Dioxide

Figure A1: Maximum 24-hour PM_{10}

Figure A2: Annual Average PM_{10}

Figure A3: 1-Hour Average Nitrogen Dioxide

Figure A4: Annual Average Nitrogen Dioxide