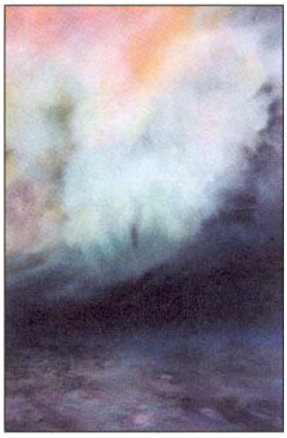

Katestone Environmental

ABN. 92 097 270 276

REPORT FROM KATESTONE ENVIRONMENTAL
TO ALCOA WORLD ALUMINA AUSTRALIA

DESKTOP REVIEW OF THE CSIRO PHASE 2, 3A AND 3B (FINAL REPORTS) FOR ASSESSMENT OF THE ALCOA WAGERUP REFINERY EXPANSION

March 2005

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1. Scope of Expert Review

Katestone Environmental has been commissioned by Alcoa to prepare independent expert advice, in the form of a desktop review of project studies related to Alcoa's Wagerup 3 Refinery expansion, in order to assist the Emissions and Health Working Group. In addition the desktop review may be used by Alcoa to provide additional information to regulatory agencies and the public.

This report presents a review of the final air dispersion modelling reports for the Wagerup 3 Refinery expansion prepared by CSIRO and comments on amendments to the draft reports and additional information prepared by CSIRO in response to issues raised in our initial review (Katestone Environmental 2005). Based on feedback from the community on the initial review, this report aims to present the issues in an easy to understand language and identify the significance of the findings of the previous technical review report. This report has benefited from feedback from the community given in response to the initial review.

The project reports to be reviewed in this report are:

"Meteorological and dispersion Modelling Using TAPM for Wagerup Phase 1: Meteorology" Prepared for Alcoa World Alumina Australia by CSIRO Atmospheric Research, November 2004. – Final report Appendix

"Meteorological and dispersion Modelling Using TAPM for Wagerup Phase 2: Dispersion" Prepared for Alcoa World Alumina Australia by CSIRO Atmospheric Research, February 2005. – Final report

"Meteorological and dispersion Modelling Using TAPM for Wagerup Phase 3A: HRA (Health Risk Assessment) Concentration Modelling – Current Emissions Scenario" Prepared for Alcoa World Alumina Australia by CSIRO Atmospheric Research, 14 February 2005. – Final report

"Meteorological and dispersion Modelling Using TAPM for Wagerup Phase 3B: HRA (Health Risk Assessment) Concentration Modelling – Expanded Refinery Scenario" Prepared for Alcoa World Alumina Australia by CSIRO Atmospheric Research, 11 February 2005. – Draft Final report

This desktop review is intended to evaluate the air quality assessment prepared by CSIRO and presented in the reports listed above to determine if the information is adequate, whether the methodologies used are appropriate to determine the impacts on air quality due to the refinery and whether the conclusions drawn from the work are appropriate. This review is not intended as an audit of the provided input information (eg. the completeness of the emissions inventory), an evaluation of the process or technology, or an assessment of the air quality impacts of the project; these tasks are for the proponent and the governing environmental authorities. This review focuses on the robustness and reliability of the modelling methodology and the conclusions drawn from it.

2. Review of reports

2.1 Phase 1 report – Meteorological assessment

As this report was finalised when reviewed, an Appendix was added to address some of the issues identified in our previous review. These issues can be summarised as follows:

(a) Inter-annual variability of wind direction

CSIRO's previous reports found that there is significant inter-annual variability in wind direction frequency at Wagerup. Our review requested that the impact of inter-annual variability in meteorological conditions should be investigated and the implications for ground-level concentrations (and HRA outcomes) should be considered.

The inter-annual variability was presented in the Appendix of the Phase 1 report (and repeated in both Phase 3 reports). The variability was investigated over the years 1997 to 2004 from 6-hourly synoptic analyses used as input into TAPM. It would have been better to investigate the variability using hourly measurements taken in the region, rather than a model output. However, given that it is difficult to obtain good quality and consistent data for such a long period for the region, the analysis presented by CSIRO in the Appendix is adequate. The analysis indicates that the variability is typically ±30% about the mean (up to 49%). The year chosen for modelling is within 20% of the average wind year, except for easterlies that are 33% less frequent for the year chosen than a typical year and southerlies are 24% more frequent.

CSIRO conclude that the inter-annual variability would result in the same variability in the annual average concentrations predicted by the model. Therefore the annual averages presented in the Phase 3 reports could be expected to be either 30% higher or 30% lower at a particular location depending on the year.

(b) Wind speed and direction frequency distribution predicted by TAPM

Our previous review identified the importance of adequately predicting the actual local frequency of wind direction and wind speed. CSIRO were requested to show that the differences in the frequency of winds (direction and speed) predicted by TAPM compared with actual measurements do not adversely impact on ground-level concentrations (particularly annual averages) and hence the validation of air quality impacts. In particular, it was evident that the model under-predicted the frequency of light to moderate wind speeds and the frequency of winds in the northerly sector during the time of maximum odour complaints (8 – 11 am).

These issues were not directly addressed in the revised reports but were indirectly addressed through the use of data assimilation in the modelling. By including data assimilation the winds generated by the model better reflect those measured and hence display a more representative frequency distribution of light winds and northerly winds. The results of modelling with data assimilation were presented in the Phase 3.

The results of modelling with data assimilation indicate that the predicted concentrations are quite sensitive to the wind speed and frequency of wind direction. The peak short-term concentrations (presented as maximum, RHC (robust highest concentration) and 10^{th} highest 1-hour average) are higher at most receptors, particularly in the south on the western side of Yarloop. The annual averages are predicted to be either the same or higher (over twice as high in some areas of Yarloop) with the inclusion of data assimilation. As the frequency of northerly winds was significantly under-predicted by the model it is understandable that the annual averages in this area are higher with the inclusion of data assimilation. However, as most areas receive higher annual averages this would indicate that the results are also sensitive to the frequency of light winds. More details are presented in Section 2.3 on the uncertainty in modelling.

2.2 Phase 2 report – Dispersion

Substantial additions have been made to the Phase 2 final report addressing most of the issues raised in our previous review. Most of the new work has been presented in Appendix A, which presents the results of remodelling with daily emission rates, rather than a constant rate for the year long run. The justification of combining closely located stacks to take into account the enhanced buoyancy is also presented in the new Appendix A. The revised modelling results and the two recommendations identified in our previous review for the Phase 2 report (reproduced below) are discussed in the following section.

(a) Detailed testing of model performance

Recommendation: Using techniques described in ASTM (2000), test the model's performance for key meteorological regimes, particularly those important to the transport of emissions to sensitive residential areas.

Testing the models performance in more detail would be beneficial as the difference in the performance of the model between night and day and summer and winter is significant. More information regarding the reason the model under-predicts during the winter and nighttime and over-predicts during the summer and daytime would help CSIRO and the reviewer to assess the model's performance (this type of analysis could also be undertaken for the new modelling results presented in Appendix A).

Due to the limited ambient pollution monitoring data available for verification and possible contamination of the data by other sources, it can be justified that further testing is not likely to produce a reliable outcome. CSIRO have used both Upper Dam and Boundary Road sites for verification of the models performance with only minor scrutiny of the data to separate out the signature from the refinery operations. In Appendix A, only data from Upper Dam was selected for model verification due to the significant influence of other sources at the Boundary Road site. It was stated in our previous review that the data from the Boundary Road site is significantly influenced by other sources and therefore more weight should be given to the Upper Dam site or more analysis of the Boundary Road site is required to better identify the refinery signature at this site.

Due to the significant number of complaints from residents (perhaps indicating a sensitised population) in the vicinity of the Boundary Road site a more in-depth analysis and justification of refinery signature at this site may be warranted. The revised report included additional analysis in Section 6, which sumarised the important meteorological conditions under which the model predicted adverse impacts at sensitive receptors. Validation of the modelled pathways by analysis of actual measurements is advisable to provide additional support for these findings.

(b) Buoyancy enhancement

Recommendation: Test the model's performance at Upper Dam using buoyancy enhancement for the multiflue stacks, as used in the Phase 3a modelling.

This recommendation was addressed and presented in Appendix A of the Phase 2 report. It has been assumed that the scenario presented in Appendix A of the Phase 2 report is for the model without wind data assimilation, however, this is not stated.

The use of buoyancy enhancement for multiflue stacks is appropriate and the results presented in the Phase 2 report are closer to the measurements at Upper Dam than those without buoyancy enhancement. The model tends to under-predict the top few measurements and concentrations in the 2-10 ppb range. The apparent under-prediction of the maximum concentrations has been discussed earlier and could be caused by the modelled flow rates from the GT being high compared to actual flow rates of the GT during peak emissions. The under-prediction in the 2-10 ppb range is probably a result of modelling the refinery emissions and not other sources that could also contribute to measured levels at the site.

(c) Daily emission rates

The validation study undertaken by CSIRO in the original Phase 2 report used a constant emission rate for all the refinery sources. Due to changes in operating conditions throughout the year, the emission rates for each source can vary significantly from day to day and probably also from hour to hour. Our initial review recommended the use of detailed hourly emission rates for a more robust model verification process due to the likely significant variability. This has been presented in Appendix A of the Phase 2 report.

It is unfortunate that CSIRO has gone to the trouble of modelling daily emission rates (of which there is significant variability) but has not also modelled the corresponding daily flow rates. The flow rates will change as the operating conditions of the equipment change. Typically, for higher equipment loads the flow rates are also higher resulting in more buoyant plumes and hence relatively lower ground-level impacts. The most significant changes in emission rates are for Boiler 1 and the Gas Turbine these two sources are discussed separately below.

The emissions of NO_x from Boiler 1 were high during October and November (up to three times higher than the level modelled as the average emission rate in the main section of the Phase 2 report). During the peak operating conditions of the boiler the flow rates would also be higher resulting in a more buoyant plume and hence lower ground level concentrations. Therefore the modelling of this source is conservative and the actual ground-level concentrations during peak operating conditions would be lower than the model predictions.

The opposite is the case for the Gas Turbine. During September and November the Gas Turbine emissions were four times higher than typical operations. This is presumably due to the turbines operating in the critical peak NO_x regime of between 60-75% turbine load. During this regime not only are the NO_x emissions significantly higher than at peak turbine loads but the flow rates are also lower resulting in a less buoyant plume and worse dispersion (i.e. higher ground-level concentrations) than during peak operating conditions. This may be the reason for the under-prediction of the peak impacts by the model.

Analysis of the conditions during which the peak impacts are predicted and the corresponding operating conditions for each stack could help resolve this issue. Alternatively, modelling the actual daily flow rates for the stacks should eliminate the apparent under-prediction of the peak impacts by the model (Table 1A indicates that the RHC ratio is 0.8, which means the highest concentrations predicted by the model are lower than measurements by 20%).

2.3 Phase 3A report – Concentration Modelling of Current Operations for HRA

The final version of the Phase 3A report presents additional information on the method used to combine closely located plumes into a single plume to account for enhanced plume buoyancy and more detail on model uncertainty.

(a) Model uncertainty

Uncertainty in model results can be broken into uncertainty in meteorological fluctuations and model uncertainty. The uncertainty in modelling results depends on what you are trying to predict. Annual averages across a wide area may be quite accurately estimated, whilst short-term peak concentrations at a specific location may be poorly estimated. Therefore to get a better understanding of uncertainty that is important to this project we need to break down the modelling results and determine the uncertainty in meteorological fluctuations (e.g. location or change in conditions from year-to-year) and model uncertainty, which should be fairly consistent from run to run for a particular location and model setup.

There is a much higher uncertainty in the modelling results if trying to predict the right concentration at the right location for the right time. This means that the predicted impact may vary significantly at a particular receptor (such as those selected in the CSIRO report). The uncertainty can be reduced by considering the maximum impact irrespective of location. At the maximum exposed location the peak impacts should not vary significantly. This is generally why a full year (or more) of meteorological conditions is included in an air quality assessment and impacts are presented as the maximum predicted concentration over the modelling domain. Extreme statistics, such as maximum 1 hour average predicted over an entire year, are very difficult to predict and have a large uncertainty. For this reason modelling results are quite often assessed by the 9th highest concentration (or 99.9th percentile) or the robust highest concentration (RHC) rather than the maximum.

The annual average at a particular location will also vary, particularly from year to year and is generally dependent on the frequency of winds that occur in a particular direction. The uncertainty from year to year due to variation in wind patterns at Wagerup has been shown by CSIRO to result in a variation of ±30% for annual average concentrations at a selected receptor location. Generally if one location, say Hamlet, receives a higher annual average in a typical year due to a significant percentage of winds directing emissions from the refinery towards that location, another location, say Yarloop, will receive a lower annual average as there may be less winds than average that take emissions from the refinery to Yarloop. Therefore it is important to select the maximum exposed location for longer-term averages.

The inclusion of data assimilation in the model has a significant affect on short-term impacts (maximum 1-hour average and RHC) and the annual average. Short-term concentrations decreased in some areas, such as the receptors to the west. In most areas the inclusion of data assimilation resulted in higher concentrations, with concentrations 20-50% higher. One location (Receptor 3) on the south-western corner of Yarloop had predicted impacts that are three times higher with the inclusion of data assimilation.

Table 1 presents the predicted impacts for the current operations with and without the inclusion of data assimilation in the modelling. This shows the sensitivity of impacts at selected locations to the inclusion of data assimilation. We have contacted CSIRO and requested a contour plot showing the predicted impacts for the data assimilation scenario; this is presented in Figure 1. This can be compared directly to Figure 25 in the Phase 3A report to see the difference that data assimilation makes to the overall contours. From inspection of the contour plot Receptor 3 represents almost the maximum exposed receptor, a very small area further to the west received a concentration above 250 μg/m^3. Therefore the inclusion of data assimilation increases the maximum on the model domain by about 50% for short-term impacts.

Table 1: Summary of predicted maximum 1-hour average concentrations of NO_x for current operations of the Wagerup Refinery with and without data assimilation (μg/m^3)

Receptor	Predicted maximum 1-hour average concentration of NO_x (μg/m^3) for peak emission scenarios		
	Current operations	Current operations with wind data assimilation	Ratio
1	55	83	1.5
2	69	90	1.3
3	75	233	3.1
4	84	168	2.0
5	95	95	1.0
6	89	89	1.0
7	84	33	0.4
8	36	29	0.8
9	41	37	0.9
10	42	29	0.7
11	48	38	0.8
13	34	34	1.0
14	85	102	1.2
15	75	112	1.5
16	52	52	1.0
Maximum on grid	>150 <200	250	1.25-1.7

The figure indicates the plumes are very narrow and demonstrates the large variability in impacts for a particular location. Therefore to reduce model uncertainty it is advisable to present the maximum exposed location as well as the individual receptors.

Figure 2 presents the contour plots for annual average concentrations with and without data assimilation. Predicted concentrations at all locations remain the same or increase by as much as 100% at a particular location. The maximum on the model domain is also increased by 100% with the inclusion of data assimilation, as are most locations in Yarloop. This is probably due to the assimilated data slowing down the TAPM winds and increasing the frequency of northerly winds and hence predicting higher concentrations particularly in Yarloop.

Figure 1: Contour plot of predicted maximum 1-hour average concentrations of NO_x for current operating scenario (6600tpd) of Wagerup Refinery predicted by TAPM with data assimilation.

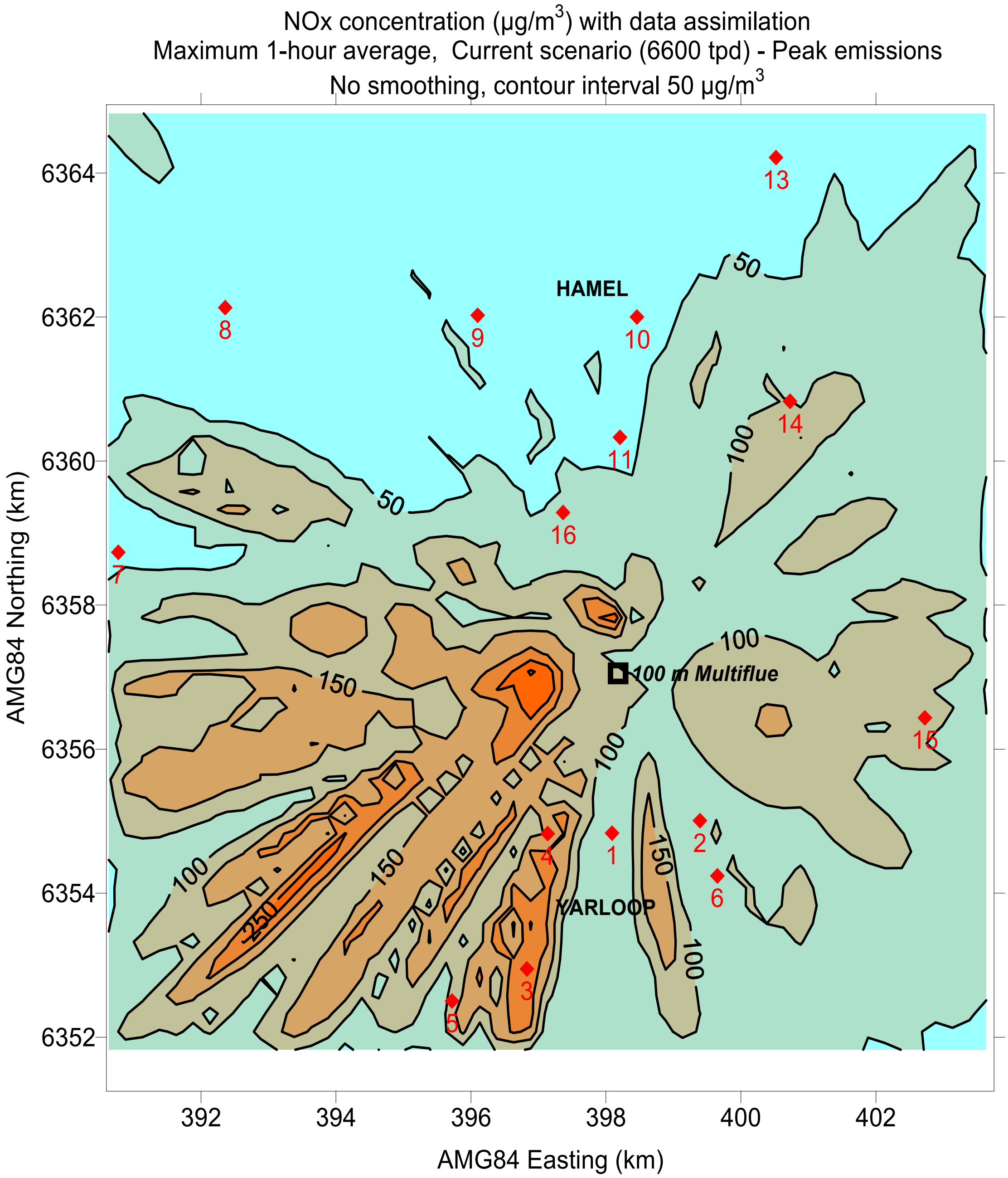
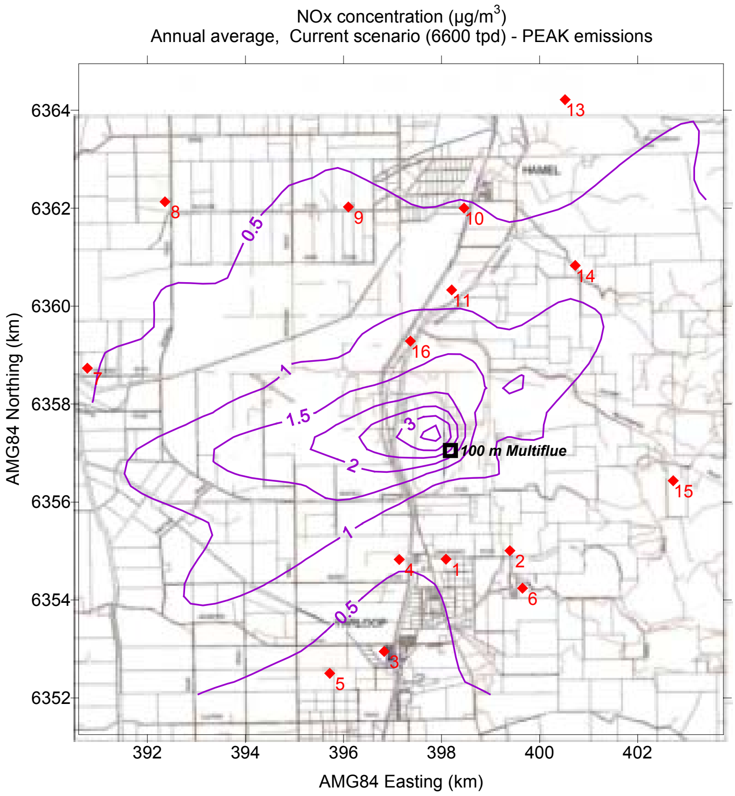


Figure 2: Contour plot of predicted annual average concentrations of NO_x for current operating scenario and peak emissions (6600tpd) of Wagerup Refinery predicted by TAPM (a) without and (b) with data assimilation.

(a)



(b)

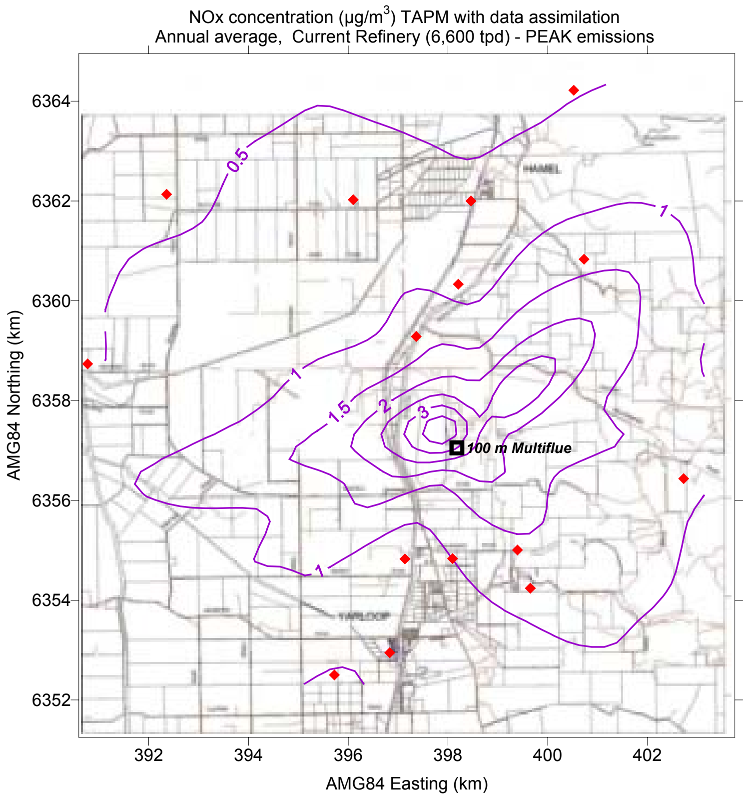


Table 5 of the Phase 3 reports should be replaced with the TAPM results presented in Table 7 of Phase 2 report. Table 5 incorrectly presents an average of the modelled RHC ratios, which is not suitable because of the effect of averaging is to under-represent the errors (the positive and negative errors cancel out). As noted in our previous review, studies not relevant to the Wagerup study should also be removed. The RHC ratio for the final configuration tested in the Phase 2 report and used in the Phase 3 modelling should also be presented, which is 0.8 (from Table A1 in Phase 2 report). The range in RHC ratios for TAPM presented in the Phase 2 report is 0.7 to 1.75 (i.e. a 30% under-prediction to a 75% over-prediction).

It would be useful to include a receptor at the Upper Dam site in Table 6 of Phase 3 reports as it may be shown that with data assimilation the under-prediction of RHC at Upper Dam is corrected (based on receptor 14 showing RHC 30% higher with data assimilation, this is also confirmed by inspection of the contour plots).

From inspection of contour plots (e.g. Figure 25, 26 and 27) it can be seen that the receptors chosen for detailed analysis do not include the maximum exposed location outside the plant boundary. An area approximately 2 km to the west of Yarloop (west of receptor 6) receives the highest short-term concentrations and should be included in the HRA as the maximum exposed location.

CSIRO draw the conclusion that the level of uncertainty in the modelling results presented in the Phase 3 reports is a factor of 2 (i.e. the actual value lies in the range –50% to +100%) for both short-term impacts and annual averages. This may be the case for each individual receptor location but may be overstated for the maximum exposed receptor. Recent model validation studies undertaken by CSIRO (Hurley et al, 2005) for TAPM V3 (which is closer to Version 2.6 used in the Wagerup studies compared to TAPM V2) showed that the RHC ratio was in the range 0.89 – 1.39 for maximum concentrations at selected distances from the source. The ratios of mean concentrations were in the range 0.88 – 1.64. Based on these results and those for the final configuration of the model predictions at the Upper Dam site (RHC ratio of 0.8), the peak impacts are more likely in the range 0.8 to 1.5 (i.e. results presented in the CSIRO reports 3A and B are actually in the range –20% to + 50%) for the maximum exposed location.

In Yarloop the modelling may have underestimated the maximum impacts (both short-term and long-term), as data assimilation was not included. At Yarloop the short-term maximums and long-term averages are more likely to be double those presented in the CSIRO reports.

We recommend that the modelling is redone to include data assimilation and an analysis of the sensitivity of impacts is undertaken particularly in Yarloop, when more data are available for the 30 m tower at Bancell Road. This will enable better data assimilation for a longer period of time.

It should also be noted that as long as the expansion scenarios do not contain any significantly different source types (such as 200 m stacks or buoyant line sources) the model uncertainty would be inherent in both current and expanded scenarios. Therefore it is important to look at the change in impacts rather than the absolute magnitude of predicted ground-level concentrations.

2.4 Phase 3B report – Concentration Modelling of Proposed Expansion for HRA

The scope of this review does not cover verification of emission rates, however, it does cover the ground level concentration predictions. Therefore we have presented a summary of a selection of results for current and expanded operations for comparison. We have also commented on the appropriateness of the emission rates used in the modelling based on the information provided in the Appendix A of Phase 2 reports for daily average emissions.

(a) Emission rates

The modelling results presented in Phase 3A and 3B use peak emission rates for short-term averages and average emissions for annual average concentrations. For the short-term averages, this should be a conservative assumption as all sources are modelled with peak emissions at the same time. The total emissions of NO_x from the current refinery operation are modelled as 32 g/s for average emissions and 75 g/s for peak emissions. From inspection of the daily emission rates (Figure A2 (j) Phase 2 report) the total emissions from the refinery are in the approximate range of 30 to 50 g/s. Therefore the total peak emission from the refinery are typically much less than that assumed in the modelling.

The most significant sources of NO_x from the current operation of the refinery (peak emissions as modelled) are Boilers 1 (24%) and 2 (22%) and Gas Turbine (18%). The daily emission rates reported for Boiler 1 can be up to 35% higher than the peak emission rate that is used in the modelling (approximately 15 days out of 365). It should be noted that this is also a daily average emission rate and that on a shorter averaging period, such as hourly average, the emission variability may be even higher. This source will be fitted with low NO_x burners for the expansion and as such the emission rates will decrease significantly, therefore the under estimation of the peak emissions is not a significant issue.

The Gas Turbine is modelled with peak emissions of 13.6 g/s, up to 70% lower than the peak daily emission rate for the 2003-2004 period. This may be due to the peak emissions only representing the Gas Turbine operating at full load when emissions are actually lower than the turbine operating at 50-75% load. At lower load the emissions from gas turbines are higher than at full load and the flow rates are lower, and hence plume rise and dispersion, are lower resulting in potentially higher ground level concentrations than operations during full load. The current operations have included the low load for a significant period (all of September) this should also be modelled as a potential scenario for the future operations.

Generally the peak emission scenario is conservative as all sources are assumed to be operating at peak emissions at the same time and during the worst meteorological conditions. However, individual sources may operate at higher emission rates than those modelled but this is likely to occur very infrequently and is unlikely to coincide with peak emissions from other sources or worst case meteorological conditions.

(b) Impacts

NO_x was selected to show the difference in short-term impacts due to the proposed expansions. The results for current operations, Case 6 and Case 7, are summarised in Table 2. At most locations the impacts are lower then the current operations. For the expansion (Case 6), two new gas turbines are included with significant emission rates of NOx (18 g/s/source) compared to the existing sources. The NO_x emissions from the calciners are slightly increased, as is the exit velocity and there are two new calciners with similar emissions to the existing Calciner 4. The only significant change in emission rates and characteristics for the existing sources that could result in a decrease in NO_x impacts is the increase in the height of the Calciner 4 stack from 49 m to 100 m multiflue and a significant decrease in emissions from the existing boilers (due to retrofit of low NO_x burners to the existing boilers). The only area that receives higher impacts for Case 6 expansion is to the west of the plant (where there are no receptors identified). A receptor should be chosen in this area at a location outside of the land owned by Alcoa to show the maximum exposed location.

The Case 7 expansion scenario involves two additional boilers that are similar to the existing boilers but with a slightly taller stack. From inspection of Table 2, the only location to receive an increase in impacts is Receptor 15. From inspection of the contour maps for each modelling scenario there appears to be little difference in the impacts. This shows the sensitivity of predictions to the receptors selected and therefore we recommend that the maximum prediction at all off-site locations also be presented.

Table 2: Summary of predicted maximum 1 hour average concentrations of NO_x for current and expanded operations of the Wagerup Refinery (µg/m^3)

Receptor	Predicted maximum 1 hour average concentration of NO_x (µg/m^3) for Peak emission scenarios		
	Current operations	Expansion Case 6	Expansion Case 7
1	55	42	48
2	69	55	51
3	75	60	60
4	84	68	73
5	95	78	72
6	89	59	75
7	84	79	67
8	36	38	28
9	41	41	40
10	42	42	42
11	48	44	41
13	34	31	32
14	85	75	74
15	75	62	90
16	52	45	47

Note: shaded cells represent an increase in impacts for the expanded operations.

In order to determine the pollutant that is most critical for the HRA we have used the CAPCOA HRA96 program as a screening tool. This HRA methodology is accepted in most states in Australia, but not Western Australia. Consequently the detailed results are not presented here but the results have been used to determine the most critical pollutant based on the relative toxicities of each pollutant that is emitted. The most critical pollutant for the HRA is Acrolein, followed by Mercury, Acetaldehyde, Formaldehyde and Manganese. Table 3 presents the modelling results for current operations and expanded operating scenarios for Acrolein for short-term and long-term averages.

Table 3: Summary of predicted ground level concentrations of Acrolein for current and expanded operations of the Wagerup Refinery

Receptor	Predicted maximum 1 hour average concentration of Acrolein (x10^{-2} µg/m^3)			Predicted annual average concentration of Acrolein (x10^{-4} µg/m^3)		
	Current operations	Expansion Case 6	Expansion Case 7	Current operations	Expansion Case 6	Expansion Case 7
1	3.2	3.0	3.0	2.8	2.6	2.6
2	4.5	3.6	3.6	3.8	3.0	3.0
3	3.3	3.0	3.0	2.0	1.8	1.8
4	4.2	3.4	3.4	2.6	2.6	2.6
5	3.7	2.4	2.5	1.9	1.6	1.6
6	4.7	4.1	4.1	3.1	2.6	2.6
7	3.2	3.6	3.6	2.4	1.7	1.7
8	2.3	2.1	2.1	1.9	2.0	2.0
9	2.6	2.8	2.8	3.0	3.2	3.2
10	2.9	4.5	4.5	2.4	3.4	3.4
11	3.0	4.7	4.7	4.0	5.5	5.5
13	1.9	2.4	2.4	1.5	1.9	1.9
14	3.6	3.6	3.6	3.6	4.3	4.3
15	6.2	6.7	6.7	4.9	4.0	4.0
16	3.4	3.8	3.8	6.3	7.2	7.2

Note: shaded cells represent an increase in impacts for the expanded operations.

The calciners are the only stack sources with Acrolein emissions at the Wagerup refinery. During the expansion two additional calciners will be installed and the stack height for Calciner 4 will increase and be combined with the new 100 m multiflue Calciner stack. The significant decrease in impacts in some areas (mainly south of the plant) is likely to be due to the improved dispersion of Calciner 4 after the expansion when it is combined with the exhausts from Calciner 5 and 6 in a 100 m multiflued stack.

Due to the changes in emission rates and stack characteristics (e.g. increased stack height for Calciner 4) for the proposed expanded refinery it is difficult to check the validity of the predicted impacts for the refinery expansion. However, based on the changes noted above in emission rates and stack characteristics the changes in impacts seem reasonable.

3. Summary of review

Generally the use of TAPM for modelling the Wagerup Refinery plumes should be suitable, and is probably the best available model. It is commendable that CSIRO has tested the TAPM scheme against many data sets and are constantly upgrading the model. However, the performance of TAPM can be quite mixed and depends on the situation being modelled and the performance measures required for a particular situation. The model appears to be more useful than many comparable models and the recent upgrades to the model have been shown to improve the model's performance. It has been recognised by the developers that there are circumstances in which the model over-predicts surface wind speeds and may have problems with dispersion in complex terrain. We point out that any model or measurement process has associated errors for which it is important to estimate the likely influence on the conclusion of a given study, however, keeping this in mind the errors of a particular model will be the same for the current scenario as for the expansion and therefore the relative difference in impacts can be as important as the magnitude of impacts.

The revised reports prepared by CSIRO have addressed either directly or indirectly the significant issues identified in our previous review. Some of the additional information requested in our review has not been supplied. The question "is the model predicting the right answer for the right reason" remains unanswered. It would give more confidence in the results if this question was answered but due to the limited monitoring information available for the region it may not be possible.

The model setup verified in the model validation study presented in Phase 2 (Appendix A) has been shown with daily average emission rates to be a suitable configuration of the model. The peak few concentrations are slightly under predicted by the model which may be a result of not using the actual daily average operating conditions (e.g. flow rates and exit velocities) for each source or not including data assimilation.

We still recommend that the model use data assimilation as the more appropriate meteorological scenario for the region. This is shown to increase the impacts in the Yarloop area particularly, for both short-term and long-term ground-level concentrations. Overall the most exposed location is higher with data assimilation for peak 1-hour average concentrations and annual averages.

Modelling results should be presented for the maximum exposed location as well as at the discrete receptors. This will reduce the uncertainty due to year to year variability in wind patterns.

The peak emission scenario used to predict the short-term impacts is conservative as all sources are assumed to be operating at peak emissions at the same time and during the worst meteorological conditions, however, individual sources can operate at higher emission rates than those modeled, though there is likely to be a low risk that these short-term peaks will coincide. Therefore it is likely that the actual impacts will be lower than those presented if actual emission rates were used.

The uncertainty in the predicted modelling results presented in the Phase 3A and B reports for peak short-term impacts are likely to be in the range 0.8 to 1.5 (i.e. results presented in the CSIRO reports 3A and B are actually in the range –20% to + 50%) for the maximum exposed location. The uncertainty is slightly higher at Yarloop where the modelling may be an under prediction of the peak and annual average concentrations by a factor of 2 (i.e. results presented in the CSIRO reports 3A and B are actually + 100%).

It should also be noted that as long as the expansion scenarios do not contain any significantly different source types that are not similar to the range of source types modelled for the current operations (such as buoyant line sources), the model uncertainty would be inherent to and similar in magnitude for both current and expanded scenarios. Therefore it is important to look at the change in impacts as well as the absolute magnitude of predicted ground-level concentrations.

For the Refinery Expansion scenarios the impacts decrease and increase depending on the pollutant and location. Due to the changes in emission rates and stack characteristics for the proposed expanded refinery it is difficult to check the validity of the predicted impacts for the refinery expansion. However, based on the reduced emissions for some sources and better dispersion for others with the inclusion of a new multiflue source, the changes in impacts seem reasonable.

Generally the modelling undertaken for the Wagerup 3 Refinery expansion adequately assesses the potential impacts on the local atmospheric environment so long as a degree of conservatism is taken into account when applying the uncertainty factors from the modelling results presented by CSIRO in the HRA. We also strongly recommend that the maximum exposed location outside the Alcoa lease boundary is also presented and the change in impacts for the expansion assessed at this location.