INDEPENDENT AIR QUALITY REVIEW

WESTCONNEX - M4 EAST

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Independent Air Quality Review
WestConnex - M4 East

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1 SUMMARY

The preliminary review of the WestConnex M4 East Air Quality Assessment Report (**Pacific Environment, 2015a**) found a number of potentially significant issues that may affect the estimated impacts and how the assessment is received. However, regardless of these issues, the fundamental conclusions of the assessment were considered unlikely to change greatly.

This view was based on the generally sound approach whereby the modelling is used to make a relative comparison between the "do minimum case" and the Project case. Such a relative comparison effectively minimises the influence of the modelling assumptions made, apart from the predicted traffic numbers which govern any predicted relative change between the two cases being compared.

How the model calculates air emissions using the traffic numbers, and how it then predicts the dispersion/ pollutant levels that arise due to these emissions is done in the same fashion for each case, using the same assumptions, apart from traffic numbers. These assumptions primarily affect the model accuracy at predicting an absolute pollutant level, but as they are applied in the same way in each case there is only a small effect on the predicted relative difference between each case. Thus whilst the modelling may be predicting an absolute pollutant level in the future that will be higher or lower than may actually occur, the model would still provide a reasonable estimate of the relative change in the pollutant levels that would arise due to the Project. As this change is small, it is unlikely that the predicted outcomes would change greatly due to the issues found in the modelling.

In responding to the issues raised, the Proponent provided additional information at meetings held on 10 November and 1 December 2015. The Proponent also provided a detailed written response to agency and public submissions that included a justification of the assessment methodology and a response to the issues raised in the preliminary review which included the model selection, choice of meteorological data, and modelling accuracy issues. Although some of the responses provided for the issues raised in the review, such as meteorological performance and various model assumptions indicate the issues remain, making the modelling less than ideal, these issues are not critical enough to affect the fundamental results in the assessment.

Thus in regard to making a valid assessment, the model is used appropriately to provide a convincing assessment of the likely relative change in pollutant levels that may be experienced at any one location. Clear and informative graphs are provided to illustrate that the relative change in pollutant levels would be generally small, and for most receptors, this change would be a reduction in pollutant levels, but for a minority of receptors there would be a small increase.

Overall, this indicates that there would be reduced exposure to air pollutants for the local population, and for the receptors where there may be an increase, this would be relatively small and hence within acceptable bounds.

On this basis the proposed Project can be considered sound.

Issues with the modelling in so far as the predicted absolute levels of air pollutants remain unresolved, and hence provide uncertainty in this regard. This review outlines many of these issues in detail, and for every issue it is noted that it would not change the fundamental finding that there would be a small relative change, that is generally positive. These underlying issues have been identified by other agencies and the public as being of concern. To minimise such issues, it is suggested that DP&E, EPA and RMS consider developing an agreed approach for assessing future major roadway and road tunnel projects.

Overall, it is found that the predicted Project impacts fundamentally depend on the predicted traffic numbers.

To ensure that the air quality predictions are met in practice, in-tunnel air quality limits, including ventilation stack limits have been developed to be applied in the conditions of approval for the Project. These conditions also set out monitoring and reporting requirements that will demonstrate that the required limits are being met.

2 INTRODUCTION

Todoroski Air Sciences has been engaged by the NSW Department of Planning & Environment (DP&E) to review and provide independent advice in relation to air quality matters associated with the proposed WestConnex M4 East (hereafter referred to as the Project). The New South Wales (NSW) Roads and Maritime Services (RMS) is the Proponent of the Project.

This report summarises the review of the air quality assessment for the Project, the Proponent's response to the preliminary review and also agency comments. The key technical issues are discussed in the body of the report, and the complete list of technical issues examined in the review is summarised in **Table A-1** in **Appendix A**.

2.1 Scope of the review

The independent review covers the following key tasks:

1. Preliminary Review to comment on the technical adequacy and completeness of the air quality assessment in the Environmental Impact Statement (EIS)

2. Impact Assessment Review to consolidate the findings of the Preliminary Review, responses to the preliminary review, agency comments RMS's reports, participate in meetings and provide technical input and comments.

3. Prepare a Final Report on the assessment conducted in Tasks 1 and 2, addressing any Department comments.

The following documents were considered in the independent review:

- Appendix H Air Quality Assessment Report (**Pacific Environment, 2015a**) which forms part of the Environmental Impact Statement for the WestConnex M4 East;
- Agency comments related to the air quality impact assessment;
- Presentations outlining additional work (analysis, sensitivity testing, response to peer review and agency comments, etc.) (**Pacific Environment, 2015b**); and,
- WestConnex M4 East Submissions Report (**RMS, 2015**).

3 PROJECT OVERVIEW

NSW RMS is seeking to upgrade and extend the M4 Motorway from Homebush Bay Drive at Homebush to Parramatta Road and City West Link (Wattle Street) at Haberfield.

This upgrade and extension includes twin three-lane tunnels approximately 5.5 kilometre (km) long tunnels and associated surface works including interchange ramps at various locations and installation of tunnel ventilation systems. Eastern and western ventilation facilities would be located near Wattle Street and Underwood Road, respectively.

Figure 3-1 presents the location of the Project and key features.

Air quality assessment for the Project includes assessment of the following scenarios:

The in-tunnel air quality scenarios included:

- Expected traffic scenarios, optimum or best operating conditions with traffic at a speed of 80km/h
- Capacity traffic flows with various speeds;
- Vehicle breakdown

The ambient air quality scenarios included:

- Traffic scenarios above for:
  - 2014 – Base year
  - 2021 – Do minimum (no Project)
  - 2021 – Do something (with Project)
  - 2031 – Do minimum (no Project)
  - 2031 – Do something (with Project)
  - 2031 – Do something cumulative (with Project and M4-M5 Link)
- Regulatory worst case scenarios – compliance with tunnel ventilation outlets.

The 'do minimum' and 'do something' includes existing sources, the King Georges Road Interchange Upgrade and the M4 Widening. The 2031 'do something cumulative' further includes ventilation outlets that would be installed for the M4-M5 link.

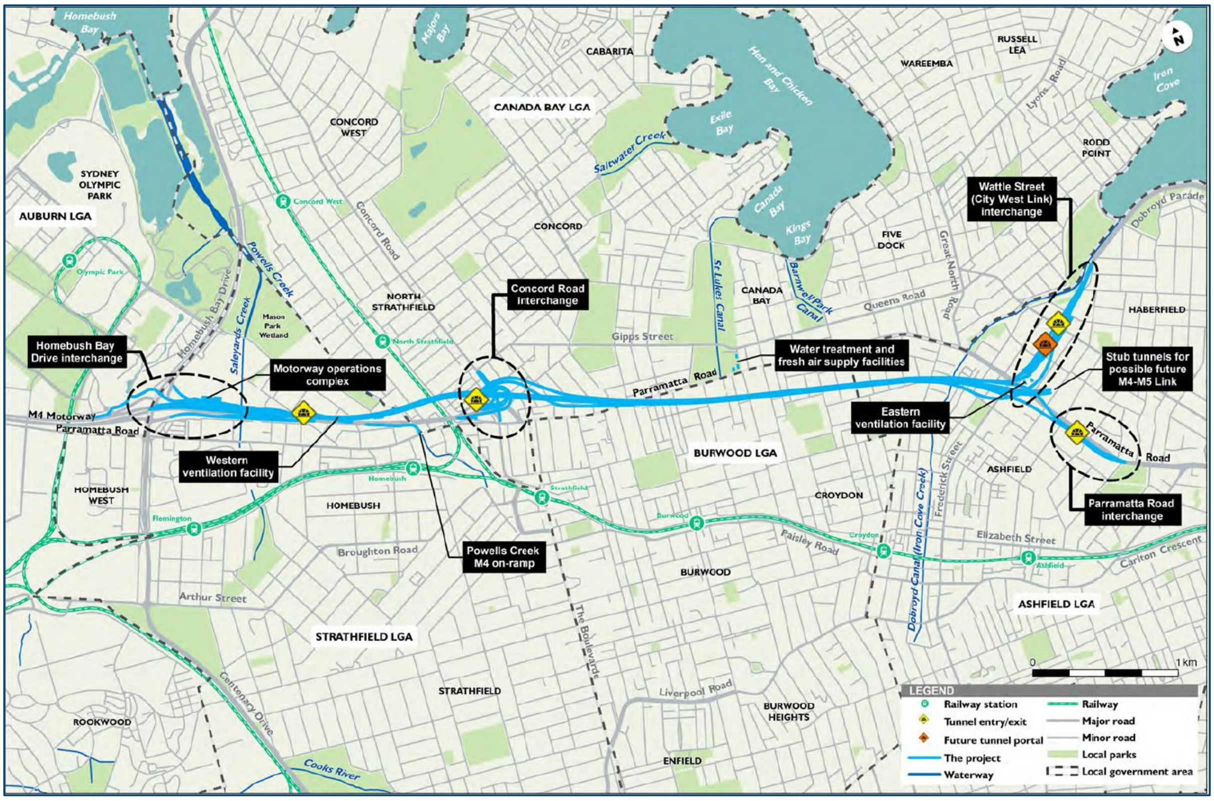

Figure 3-1: Project location and context

4 FINDINGS OF THE PRELIMINARY REVIEW

The key findings of the preliminary review of the Air Quality Assessment Report for the WestConnex M4 East (**Pacific Environment, 2015a**) are outlined below.

4.1 Apparent bias in the counting of receptors

The receptor selection appears to be significantly biased towards receptors located further from the road, with a significant underestimation apparent in the number of receptors near to the road. Whilst generally most receptor localities are included, there are several aspects in the assessment that would bias the results, and consequently may affect the health risk assessment (outside the scope of the air quality review).

The number of dwellings on several residential blocks some distance from the road were counted and it was found that there are many more receptors than actually exist. The assessment includes many more receptors than there are dwellings along the streets, additional rows of receptors are added between rows of houses, and in some cases rows of receptors are included along small lanes and local roads. Overall, it was estimated that approximately 50% more 'Residential, workplace and recreational (RWR) receptors' (than actual dwellings) appear to be included in the assessment for the locations away from the road.

For receptors near the road, large multistorey apartment buildings are represented by a single RWR receptor, generally in the centre of the building, whereas there appear to be many, possibly dozens of apartment dwellings within these buildings, some of which are only metres from the road. There appears to be a large underestimation in the number of dwellings in this regard. For some of the locations this could be an underestimation by a factor of ten or more in the number of actual sensitive receptors.

The same situation appears to apply for the large office buildings, and some of the largest are not included in the assessment at all. Some of these offices have outside parking lots containing many hundreds of cars, indicating many hundreds of people would be present during the day when there are likely maximum pollutant emissions.

This is primarily an issue of both;

- underestimating the maximum impacts at apartment blocks (as the RWR receptor is further from the road than many of the actual apartments), and also,
- the accuracy of the findings, as the study presents results for the <u>scale of the impact</u> (see Figure 8-43) and the decrease or increase in impacts (see Figure 4-44) <u>in terms of the number of RWR receptors affected</u>, (and this balance of impact may significantly alter once one considers the bias in receptor densities inherent in the assessment).

4.2 Monitoring data

Review of existing Office of Environment and Heritage (OEH) monitoring data for air quality is detailed and well presented.

There does not appear to be any comprehensive Project specific monitoring data presented. It appears that the assessment only provides some graphical, monthly mean data from only one of the five Project specific monitoring sites, the background monitoring site at St Lukes Park station.

On the basis of this analysis, which is often for just two months i.e. two monthly average data points, the consultants deem the OEH monitoring sites are representative of background locations in the assessment.

The analysis also does not appear to consider that the OEH monitoring data in Sydney for 2014 for NO_2 and Particulate matter are significantly lower than is typical.

Overall, this aspect of the analysis is not convincing, and erodes confidence in the approach applied to consider the relatively important background air quality levels that directly affect the predicted cumulative air quality levels.

A reasonable effort should be made to present the complete, up to date set of local monitoring data, and to conduct an analysis of the measured levels on an hourly, daily etc. basis, consistent with criteria averaging periods.

4.3 Representation of background data in the modelling of cumulative effects

A spatially varying annual mean concentration has been used for NO_2 and PM_{10} in an urban area, for 2014.

An analysis of the long term trends in NO_2 shows that unusually low results were recorded across the network in 2014, and the use of these data to represent the background levels is questioned.

The spatially varying grid also shows large gradients in pollutant levels at monitors that are close together in the modelling domain. The method used can introduce unnecessary errors in an assessment, such as when unrepresentative data are used and significantly skew the outcomes, for example in this case where data from the NorthConnex NC 02 monitor (which is near the intersection of Pennant Hills Road and the M2 Motorway) are used to represent underlying background levels.

For $PM_{2.5}$, a background level of 8µg/m^3, which is equal to the NEPM reporting standard has been applied. This means that all predictions at all locations would exceed the NEPM value, which would not occur in practice.

The basis for this approach is unclear and is at odds with the level of effort and detail applied for other, perhaps less significant pollutants being assessed. The approach would misrepresent the likely cumulative impacts for $PM_{2.5}$, one of the most significant pollutants associated with motorway operations.

A contemporaneous assessment method for short-term impacts (per the NSW Environment Protection Authority [EPA] Approved Methods), and also statistical methods, which do not appear to be explained, would appear to have been used for some situations. Synthetic data sets, using the highest reading from any one of three monitors appear to be used also. It is not clear if the use of the statistical or synthetic data sets would affect the results significantly relative to an assessment per the Approved Methods.

Overall, given that there is roadside and "background" monitoring data being collected in the near vicinity of the Project, it is unclear why the actual data measured closest to the receptors are not used (other than there is insufficient data for one year), or why there does not appear to be any model calibration with the available local data.

It is not ideal that many differing methods appear to have been applied to account for the background pollutant levels in the assessment. This introduces unnecessary error or bias in the integrity of the overall set of results and it is not clear that the approach applied is conservative in every case, or improves the transparency, accuracy or validity of the assessment.

Overall, it would be useful to consider using the locally measured data in a straightforward approach, consistent with the NSW Approved Methods definitions and means of accounting for background pollutant levels.

4.4 Meteorological data choice

Data from the Bureau of Meteorology (BoM) Canterbury Racecourse Automatic Weather Station (AWS) during 2014 calendar year was chosen for use the modelling as: *it was the most recent year, located closest to the centre of the modelling domain and was considered representative of the general wind patterns*.

The meteorological data analysis does not provide any convincing, or reasonable justification of the choice of the data used for the modelling.

The analysis provided appears to contradict the consultant's claimed suitability and representativeness of the data for the locality near the Project. For key metrics, such as wind speed and occurrence of calms, the consultant has selected the least representative data from the poorest performing station relative to the other meteorological stations in the vicinity of the Project.

The station recorded substantially fewer calms and much higher average wind speeds than are typical, or measured in the locality. For example, in comparison to the BoM Canterbury Racecourse AWS, the EPA Earlwood and Rozelle sites recorded lower annual average wind speeds (1.3 and 1.7, vs. 3.3 metres per second (m/s)) and a higher percentage of annual calm periods (22 and 22.1 vs. 8.6%) (refer to **Table H-1, Appendix H**).

The consultant does not appear to have considered that the latest (June 2014) BOM report for the selected Canterbury Racecourse station shows that the weather sensors were last replaced in 1995 with mechanical instruments.

4.5 Meteorological modelling issues

The correlation between the GRAMM predicted wind speed with actual measured data shows good overall correlational at the chosen meteorological monitoring station site (except for wind speeds above 5m/s where the correlation is poor). However perfect correlation would normally occur for this type of analysis, which indicates that the overall inherent inaccuracy of the GRAMM modelling data is at least approximately 8% (i.e. R^2 =0.92), but is larger at higher wind speeds.

The model also displays generally poor spatial performance, as evident in the relatively poor correlation in the predicted wind speed with the actual data at other sites, for example only approximately 45% correlation with the Rozelle wind speed data.

The data analysis indicates a non-linear relationship exists between the modelled and measured data, and shows that there is a significant tendency for the model to underestimate high wind speeds. This is at odds with more commonly used meteorological models such as TAPM, WRF and CALMET.

The model's inherent performance would make sense given that it is specifically designed for modelling low wind speed and calm conditions in extreme temperature inversion environments in mountainous European valleys, but it does not engender confidence in this application in Sydney.

Overall, the model performance is considered poor (by contemporary standards), possibly due to a poor modelling approach and poor data selection.

This may not be a significant issue for the most impacted receptors very near to the road, as the precision of the meteorological representation in the air dispersion modelling would make only a moderate difference (all other things being equal) over short distances of a few tens of metres.

However it is likely to be a relatively significant issue in regard to the background modelling of the Sydney Road network that underpins the assessment approach.

4.6 Assessment of Impacts

As the selected model cannot conduct chemical transformation calculations, an empirical method was used, based on an analysis of selected ambient monitoring data, but it is unclear whether this is applicable per the varying methods used for assessing cumulative levels.

4.7 Air dispersion modelling

The assessment used the GRAL model to predict operational impacts on ambient air quality. Modelling scenarios included the expected traffic scenarios and regulatory worst case scenarios (to assess compliance with concentration limits for tunnel ventilation outlets).

It is noted that no building wake effects were included due to time constraints, and to save time a large model grid resolution was used. Part of the reasoning given for not considering building wake effects is that the model is incapable of assessing the effects reliably with a grid spacing greater than 5 metres (m). It is noted that if this is correct, then it follows that the model may also not be reliable in the predictions of impacts in close proximity to the road.

This issue should be considered carefully as the impacts at the nearest receptors are most significant, and there is a need to ensure these are not underestimated due to expediency in the approach.

The consultants modelling strategy/ assessment approach appears to be too complicated to deliver accurate results with the selected model, and consequently it appears that it has been necessary to use the model in a less than ideal manner.

The use of the GRAL model for assessing portal emissions would be sensible and reasonable if portal emissions might occur or be permitted.

However, given that;

- there is no need to assess non-permissible portal emissions;
- other models perform considerably better in representing the prevailing meteorology (which matters in this case as the consultants approach includes the modelling of distant roads); and,
- the "effort" required to conduct the chosen modelling approach would appear similar to more advanced, well established models that are able to conduct chemical transformation calculations, whereas significant additional work was necessary in this case to develop an empirical approach as the model cannot do such calculations.

It would seem that other models may have been used to overcome the difficulties encountered with the model and assessment approach used.

Overall, the rationale for the consultant's modelling approach and selection of the model is unclear and unconvincing.

4.8 Model inputs

The domain encompassed by the traffic model appears to exclude the Port Botany container terminal, which involves a large number of some of the most polluting vehicles on the Sydney Road network.

The reviewer did not have access to the traffic report (at the time of preparing the preliminary review), and it may be the case that the traffic assessment already considers the possible issue that if the Project results in improved access from the Port to the M4, or a faster route to areas beyond, then a larger than anticipated increase in heavy vehicles and hence pollution impacts and poorer in-tunnel air quality may occur.

It is important to ensure that this potential issue is considered, and has been applied in the assessment of impacts.

In responding to this, the proponent confirmed that the traffic predictions used in the modelling include the effects of traffic from Port Botany.

5 RESPONSE TO THE PRELIMINARY REVIEW

Meetings were held on the 10 November 2015 and 1 December 2015 where the Proponent presented additional information and analysis responding to the key issues raised in the preliminary review and other air quality related issues raised by other agencies reviewing the Project.

The following is a summary of the responses to the preliminary review.

5.1 Bias in the counting of receptors

The proponent acknowledged that it has counted "receptors" at locations where there was no dwelling, leading to the inclusion in the RWR receptors of many non-existent receptors further from the roads, and the omission of some of the existing receptors near to roads.

However, the two core issues that arise from this bias were not found to be significant:

1. The health risk assessment was based on small "suburban block, or apartment unit" sized population clusters, thus the findings that relate to potential health impacts are unlikely to be significantly affected;
2. The omission of some receptors nearest the roadway would likely make the balance of positively/ negatively affected receptors less favourable to the Project, i.e. show fewer than actual positively affected receptors, because most of the roads would see a decrease in impacts due to the Project.

Overall the proponent has provided an adequate response, showing that this issue would not materially affect the general conclusions reached in the health risk assessment or the overall relative change projected to occur with and without the Project for the entire community.

5.2 Model selection and approach

The use of the GRAL model for this Project was justified by the proponent for the following reasons:

- Established model for regulatory applications (overseas);
- Ability to model different sources, varying scales (e.g. streets to whole cities), and high resolution;
- A Lagrangian model which has special algorithms for dispersion in low wind speed conditions, consideration of terrain and topography, including the presence of buildings in urban areas, and performs better than Gaussian models;
- Can take into account wake effects;
- Validated in a wide range of studies; and
- Good relationship with developers from previous projects.

The justification provided by the Proponent for the use of the GRAL model is generally reasonable, however, for the Project, some of the reasons provided for the model selection are not directly relevant, and the model does not appear to be fully utilised in this case (as compared to many of the validation studies where it's features are used, and the modelling configuration is different). For example the model features related to buildings, wake effects, modelling of road tunnel portals, high spatial resolution, are not utilised in this case. This means only a few of the reasons provided for the model selection may remain relevant to this case, as examined below.

It is stated that the model has the ability to model different sources, varying scales (e.g. streets to whole cities), and high resolution. However, many other models that are accepted and proven for regulatory use in NSW can also do this. There are specialised models for roads and many models that can model stack emissions very well. The results of these specialised models can be expected to be generally superior to those produced by general models, and the results of two models can be added if cumulative levels are required. This may improve the overall reliability and accuracy of an assessment relative to using a single general model. The logic that on one hand a single model would be more desirable does not accord with the proponent's logic for the use of three methods to calculate emissions from traffic, and three methods to calculate background pollutant levels. Why would it be appropriate to use separate methods for specific circumstances for components of the model inputs, but not use specific models for specific circumstances for the modelling itself?

Thus there is no good reason to use the same model for modelling stacks and roads as was done in this case.

This is also the case because roads and tunnel stacks have greatly different levels of impact at different locations. It is necessary for in-tunnel air quality to be protective of health for tunnel users for short term exposure, thus the emissions at the stack would necessarily be low. Almost any reasonable stack design will cause its emissions to be dispersed and diluted by large factors before the emissions reach any roadside receptors. Therefore the only aspect of the proposal with tangible scope for impact is the road emissions affecting nearby receptors and the stack emissions impinging on any tall buildings that may be near to and higher than the stack. It would thus make sense to have an accurate road traffic model, and a model that performs well at predicting stack emissions.

It is stated that the model is an established model for regulatory applications overseas, however it would appear that this may only be referring to tunnel portal emissions in Austria, which are not relevant for this assessment.

In regard to regulatory acceptance, or meeting performance standards, the GRAL documentation (see http://app.luis.steiermark.at/berichte/Download/Fachberichte/LU_08_14_GRAL_Documentation.pdf) only refers to Austria, Germany and Australia. The documentation states:

"The current version of GRAL satisfies the quality criteria [for compliance with Austrian Guideline RVS 04.02.12] *in all cases and, thus, completely complies with the guideline."*

"GRAL does not comply with [German] *guideline VDI 3783-9 with regard to the following requirements:*

1. *There is no example application described in the manual.*
2. *There exist no 3 certified publications in professional journals.*
3. *The grid is not non-equidistant in the horizontal direction.*
4. *There is no online control of the standard deviations and the area mean values.*

It can be seen that non-compliance concerns some formal criteria, while the performance criteria of the test cases are met."

"GRAL is recommended by the National Health and Medical Research Council, Australian Government, as dispersion model for regulatory purposes for road tunnel portal emissions (NHMRC, 2008)." However this does not appear to be correct.

The model has been set up so that it is not possible for the proponent to extract/ produce the information required in the NSW Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, 2005 (Approved Methods), nor to enable a full evaluation of the model performance, for example in relation to time series data, as needed for a complete assessment. Thus it is not clear that this model is suitable for use in NSW, per the current NSW regulatory expectations, (noting that there is no regulatory regime specifically set out for the assessment of road projects).

It is stated that the model has special algorithms for dispersion in low wind speed conditions, implying that it performs well under such conditions. However the actual model performance at night time, when low wind speed conditions dominate was tested and found to be poor. The model overestimates impacts by a large degree under such conditions. In response to a related issue (GRAL Predictions) raised by the NSW Chief Scientist and Engineer, the proponent states: "*It is agreed that the model chain is overestimating concentrations at nighttime. This appears to be more a function of the GRAL predictions than the background."*

It is claimed that the model performs better than Gaussian dispersion models, however the claim has not been tested by the proponent in this case, and instead numerous assumptions that erode the likely model performance have been applied in order to save time/ cost. For example, the assessment was conducted with limited categories of wind speed, and this resulted in poor model performance under high wind speeds. There are also other such assumptions applied in the model.

The model documentation and validation studies prepared by the model developer list many validation studies. None of these studies make a comparison of the GRAL model performance relative to the air dispersion models that are approved for use in NSW, however it is noted that ISC was tested and can be expected to provide similar results to the approved model AUSPLUME, and also that in the past CALINE 4 has been used for road projects NSW.

Notably, the validation completed by the model developer for road emissions shows that the model generally underestimates emissions near the source, often by a large margin. This trend is not obvious in the numerical performance metrics provided in this assessment and in the GRAL documentation, which are generally limited to the calculation of the Normalised Mean Square Error (NMSE) and Fractional Bias (FB).

Other's evaluation summaries of the GRAL model performance show additional model performance data. For example for the Hornsgatan street canyon study, (a situation that is similar to parts of Parramatta Road at present, and most certainly like the road in future) the model correlation with the observed roof top data is poor, with an R^2 correlation coefficient of 0.13 (meaning that GRAL can only account for approximately 13% of the variance in the observed data) reported by the European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM).

The GRAL documentation for the same location states; *"The annual mean NOx concentration and also peak concentrations have been simulated well with GRAL/level2. When buildings are not taken into account, GRAL underestimates concentrations significantly."* It is pointed out that it is not known by the reviewer if the poor correlation reported by ETC/ACM relates to the performance of GRAL/level 2, GRAL/Level 1 or GRAL model configuration. However it is also noted that in this assessment buildings have not been considered.

Other relevant validation work performed by the model developer examines the GRAL model performance at predicting the levels of tracer gas released along US highways or from line sources that represent a road or similar source.

For the Highway 99 data collected in 1984, GRAL had a relatively higher NMSE than other models (apart from CALINE) and no fractional bias. GRAL overestimates low concentrations and underestimates high concentrations, as shown in **Figure 5-1** which presents a plot, showing the observed and modelled mean concentrations of the tracer gas as a function of distance from the road.

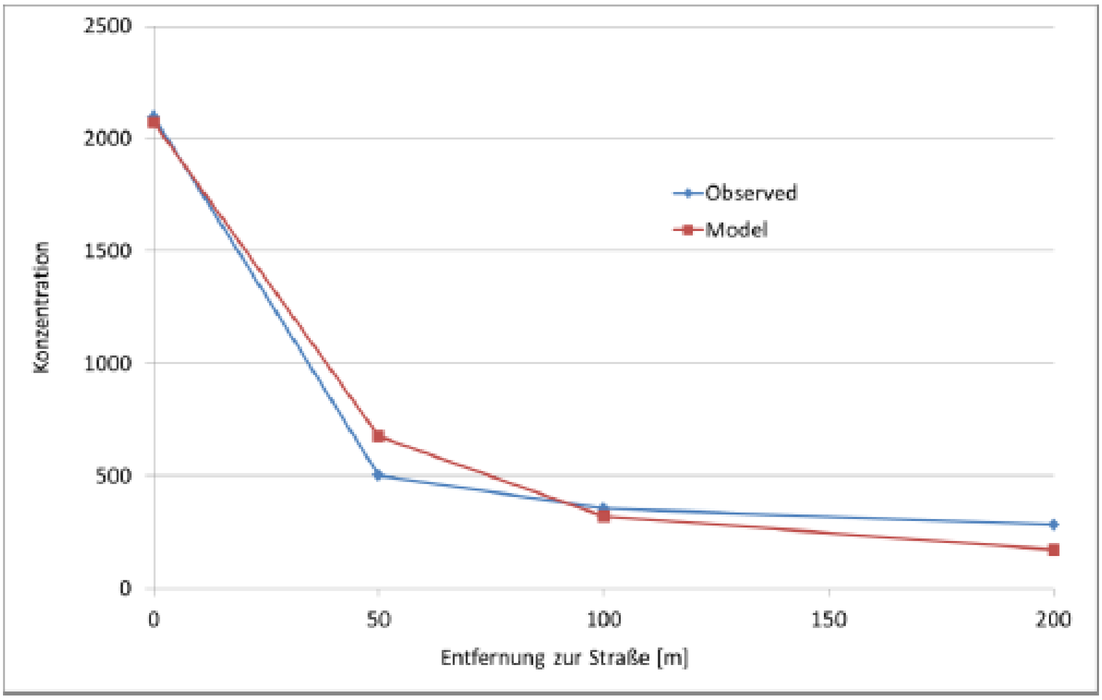

Figure 5-1: Observed and modelled mean concentrations of tracer gas (vertical axis) as a function of distance from the road (horizontal axis)

For the Idaho Falls data collected in 2008, GRAL had the largest NMSE, and zero fractional bias. GRAL appears to underestimate almost all of the measured (observed) results, as shown in **Figure 5-2** which presents the Quantile-Quantile plot of observed and modelled concentrations. The location is characterised as having flat terrain with low lying scrub 10 to 30 cm in height.

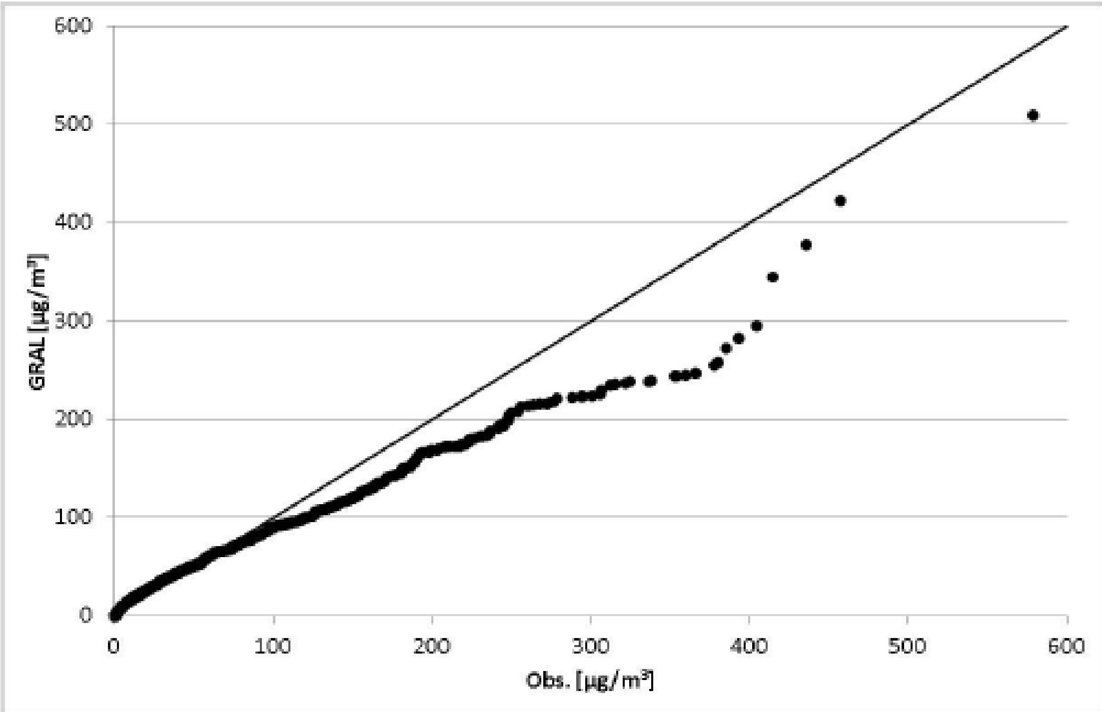

Figure 5-2: Quantile-Quantile plot of observed and modelled concentrations (Idaho Falls)

For the Idaho Falls with noise barrier data, only GRAL was evaluated. It had a relatively high NMSE of 3.1, and fractional bias of 0.1. GRAL appears to somewhat overestimate the very highest concentrations, but has some significant underestimation of moderate concentrations, as shown in **Figure 5-3** which presents the Quantile-Quantile plot of observed and modelled concentrations. The experiment has a 6m high and 90m long noise barrier downwind and parallel of the 54m metre long line source from which the tracer gas was released. The two monitors near to but upwind of the noise barrier recorded gas concentrations up to 20 times higher than the downwind monitors. The data from these high reading monitors was excluded in the GRAL model validation.

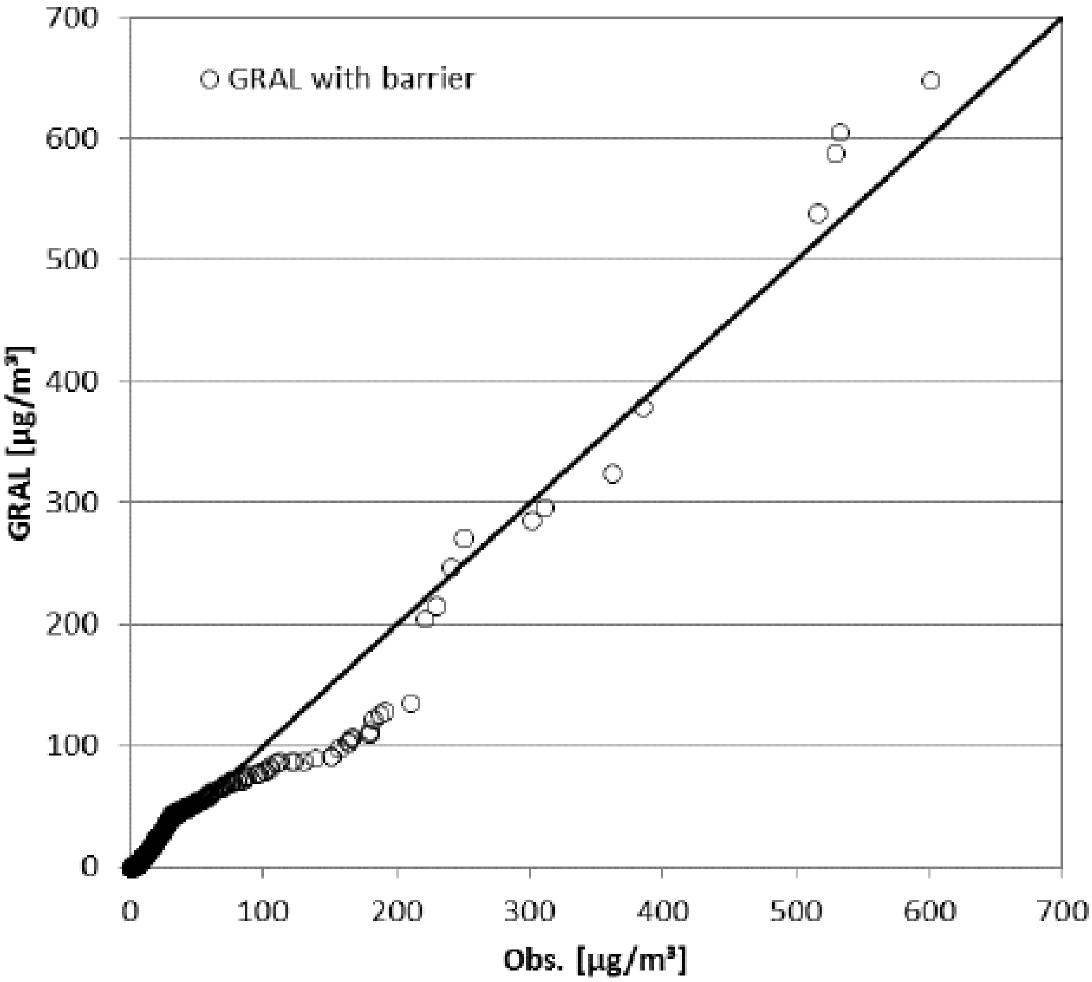

Figure 5-3: Quantile-Quantile plot of observed and modelled concentrations (Idaho Falls with noise barrier)

The model appears to have been selected and applied to the assessment with only limited verification of its reliability in accurately estimating likely road traffic pollutant concentrations at potentially affected receptors. A comparison between measured and modelled data at two roadside locations is provided, at Appendix J. This shows generally good model performance for NO_x at one monitoring site (RMS F1), and poor daytime model performance at the other site (RMS M1). (see **Section 5.3**)

Some verification of the meteorological performance is also provided at Appendix H and in the responses to the preliminary review. From this it is clear that the model does not perform well at modelling the spatially varying weather conditions, especially at high wind speeds. (See **Section 5.4 to 5.6**)

Thus it is not shown that the model performs better than other models, nor that it performs to an acceptably accurate degree in this case. As a result, the overall modelling approach and selection of the model remains unconvincing.

The key question in this regard is whether these issues matter in regard to the conclusions reached in the assessment (i.e. would using different models, or different assumptions/ settings in the GRAL model result in a different conclusion).

In consideration of this question it is relevant to observe that;

- Road traffic pollutants have the most effect on receptors very near to the road, and the effects diminish rapidly with distance away from the road. The prevailing weather affects the dispersion of air pollutants more significantly with increasing distance from the source. Because the most significant impacts occur at receptors within tens of metres from the road, the poor spatial performance in the meteorological component of the model cannot be vitally important in this case for the most affected receptors.

  However, the assessment findings that relate to receptors more than many tens of metres from the road are dubious, but as it is known that these receptors could not be significantly affected, this issue is unlikely to be significant.

- The core findings of the assessment are based on a relative comparison between a do-minimum case and the Project case, and the same key modelling assumptions are applied in both cases. This aspect of the assessment makes use of the model in a reliable manner as the relative comparison is not greatly affected by the absolute accuracy of the model assumptions and inputs (other than the traffic number predictions for each case). Determining whether traffic related air pollution effects at receptors would increase or decrease significantly is the key outcome of interest for this assessment and the use of the model to make this relative comparison is a convincing and generally reliable way to assess this matter.

Therefore it is reasonable to assume that the application of the GRAL model (or indeed almost any other model if used reasonably) is likely to be adequate for the purpose of the assessment of the most impacted roadside locations, provided that only a relative assessment is being made.

Overall it can be concluded that:

- the model has not been shown to provide accurate predictions of the absolute levels of air pollutants;
- the modelling approach and selection of the model is unconvincing; however,
- the approach of making relative comparisons at any one location effectively bypasses issues with the modelling, and is reliable; and,
- the key conclusions in the assessment (and health risk assessment) relate to relative changes in impact at any location, and are reliable.

5.3 GRAMM/GRAL validation

The Proponent states that the GRAMM/GRAL has been validated using data sets for multiple countries, multiple source types and multiple terrain types and that its performance is at least as good as other models.

The model developer is more circumspect in regard to the performance of its model stating that :

"GRAMM/GRAL performance in NSW had not been evaluated prior to its use for this Project. Thus the Proponent conducted sensitivity tests using local data to evaluate the suitability of GRAL to the local conditions."

The Proponent compared the GRAL modelled results with the measured data at two roadside monitoring sites and found that GRAL overestimates the (monthly and daily average) measured NO_x road increment at the RMS F1 monitoring station significantly, overestimates the hourly evening and night time levels at the M1 monitoring station, and significantly underestimates the measured levels in the daytime. The average hourly measured and predicted levels at the M1 monitoring station are shown in **Figure 5-4** below, which is part of Figure J-8 of the assessment.

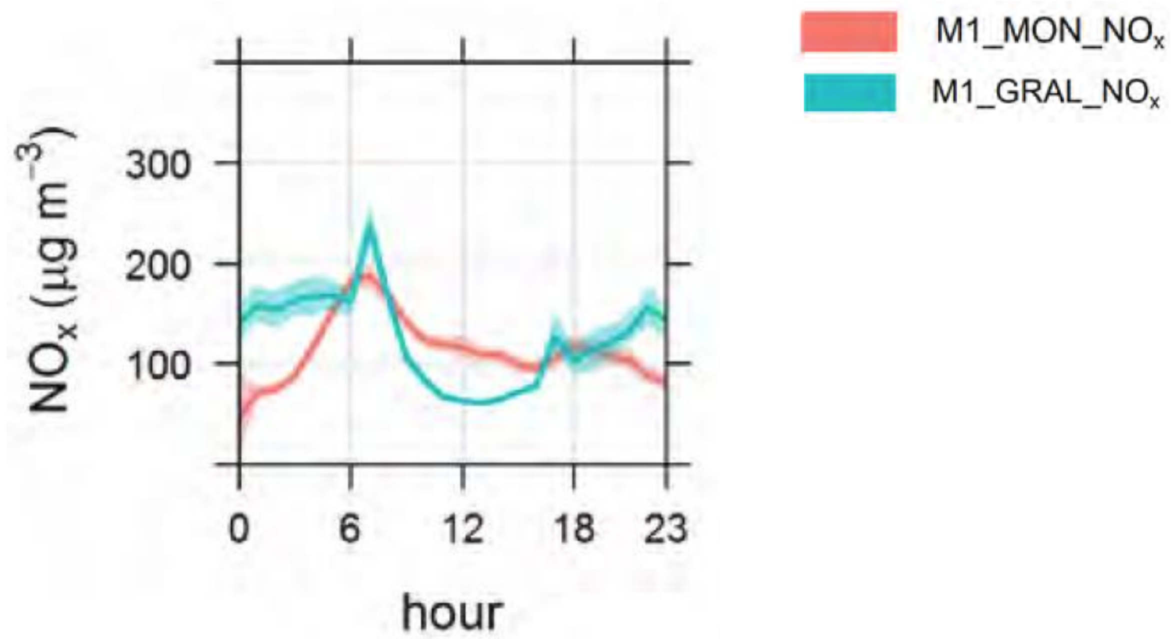

Figure 5-4: Plot showing predicted (GRAL) vs. measured (MON) average hourly NOx levels at monitoring location M1

In this regard the Proponent states that *"For the M1 site the concentrations tended to be....underestimated during the middle of the day"*. It would be more accurate to state that the model significantly underestimates the hourly NOx levels for every hour of the year from 8am to 4pm at this location. It should be noted that the model performed worse on weekdays and better on the weekend than is indicated in the graph, but this may be due to the model using the higher weekday traffic levels to predict the weekend NOx levels.

The modelling over predicts the measured night time levels by a large degree at all times at both the F1 and M1 locations, which may be due to the meteorological settings or the inherent model calculation methods. This is most significant when one considers that hourly assessment criteria are used.

The modelling was unable to reliably predict the daytime hourly NOx levels at the RMS M1 monitoring station, but was able to reliably predict daytime hourly NOx levels at the RMS F1 monitoring station. This raises concerns regarding about the accuracy of the modelling (inherent to the model and the modelling assumptions applied).

The concerning issue is that the RMS F1 monitoring station (western M5 tunnel portal) and the RMS M1 station (eastern M5 Tunnel Portal) would both experience relatively high levels of traffic induced pollution. Typically the RMS M1 location experiences approximately 20 to 30% higher levels of NOx than the RMS F1 station, but the stated model overestimation (on average) varies from 88% (F1) to 5% (M1), This appears to be due to large overestimations in the night time levels, and on weekends (some of this would be related to the model performance and estimated traffic volumes applied in the model).

Whilst both monitoring locations are near to noise walls and trees and are thus compromised in receiving traffic emissions directly, the large difference in model performance is not reasonably examined in the assessment, apart from the proponent commenting that one of the locations is compromised by a noise barrier.

This situation is not ideal as the data from only these two stations appears to be available to verify the model performance for the most important case of roadside impact predictions. It is not clear why Project monitoring data were not available to be used, or sufficient such data gathered for this purpose.

The proponent has focussed its detailed evaluation of model performance on the (better performing) predictions at the F1 monitor, and its discussion is focussed on the relatively good results for the daily, and annual average predictions. These results appear to be good because the night time overestimation cancels out the daytime underestimation when the data is averaged, (i.e. not due to underlying model performance, assumptions or methods being used.)

The results indicate the model may perform poorly at predicting hourly pollutant levels at locations near to the road. However, due to many unusual assumptions made that are peripheral to the modelling set up and its fundamental performance, for example in relation to background data, the overall results appear to be adequate for estimating a 24-hour and annual average levels at the monitoring locations.

For example, whilst the model performs poorly in the daytime at one roadside site for NOx emissions, the NO_2 fraction of the NOx is the toxic component of concern. The proponent overestimates the potential NO_2 component in most situations as it uses a conservative NOx to NO_2 conversion relationship based on worst case empirical data. This on the other hand is somewhat tempered by using the 98th percentile level (not the 100th percentile level as set out in the guidelines) which reduces the estimated impacts significantly for the peak background periods, but does not address the fundamental model performance.

Regardless, when the total levels are considered, the overall approach does not appear to underestimate impacts of NO_2, and whilst it is not completely certain, this is the key outcome that matters.

5.4 Representativeness of meteorological data used in GRAMM

The meteorological data used in the modelling were obtained from the BoM Canterbury Racecourse station. The preliminary review raised concerns with this choice of data and also the meteorological modelling performance.

As part of its response, the proponent provided the figure presented below as **Figure 5-5**. The figure shows the proponent's analysis of meteorological data from different BoM, OEH and WestConnex stations comparing average monthly wind speeds recorded at each station from January 2014 to

October 2015. This analysis shows that the meteorological data from the OEH sites have high portions of calm and low wind speeds in contrast to the BoM stations.

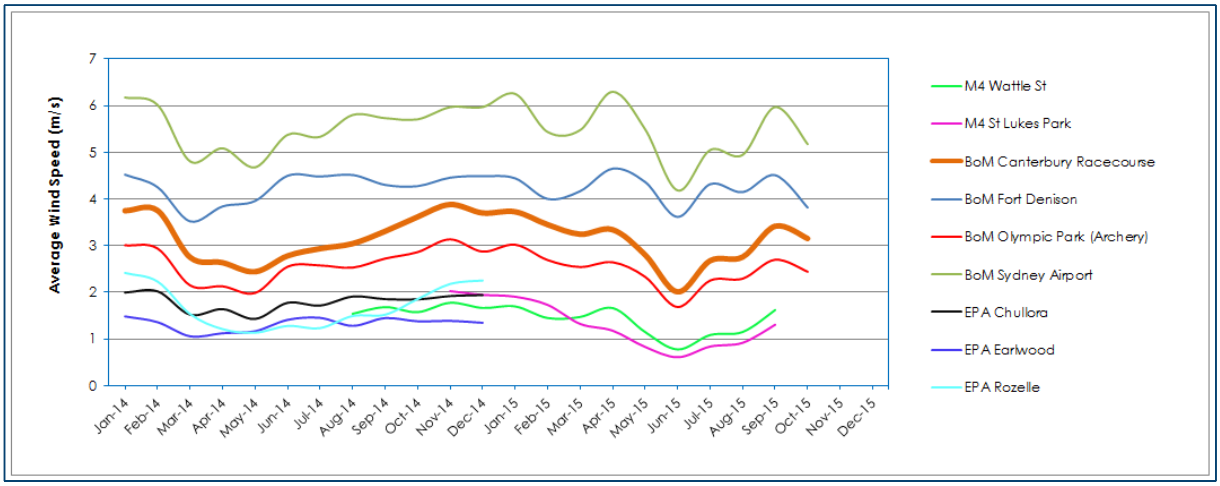

Figure 5-5: Average monthly wind speeds from January 2014 to October 2015

The Proponent notes that the data from OEH sites differ to that from BoM sites which may be due to siting and instrument differences. A significant shift in the wind patterns at the OEH sites in later years is observed, and the proponent considers this could be due to changes in the surrounds, instrument replacement and/or sensor alignment problems.

The preliminary review did not accept the validity of the statistical evaluation of the meteorological modelling performance, and hence the proponent's conclusion that overall the model simulates the meteorology with an acceptable degree of accuracy. The proponent used Canterbury Racecourse data as the input to the model and only provided a statistical evaluation of the model performance at Canterbury Racecourse, but nowhere else, to reach its conclusion.

It is not possible to test the performance of a model at predicting something that is input to the model when making the prediction. For this reason, the statistical evaluation provided by the proponent of the model accuracy at predicting the meteorological conditions at Canterbury, based on putting the measured meteorological conditions at Canterbury into the model, cannot produce any reasonably objective measure of the actual model performance, other than to indicate the smallest inherent error in the model and modelling assumptions.

It is noted that most other regulatory approved models would provide perfect (100%) performance results if the same evaluation were done, but the GRAMM model shows inherently limited performance, for example a minimum error of 8% or more for wind speed, and significant bias for higher wind speeds, (see appendix H of the assessment). The proponent conducted regression analysis of only wind speed at several sites. The analysis shows poor model performance except at Canterbury racecourse.

The review requested that the model performance be evaluated more thoroughly, for example by examining how well the model predicts meteorological conditions at the other weather monitoring locations in the modelling domain.

The proponent made a comparison between the data from the BoM Canterbury Racecourse and OEH Earlwood site and found that the Earlwood data contain a significantly high percentage of calms, low annual average wind speeds and significantly more G class conditions than at Canterbury. **Figure 5-6** presents the Proponent's comparison of the stability classes recorded at BoM Canterbury Racecourse and OEH Earlwood. Stability class is an indicator of atmospheric mixing, with progressively poorer air dispersion occurring under progressively more stable conditions (i.e. from E to G class stability).

The proponent calculated that G class stability conditions would occur for an unusually large fraction of the time annually (>40% at Earlwood and approx. 19% at Canterbury racecourse). This is unusual as such frequent G class stability is generally associated with dry arid inland desserts, and this stability class is not known to occur frequently in urban areas. This is of concern and may potentially be related to the proponent's calculations and quality control checking or the quality of the measured data.

The Proponent notes that the Earlwood station is located in a valley and in a densely populated area which could affect the wind speeds recorded at that location.

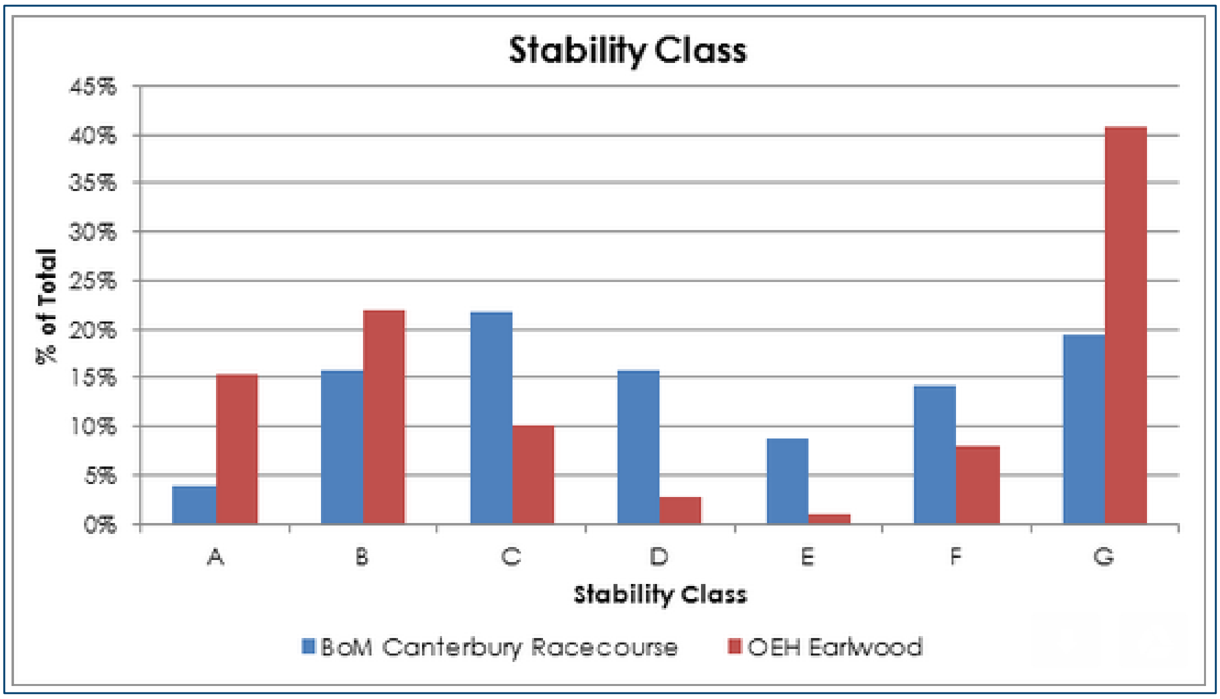

Figure 5-6: Comparison between the stability classes recorded at BoM Canterbury Racecourse and OEH Earlwood

Whilst there are differences in instrumentation, the position/ siting of the weather station, and some differing effects of vegetation etc., as would be expected, the meteorological conditions observed (measured) at the weather stations located across the study area display significant variation (e.g. up to 450% for annual average wind speed).

When using GRAMM it is necessary to select only one meteorological dataset for input to the model. The model does not allow the user to identify the location of the input metrological data. The model is however able to use terrain information, land use data, etc. to spatially adjust the wind field, but without knowing the location of the input meteorological data, the model (as set up by the proponent) appears to simply apply almost uniform (as input) weather data across to the entire domain.

For modelling of a reasonably large area near the coast, one would expect significant spatial variation in meteorological parameters and to account for this variation reasonably in the modelling. However, in this case, the way the model appears to work (and perhaps how it has been set up) results in almost uniform weather conditions across the area modelled. This may lead to inaccurate calculation of the level of impact at receptors away from the location of the weather station (where the input meteorological data were measured).

This issue is evident when considering the table below, provided by the Proponent. The table shows that regardless of the actual conditions at the various weather stations in the modelling domain, the model shows almost uniform results, with only a small spatial variation that is not representative of the actual variation in meteorological conditions. For example: when the Canterbury data are used as input to the model, the modelled wind speed at all of the weather stations is almost the same as the Canterbury data, similarly, when the Earlwood data are used in the model, the modelled wind speed at all of the weather stations is almost the same as the Earlwood data.

The model shows a spatial variation of 3% to 8% in annual average wind speed across the study area whereas the actual spatial variation in wind speed is approximately 450%.

Table 5-1: Annual average wind speeds (m/s) across the domain – observed vs. predicted using different input data

Site	Observed	Predicted using Canterbury data input	Predicted using Earlwood data input
	Annual average Wind speed (m/s)		
BoM Canterbury	3.2	3.0	**1.3**
BoM Sydney Airport	5.8	3.1	**1.3**
BoM Sydney Olympic Park	2.8	3.1	**1.4**
OEH Rozelle	1.8	3.1	**1.3**
OEH Chullora	1.9	3.1	**1.4**
OEH Earlwood	1.3	3.1	**1.3**

The proponent also had the model developer create site specific land use files (not available at the time of modelling), and re-ran the model, resulting in small positive and negative effects (see **Section 5.6**).

Overall, in consideration of the information presented in the EIS, at meetings and in response to the issues raised, it is considered that the GRAMM modelling results (using the Proponent's assumptions and model settings) indicate that the model performs poorly at replicating meteorological conditions spatially across the area of interest, and that the model appears to be fundamentally driven by the input meteorological data and only marginally affected by terrain and other inputs. Concerns also remain in regard to the selection and quality of the input data and/ or the data processing, calculations or quality control procedures in this regard.

This issue warrants consideration if comparing the predicted results at one location with those at another location. The concern is that the pollutant concentrations that are predicted at one location may not be reasonably comparable to the levels predicted at some other location (with differing meteorological conditions) as a result of the poor spatial simulation of the actual meteorology.

It is however important to note that this is not a significant issue when making a relative assessment of the potential increase or decrease in effects at any one location. The model would still predict an increase or decrease in effects and the relative change would be proportional to the predicted impacts.

It is also important to note that accurately modelled meteorological conditions[1] should not be a critical factor for estimating impacts at the most significantly affected locations closest to the roads, given that these locations would be within tens of metres from the source (as the likely variation in the meteorology would not greatly influence air dispersion over such short distances). It is noted that the proponent also mentions this at Appendix H.

In conclusion, whilst the meteorological aspects of the modelling are poor, this may not be a key issue in the conclusions reached. The issue of how the poor meteorological modelling may affect the results is examined in more detail in the following sections.

5.5 Sensitivity of GRAMM/GRAL to meteorological data

The Proponent assessed the influence of the meteorological data on the predicted pollutant levels by re-running the model using meteorological data from the OEH Earlwood station.

The analysis shows that modelling with the lower wind speed meteorological data from Earlwood results in higher predicted annual average $PM_{2.5}$ across all RWR receptors compared to the use of BoM Canterbury Racecourse data (see **Figure 5-7**). Modelling with the Earlwood data also resulted in larger changes (both increases and decreases) in the annual average $PM_{2.5}$ due to the Project (see **Figure 5-8**).

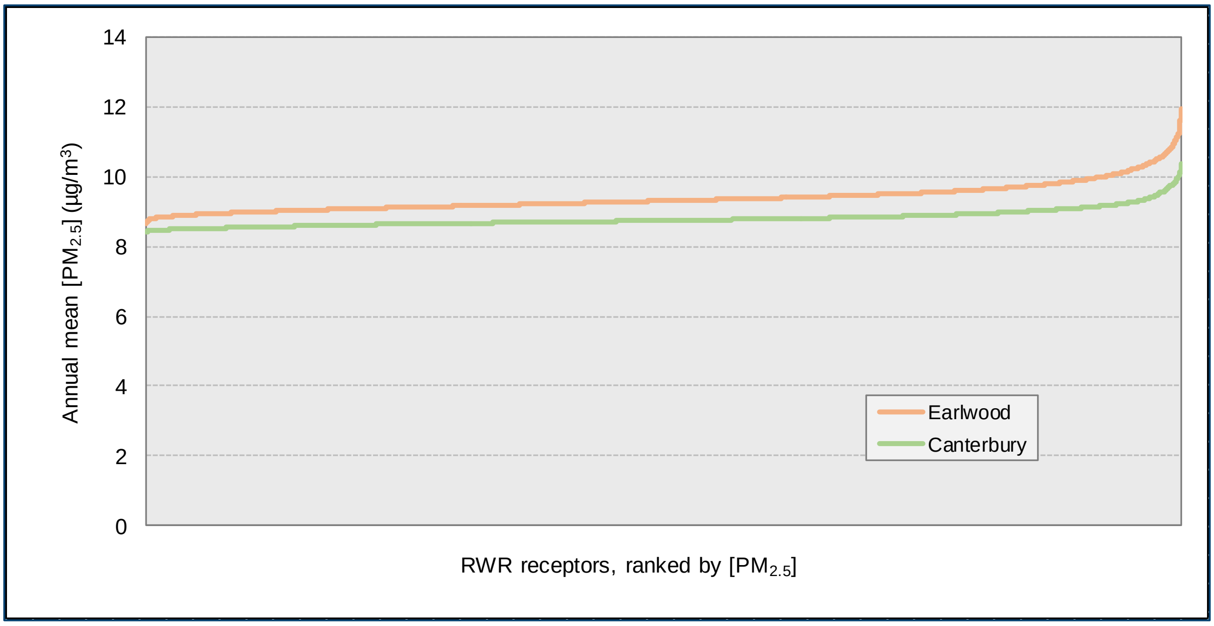

Figure 5-7: Annual mean $PM_{2.5}$ concentrations at RWR receptors - for different meteorological data inputs

[1] Other than knowing whether the wind is blowing road traffic pollutants to or from a nearby receptor, which is not an issue in this assessment

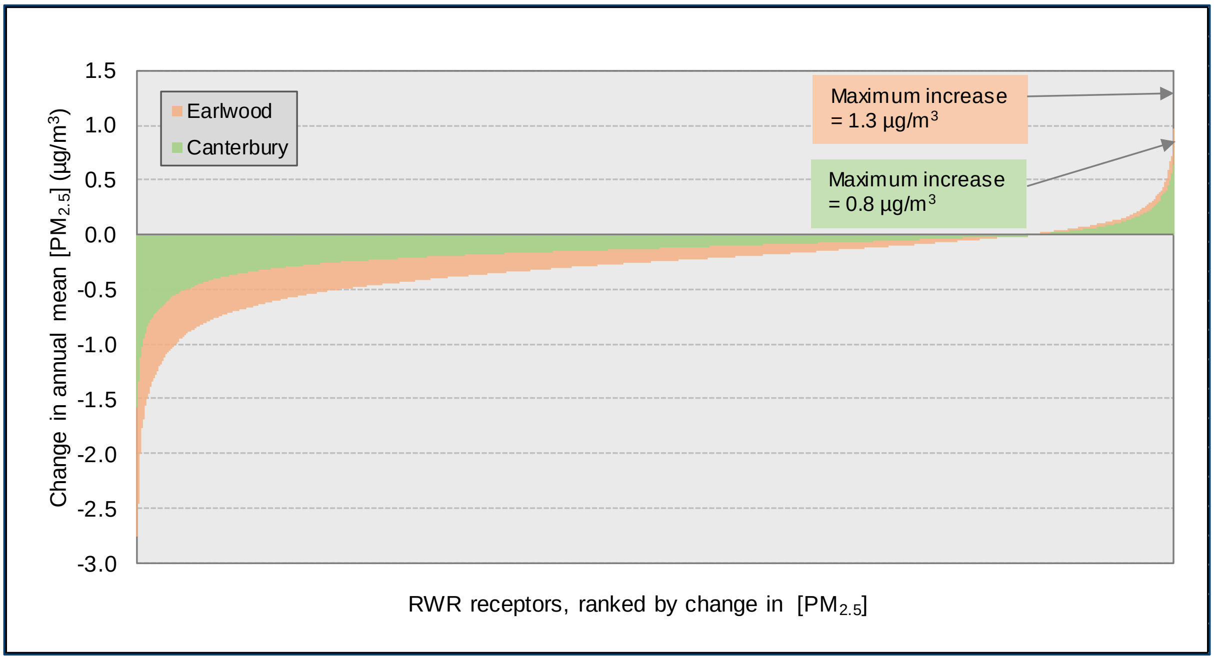

Figure 5-8: Relative change in the annual mean PM2.5 - for different meteorological data inputs

The analysis of the modelling based on the meteorological data from the BoM Canterbury Racecourse and the OEH Earlwood station provides an indication of the potential range of predictions across the domain, and is a reasonable means of examining the range of potential variation in the predicted results due to only the difference in meteorology.

Examination of **Figure 5-7**, when considering that an arbitrary background level of 8µg/m^3 has been added to both sets of results, indicates that the modelled results for the traffic emission increase by approximately 40% due to the use of lower wind speed meteorological data inputs.

However examination of **Figure 5-8** indicates that the maximum relative increase in road traffic effects at any location is relatively small.

As the background levels are significantly higher than the change that may occur, even if the relative change in absolute terms may vary by 40% due to the use of the OEH Earlwood data, this change remains small and does not change the overall conclusions in the assessment for annual average $PM_{2.5}$.

5.6 Sensitivity of GRAMM/GRAL to land use

GRAMM was re-run using a spatially-varying land use file for the whole domain. **Table 5-2** presents the annual average wind speeds extracted at various locations across the domain. As shown, the use of a land use file resulted in more variation of wind speeds across the domain, however are still not representative of the observed result.

Table 5-2: Annual average wind speeds (m/s) across the domain - observed vs. predicted with and without land use data

Site	Observed	Predicted – without land use file	Predicted – with land use file
BoM Canterbury Racecourse	3.2	3.0	2.9
BoM Sydney Airport	5.8	3.1	3.9
BoM Sydney Olympic Park	2.8	3.1	3.0
EPA Rozelle	1.8	3.1	3.3
EPA Chullora	1.9	3.1	3.1
EPA Earlwood	1.3	3.1	2.9

The Proponent showed that there is no significant difference between the predicted annual mean $PM_{2.5}$ results across the domain if a varying land use file is used or not used (see **Figure 5-9** and **Figure 5-10**).

This suggests the use of a varying land use file has little influence in the performance of the model.

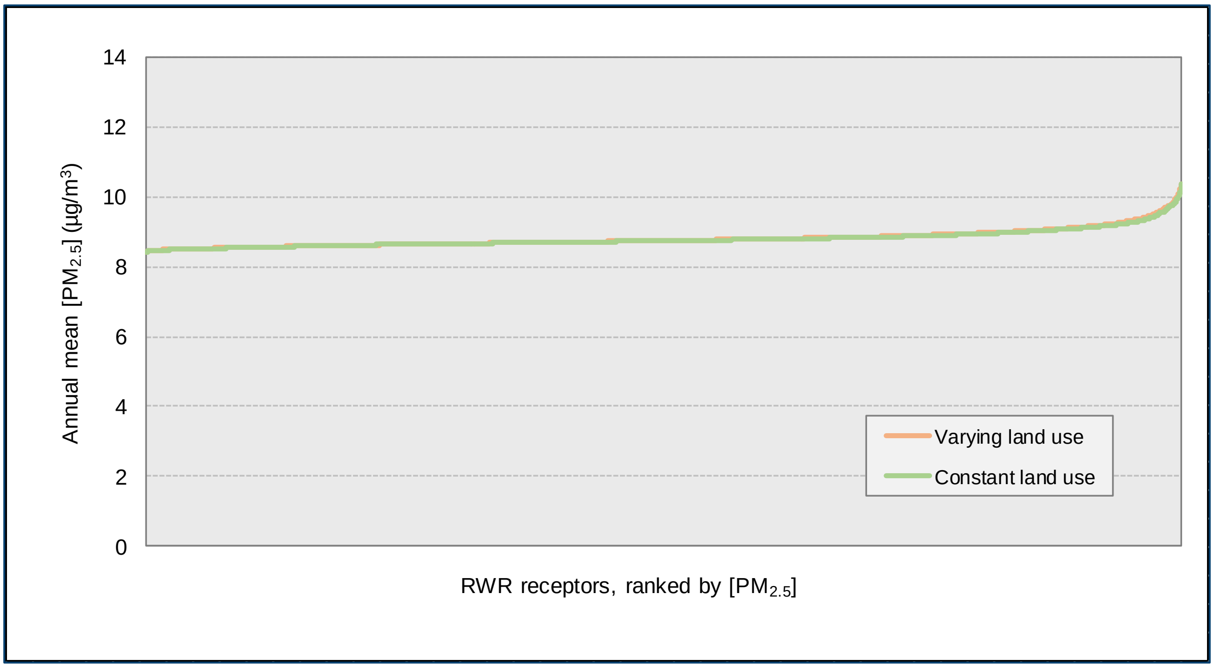

Figure 5-9: Comparison of annual mean $PM_{2.5}$ with and without varying land use

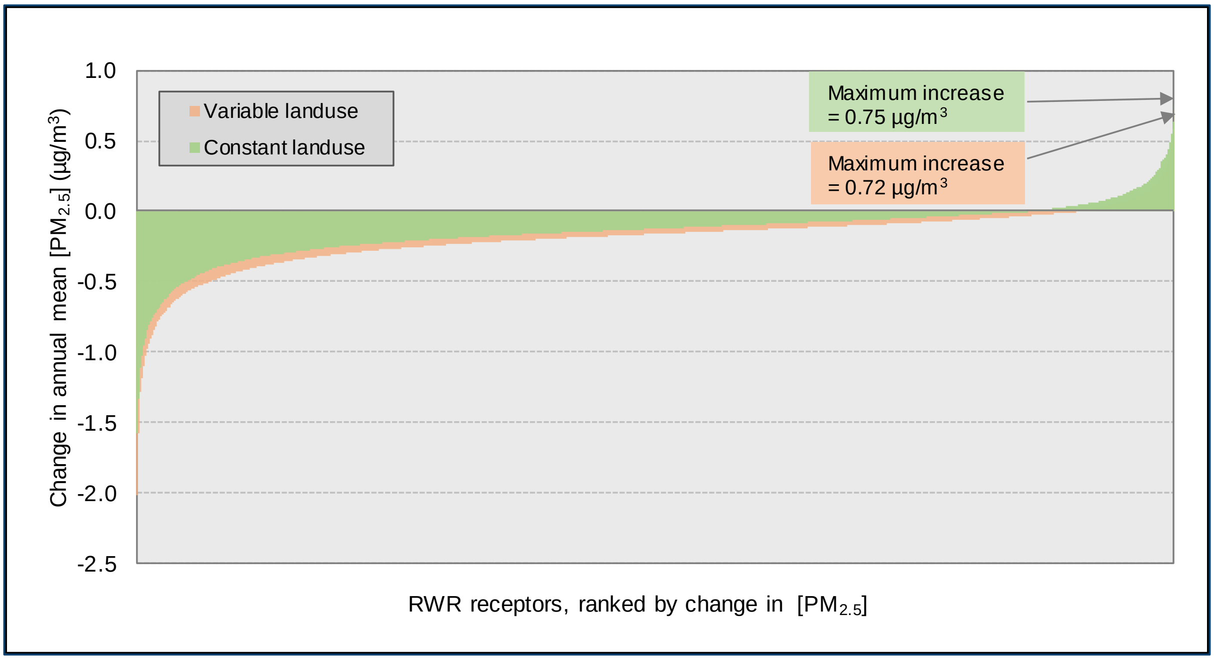

Figure 5-10: Changes in predicted annual $PM_{2.5}$ due to varying land use

5.7 Regulatory worst case scenario

Following comments from the NSW EPA regarding the assessment of the regulatory worst case scenario, the Proponent presented the maximum predicted total 1-hour NO_2 concentrations from all source contributions and the maximum predicted 1-hour NO_2 concentrations when the maximum NO_x contributions from the ventilation outlet occurs in **Figure 5-11** and **Figure 5-12**, respectively, for the community receptors.

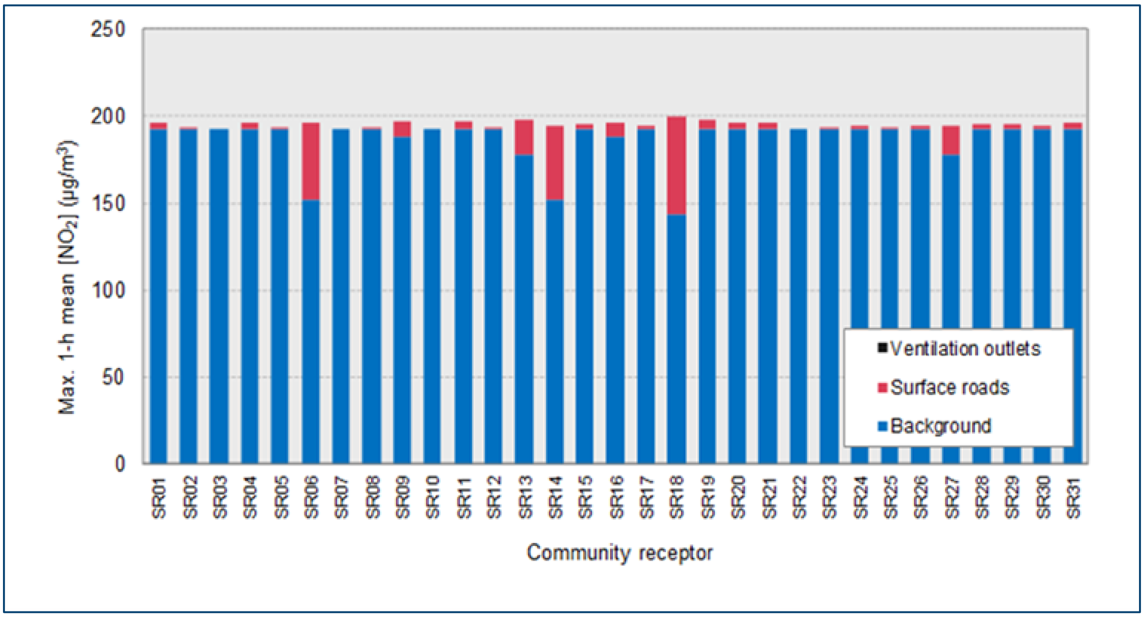

Figure 5-11: Source contributions for the maximum 1-hour NO_2 concentrations

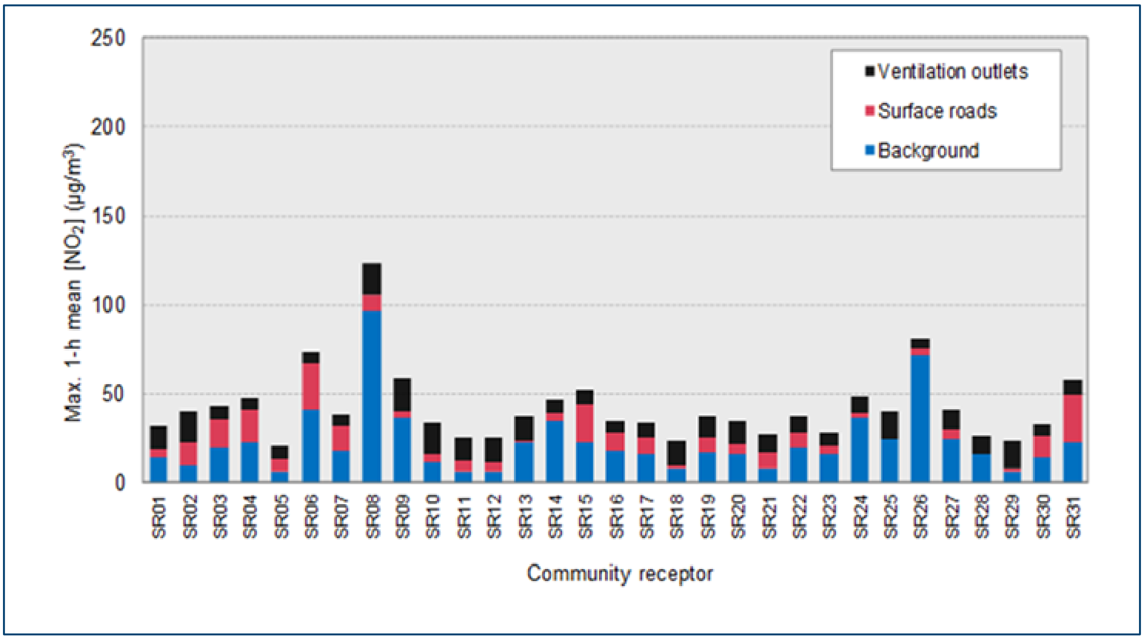

Figure 5-12: Maximum 1-hour NO_2 concentrations when the maximum ventilation outlet contribution to NO_x occurs

The figures demonstrate that the maximum impacts from the ventilation outlets occur when contributions from the surface roads and background are low and conversely, the maximum predicted concentrations at receptors occur when the contribution from the ventilation outlets are very low. The Proponent proposes further steps to address NSW EPA comments on the assessment of the regulatory worst case scenario.

6 AGENCY COMMENTS

6.1 NSW EPA

This review generally agrees with the NSW EPA comments and recommendations for the Project.

In regard to certain inputs, such as traffic modelling and the GRAL model, the NSW EPA submission states that it does not have the relevant technical expertise to provide a meaningful review and assumes the modelling system and configuration adopted is accurate.

The proponent states that it approached the NSW EPA in regard to the model selection. It would be unusual for the NSW EPA to approve the use of a model that it does not have the expertise to review, thus it is assumed the EPA is referring to a very detailed technical examination of the modelling code (that might for example be tested by the US EPA when approving the use of a model for regulatory assessment and project approval (permitting)), rather than a review of the modelling results and modelling performance which EPA does have extensive expertise in reviewing.

Issues raised by the NSW EPA in its review of the modelling include the meteorological data selection, the method for converting NOx to NO2, the results of the regulatory worst case scenario and the emission estimation technique.

A focus area of the EPA review, relates to the short term prediction of NO_2 levels. One of the issues in this regard was the applicability of the empirical relationship between NO_2 to NOx ratio used in the assessment. Whilst the proponent provides a good response in this regard, clearly showing that there is a large margin of conservatism (overestimation) in its approach, some aspects, such as effects of Ozone, were not ideally considered. In this regard, this review agrees with the proponent's comment that it is not possible to be certain about impacts far into the future, but that a reasonable assessment using conservative assumptions, based on the available information was made.

Of course it would have been better if the proponent had conducted a more complete validation of the absolute model performance, for example by obtaining the necessary roadside monitoring data needed for this, and focusing on the actual model performance instead of having to rely on many, often unusual assumptions.

6.2 NSW Health

This review generally agrees with the NSW Health comments and recommendations for the Project that are directly related to air quality modelling.

The NSW Health raised concerns similar with regard to model validation and accuracy, but notes that the relative assessment shows that the net outcome of the Project would be to reduce impacts at most receptors, and only increase impacts at a minority of receptors, by a margin that is generally small.

The agency requested that data be provided by the proponent to the local government planners in regard to air pollution near the proposed ventilation stacks. This would allow appropriate planning controls to be put in place, for example to limit the development of overly tall buildings near the ventilation stacks that may impinge on ventilation outlets emissions.

The review also considers this to be an important issue, but one that can be readily addressed. For example as done recently through the approval conditions for the NorthConnex Tunnel project.

This issue was raised at meetings with the proponent, who agreed to provide the necessary information. It is understood that approval conditions that reflect this would be put in place.

NSW Health also notes that the proposed in-tunnel limits for air pollution would be adequate to protect the health of tunnel users, but noted that exposure would be minimised if tunnel users were advised to switch their vehicles ventilation system to recirculate mode when using the tunnel. It is understood that signs to remind tunnel users to do this would be installed.

It is also understood that any approval conditions for the Project would set out the in-tunnel air quality limits, and also requirements for in-tunnel air quality monitoring to verify that the limits are met in operation.

6.3 NSW Chief Scientist and Engineer

The NSW Chief Scientist and Engineer raises very similar issues to those in this review, and provides a generally positive assessment of the technical aspects of the modelling, for example the empirical approach to converting predicted NOx levels to NO_2 levels.

The Chief Scientist and Engineer is also concerned with the assessment of absolute pollutant levels, and observes that the predicted absolute change in levels underpins the key conclusions and findings of the assessment.

The Chief Scientist and Engineer outlines the difficulty in assessing the GRAL model performance independently of other key assumptions, such as the interpolated background levels, which are used to develop the net results.

It is noted specifically that the Chief Scientist and Engineer raises the issue of poor modelling performance at Site M1, (see **Section 5.3**). In this regard, the proponent's response to the Chief Scientist and Engineer states; "*Based on the data presented in Appendix J of the Air Quality Assessment Report in Appendix H of the EIS, the interpretation is that GRAL is probably overestimating the road contribution at the F1 and M1 monitoring sites. This is shown more clearly in Figure 4.1 of this report. Here, the mapped background concentration at the F1 and M1 sites is taken to be the background contribution to the measurements, and the remainder is taken to be the measured road increment. It can be seen that there is a substantial over-prediction of the road component at the F1 site, but the prediction for the M1 site is rather good.*"

The figure referred to by the proponent provides a bar graph showing what appear to be annual average NOx levels at a number of monitoring stations. Whilst the proponent's response depends on the accuracy of its mapped background levels, and would be correct for annual average levels, it is not correct in regard to hourly levels, which are poorly predicted.

This is confirmed by the Chief Scientist and Engineer, for example; "*On a long-term basis, GRAL (as used) appears to over-estimate low concentrations, ie at less trafficked sites generally and at all sites in the summer. We suspect this may be largely driven by over-estimation at night (as indicated in Figure J-7 and J-8 of the Air Quality Assessment Report), and/or the error associated with the "conservative" background."*

And in response, the proponent agrees, stating; *"It is agreed that the model chain is overestimating concentrations at nighttime. This appears to be more a function of the GRAL predictions than the background."*

7 FURTHER TECHNICAL REVIEW OF THE AIR QUALITY ASSESSMENT

The key technical issues related to the assessment are discussed in the body of the report, and a complete list of technical issues examined in the review is summarised in **Table A-1** in **Appendix A**

These matters are largely technical or administrative in nature, and mostly stem from the lack of a specific air quality assessment methodology for road projects in NSW. These issues are not of great significance to the assessment as the current NSW methodology is technically not applicable to road projects. For this reason, it is suggested that DP&E, RMS and EPA consider developing an agreed, methodology for modelling and assessing future major road and road tunnel projects.

Based on the review of the assessment approach applied in this Project, there is clearly ample scope to develop a better approach that is more robust and effective. This would reduce the complexity, cost and time needed for such assessments, and provide the community, government and proponent with more confidence in the likely outcomes.

8 MANAGEMENT AND MITIGATION MEASURES

The management and mitigation measures for both the construction and operations impacts are considered to be appropriate and likely to minimise elevated pollutant levels in the tunnel and significant impacts in the surrounding area.

The management of air emissions (mainly dust) from the construction phase is an aspect of this Project that NSW EPA can directly regulate, and it has extensive expertise in this regard. The EPA is able to make on-the-spot assessments and to give appropriate directions in the event of any issues. Generally, most large construction projects are well managed, but will involve some level of impact on amenity due to dust. Usually such impacts relate to coarse dust particles from earthworks, which have low effects on health and are short lived. Thus air quality from construction is best managed on a day by day basis through a construction air quality management plan that can be updated as conditions change, and the construction progresses.

It is understood that potential air quality effects arising from the operation of the tunnel will be managed through two primary means. These are the inherent design of the tunnel and ventilation system that will ensure in-tunnel air quality is maintained at levels that do not adversely affect the health of tunnel users, and a ventilation system whereby the tunnel emissions are dispersed into the air, which ensures any local resident is not adversely impacted.

In this regard, air quality management conditions for the operation of the tunnel have been suggested and will be set out in the approval conditions for the Project.

9 GENERAL COMMENTS ON ROAD TUNNELS AND VENTILATION STACKS

There are many common public misconceptions and concerns about emissions from road tunnel stacks.

These include a misconception that the stack emissions will "rain down" upon residents near the stack, and therefore that the residents would be exposed to concentrated traffic pollutant emissions[2]. In reality the opposite occurs as stacks are highly effective at dispersing air pollution, and the pollutant emissions released from a reasonably designed stack will only reach ground level at highly diluted concentrations, and at significantly lower levels than traffic pollutant concentrations along an equivalent surface roads.

Due to this, compared to the emissions of exactly the same traffic on a surface road, a reasonably well designed road tunnel stack that collects these emissions and disperses them into the air will result in lower pollutant levels near the stack than near the same road (if it were on the surface). Thus the places where the people live, work and breathe the air would have lower pollutant levels. This will always occur, as the poorest dispersion weather conditions apply in the same way to for a stack and surface road.

To better understand the scale of the dilution that occurs between the stack tip and ground level, it may help to consider that the plume from a stack is generally warm, and thus buoyant and is directed upwards at a high velocity when released. The plume, say in perfectly still and uniform atmospheric conditions will be projected upwards and will continue to rise up and would not reach the ground. The plume in this situation would hypothetically be shaped like a large ever-widening cone of air. As the pollutants travel away from the stack they disperse through an ever increasing volume of clean air, greatly reducing pollutant concentrations with distance from the stack. In the presence of wind, the plume from a stack can be bent in a sideways arc. When there is a wind strong enough to deflect the plume fully sideways, it generally also results in mixing of the air which may breaks the plume apart and force the traffic pollution to mix with even more fresh air. Thus two factors are at play; as the wind speed increases the edge of the dispersed plume will of course come closer to the ground, but the wind will also cause the plume to be better dispersed and the pollution will be more diluted.

As a general rule of thumb, stacks dilute air emissions (between the stack tip and the ground) by at least approximately 50 to 100 times, and most industrial stacks achieve dilution ratios closer to at least approximately 1,000 times. Very tall, hot stacks may achieve much higher dilution ratios. The dilution achieved for a particular stack will depend on several key factors including the vertical velocity of the discharge, temperature (relative to the ambient) and the height of the stack above ground. For large volume discharges such as road tunnel stacks, the volume of the discharged air will also be significant and may affect the net buoyancy of the plume (it takes a longer time for the larger mass of air to cool as it rises upward, and it can travel further up).

Clearly, this would not apply to very tall buildings that are very near to and taller than the ventilation stack outlet. In this situation it is possible for the plume to impinge directly onto the building. For these reasons the ventilation outlets of road tunnel stacks are positioned either above or away from such tall

[2] There is some potential for stack tip downwash to occur. This is where the plume can momentarily be brought to ground, generally as a plume whorl that is brief and transient. It is noted that this would be a rare, momentary phenomena for a well-designed stack, and the taller the stack, and higher the velocity of the vented air, the lower the likelihood of such an occurrence.

buildings, and planning restrictions may be put in place to prevent such buildings being built next to road tunnel ventilation stacks at a later time.

The case of a layer of warm air above the stack, also known as a temperature inversion, is also worth considering. These conditions can occur in a valley on still, cool (usually winter) nights after a sunny day. These conditions can lead to the poorest stack dispersion as the plume may not disperse as freely as it otherwise could. However it needs to be considered that these conditions do not generally coincide with peak hour traffic and that the same conditions also lead to the poorest dispersion situation from a surface road. Thus if the surface road's emissions were released via a stack the net effects at receptors would be lower (than the same emissions release via a stack) even under such conditions. Thus it is still better to collect and release traffic emissions via a stack, as it will to minimise air pollution at the surface.

Whilst collecting traffic emissions and discharging them via a stack will result in better air quality at ground level, the in-tunnel air quality would be worse than surface road air quality, and this needs to be carefully managed for road tunnel projects. Having a sufficient number of properly positioned stacks and fresh air intakes is a crucial aspect of achieving acceptable in-tunnel air quality and better surface air quality. For example, for this Project, adding a stack near the middle of the proposed tunnel could approximately halve the in-tunnel user exposure to traffic pollution, and would also reduce above ground impacts near the stacks (which are relatively small in any case due to good stack dispersion).

Another issue is the expectation that road tunnel stacks should be filtered. Whilst conceptually this would make sense, after all the pollutant emissions are contained in the tunnel and are under the control of the operator, it turns out that treatment/ filtration is generally not a feasible option due to the large volumes of in-tunnel air and the low levels of pollution in road tunnel air.

In-tunnel air is significantly different to the emissions in a stack serving an industrial process, as it is necessary for the air in a tunnel to be diluted with fresh air to make it safe for tunnel users to breathe.

A simple way to appreciate the differences is to consider that the pollution in tunnels comes predominantly from vehicle exhaust (there is some tyre and brake dust also), and that most vehicles already have some form of pollution control, such as catalytic converters or particulate filters on diesel vehicles. This already "filtered" exhaust air from vehicles is diluted with fresh air in the tunnel so that the in-tunnel air is safe for users to breathe. There is often further dilution in the stack as there may be additional fresh air drawn in at the exit to manage portal emissions. Thus already "filtered" vehicle pollution is diluted to the point where the volume of air discharged via the stack can be hundreds of times greater (than the volume of vehicle exhaust air) and thus contains a lower level of emissions than the filtered air produced by the viable treatment options available for such large volumes of air.

However, a typical stack from an industrial process can have some form of filtration or pollution control applied to successfully reduce the pollutant concentrations. This is because the industrial stack emissions are more like emissions from vehicle exhaust, but without pollution control equipment and without dilution with fresh air. This means that the pollutant concentrations in industrial stacks are high enough so that pollution control equipment can provide a significant cleaning effect.

Generally in-tunnel pollutant levels are too low to be further treated as they are already cleaner than the output (filtered air) that viable industrial scale filters are capable to achieving. This coupled with the large volumes of air in a tunnel generally makes the filtration of in-tunnel air unviable.

10 CONCLUSIONS

The assessment applies a new modelling approach (for NSW) for the assessment of major road projects. A key benefit of the approach is its ability to consider a large number of receptors.

Like any air dispersion model, the model used is powerful at making relative comparisons, and this aspect of the assessment is done well.

The assessment convincingly shows that the proposed Project would result in reduced air quality impacts at most nearby receptors, but some increased impacts would arise at a minority of receptors, generally on side roads related to the Project.

Due to a number of shortcomings inherent to the selected model and the modelling approach and assumptions applied, the assessment is less convincing in its estimation of the potential concentration of pollutants in the air. However, this is not seen as a major issue in light of the clear evidence that the Project would only change existing pollutant levels by a small degree, and that for the majority of receptors this would result in lower pollutant levels.

On this basis, the Project can be expected to reduce the levels of air pollution experienced by the majority of the residents living in the vicinity of the Project.

Due to some shortcomings in the assessment approach, it is suggested that RMS, DP&E and EPA consider developing an agreed, standardised methodology for the assessment of air emissions arising from future major road and road tunnel projects.

The outcomes of the assessment are largely dependent on the predicted traffic emissions and hence the predicted traffic numbers. To ensure that the Project is able to achieve the claimed air quality outcomes for the operation of the tunnel, in-tunnel air quality limits, including ventilation stack limits have been developed to be applied in the conditions of approval for the Project. These conditions also set out monitoring and reporting requirements that will demonstrate that the required limits are being met.

11 REFERENCES

NSW DEC (2005)

"Approved Methods for the Modelling and Assessment of Air Pollutants in NSW", August 2005.

Pacific Environment (2015a)

"WestConnex M4 East Air Quality Assessment Report", prepared by Pacific Environment for WestConnex Delivery Authority, September 2015.

Pacific Environment (2015b)

"WestConnex M4 East Additional analysis/sensitivity testing & response to peer review and agency comments", presentation prepared by Pacific Environment Limited, 10 November 2015.

RMS (2015)

"WestConnex M4 East Submissions Report", prepared by Roads and Maritime Services [RMS], December 2015

Appendix A

Technical Review of Adequacy of Air Assessment in regard to the Air Modelling Regulatory Requirements

It is noted that the Approved Methods applies to Stationary Sources, which does not include emissions from motor vehicles. Technically it would appear that the Approved Methods is not applicable to the Project, but the existing industry practice is to adopt the Approved Methods for the assessment of road tunnel stack emissions and as a means of assessing the effects of a Project on road side pollutant concentrations.

Table A-1: Technical Review of Adequacy of Air Assessment in regard to the Air Modelling Regulatory Requirements

Requirements per Approved Methods/ Contemporary Practice	Appendix G – Technical working paper: Air Quality (AQIA)	AQIA reference	Adequate? (Y/N)
2. Methodology	Broadly, a Level 2 (refined dispersion modelling technique using site-specific input data) assessment was applied. Assessment methodology is described in Section 8 of AQIA. Methodology comparison with the regulatory requirements is addressed in more detail below for specific components of the approach.	Section 8	Y
3. Emissions inventory			
3.1 Identify all sources of air pollution and potential emissions	Traffic pollutants are identified in Section 3.2.2. Section 4.6 presents the ambient air quality standards and criteria of pollutants while the later part of Section 5.5.3 listed the pollutants among those listed in Section 4.6 that were considered not relevant to the AQIA. Section 8.2 identifies all road traffic sources in the Project domain.	Section 8.2	Y
3.2 Determine source release parameters	Source parameters of the proposed and anticipated future ventilation outlets are presented in Section 8.3.6 and Appendix I. Source parameters of the ventilation outlets for regulatory worst case scenarios are presented in Section 8.3.7. Some of the source parameters from the surface roads emissions are not presented, although these are less important. Some of the source parameters from the surface roads emissions are presented in Section 8.2.3.	Sections 8.3.6, 8.2.3 and 8.3.7 and Appendix I	Y
3.3 Estimate emission rates	As stated in Section 8.2.1, emissions from the proposed ventilation outlets were estimated using emission factors provided by PIARC (2012), emissions from traffic on surface roads were estimated by using an emission model developed by NSW EPA, and emissions from ventilation outlet of the M5 East tunnel were estimated using historical measurements. Estimated emission rates from the proposed ventilation outlets, surface roads, and the anticipated future ventilation outlets are presented in Sections 8.2.2, 8.2.3 and 8.2.4, respectively. Estimated emission rates from the ventilation outlets are also presented in Appendix I.	Sections 4.2.8.1, 4.2.8.2 and 8.3.7 and Appendix I	Y

Requirements per Approved Methods/ Contemporary Practice	Appendix G – Technical working paper: Air Quality (AQIA)	AQIA reference	Adequate? (Y/N)
	Regulatory worst case emission rates were estimated from the NorthConnex conditions of approval and are presented in Section 8.3.7. The emission rates depend on the traffic number predicted to occur, and also the emissions estimation approach. It is somewhat unclear why three different approaches are used, but each approach applies acceptable methods.		
3.3.4 Accounting for variability in emission rates	Diurnally varying emissions were taken into account in the assessment by splitting the 24-hour time period into 3 or 4 different time periods. The average estimated emission rates for each time periods were determined and the 'modulation factors' (ratios relative to the average) were used to take into account the varying emissions within each time period. No seasonal variation was accounted for the proposed ventilation outlets and surface roads emissions.	Sections 8.2.2, 8.2.3 and 8.2.4 and Appendix I	Y
3.4 Calculate emission concentration for point sources i. Actual concentration of a pollutant emitted from a source (mg/Am^3) calculated using the actual gaseous volumetric flow rate (Am^3/s) and measured emission rate in Equation 3.1 ii. Concentration of a pollutant emitted from a source corrected to the reference conditions as specified in the Regulation (mg/Nm^3 @ O_2%). This is calculated using the gaseous volumetric flow rate corrected to normal conditions (dry, 273K, 101.3kPa) and the measured emission rate in Equation 3.1. The emission concentration (in mg/Nm^3) is then corrected to the appropriate oxygen reference condition. Further guidance on correcting to reference and equivalent values is provided in DEC (2005)	Emission concentrations from the ventilation outlets are presented in Appendix I.2. Emission concentrations for regulatory worst case are presented in Section 8.3.7. Note that an Oxygen correction is not applicable to the stack emissions in this situation as the tunnel is not a combustion source and is designed to operate with a normal level of oxygen in the air.	Section 8.3.7 and Appendix I.2.	Y

Requirements per Approved Methods/ Contemporary Practice	Appendix G – Technical working paper: Air Quality (AQIA)	AQIA reference	Adequate? (Y/N)
3.5 Assess compliance with the Protection of the Environment Operations (Clean Air) Regulation.	N/A. The stack emissions were not assessed against the Regulation limit, but in any case it is noted that emissions would be well below the Regulation limits applicable to stack emissions from industrial plant.	N/A	N/A
3.6 Presentation of emissions inventory			
i. all release parameters of stack and fugitive sources (e.g. temperature, exit velocity, stack dimensions, flow rate, moisture content, pressure, carbon dioxide and oxygen concentration) (Table 3.1)	Source parameters of the proposed and anticipated future ventilation outlets are presented in Section 8.3.6 and Appendix I. Source parameters of the ventilation outlets for regulatory worst case scenarios are presented in Section 8.3.7. Some of the source parameters from the surface roads emissions are not presented, although these are less important. Some of the source parameters from the surface roads emissions are presented in Section 8.2.3.	Sections 8.3.6, 8.2.3 and 8.3.7 and Appendix I	Y
ii. Pollutant emission concentrations and a comparison against the relevant requirements of the Regulation (Table 3.2)	Emission concentrations from the ventilation outlets are presented in Appendix I.2. Emission concentrations for regulatory worst case are presented in Section 8.3.7. Comparison against the relevant requirements of the Regulation was not undertaken. But in any case it is evident that the emissions would be well below any regulatory requirements for the emissions from any scheduled or non-scheduled premises.	Section 8.3.7 and Appendix I.2.	N/A
4. Meteorological data			
4.1 Minimum data requirements	A quasi - Level 2 impact assessment was conducted. Data from three OEH and five BoM meteorological stations located within the chosen domain were analysed to determine suitability as input into the model. The Proponent has chosen to use 2014 data from the BoM Canterbury Racecourse as it is centrally located to the WestConnex Project. The use of the 2014 data from BoM Canterbury Racecourse is consistent in the Approved Methods in terms of the completeness of data and good correlation of data against at least five years of data. However, it is not clear whether the data from the Canterbury Racecourse is representative of the meteorology experienced in the M4 East Project as there is significant variations in meteorology across the modelling domain. Also, the use of the GRAMM model produces little variation in the meteorology across the modelling domain which is not representative of the actual significant variations in recorded meteorology across the domain.	Section 6.4 and Appendix H	Y
4.2 Siting and operating meteorological monitoring equipment	The AQIA applies meteorological data from the BoM Canterbury Racecourse station. The location of the station are shown in Figure 6-2.	N/A	Y

Requirements per Approved Methods/ Contemporary Practice	Appendix G – Technical working paper: Air Quality (AQIA)	AQIA reference	Adequate? (Y/N)
4.3 Preparation of Level 1 meteorological data	N/A. A quasi-level 2 assessment was conducted	N/A	N/A
4.4 Preparation of Level 2 meteorological data	Stability class was calculated using the temperature at 10m and the cloud content data from the BoM Sydney Airport AMO. The Approved Methods enumerate the methods of determining stability class in order of preference as: Turner's 1964 method, solar radiation-delta temperature method and sigma theta method. The method used by the Proponent is not mentioned in the Approved Methods. As there has is no justification provide for an alternative method, a method per the Approved methods, should have been used in this assessment, given that there are available data to determine stability class using an approved method.	Section 8.3.4	N
4.5 Developing site-representative meteorological data using prognostic meteorological models	N/A. A prognostic meteorological model was not used in this assessment.	-	N/A
5. Background air quality data, terrain, sensitive receptors and building wake effects			
5.1 Background air quality data	Data from OEH and RMS monitoring sites were analysed to determine background air quality data to be used for the assessment. For annual mean background data, spatial variation of background data was determined by mapping the available annual mean background data from monitoring sites. Data from a major roadside monitoring location was included and skews the mapped results. For short-term concentrations, a synthetic time series of background concentrations was produced by the Proponent by choosing the maximum short-term concentration for each short-term period from among two to three monitoring sites as explained in Appendix F. This would increase the conservatism of the assessment. The determination of cumulative impacts are presented in Section 8.3.8. The cumulative short-term concentrations were assessed using the methods as presented in Table A-1.1. **Table A-1.1: Methods used for the cumulative assessments of short-term pollutants** Pollutant (averaging period) / Community receptors / RWR receptors CO (1-hr mean) / Level 2 / Level 1	Appendix F and Section 8.3.8.	N

<table>
<tr><th>Requirements per Approved Methods/ Contemporary Practice</th><th>Appendix G – Technical working paper: Air Quality (AQIA)</th><th>AQIA reference</th><th>Adequate? (Y/N)</th></tr>
<tr><td></td><td><table><tr><td>CO (rolling 8-hr mean)</td><td>Level 2</td><td>Level 1</td></tr><tr><td>NO_2 (1-hr mean)</td><td>Level 2</td><td>Statistical</td></tr><tr><td>PM_{10} (24-hr mean)</td><td>Level 2</td><td>Statistical</td></tr><tr><td>$PM_{2.5}$ (24-hr mean)</td><td>Level 2</td><td>Statistical</td></tr></table>
The use of the Statistical method is not compliant with the Approved Methods.

The Proponent justifies the use of the statistical method by showing a comparison between the results of the contemporaneous and the statistical methods, however this shows a poor correlation.</td><td></td><td></td></tr>
<tr><td>5.2 Terrain data and sensitive receptors</td><td>Terrain and land use of the Project area are briefly described in Section 6.2.
Based from the modelling results, the model does not respond adequately in regard to the terrain and land use data.
The sensitivity analysis done for the land use shows that the model varies the meteorology slightly across the domain but does not adequately reflect the observed data.</td><td>Sections 6.2 and 8.3.6</td><td>Y</td></tr>
<tr><td>5.2 Building wake effects</td><td>Building wakes can be, but were not taken into account in this assessment.

The validation studies used to justify the selection of the model show poor performance for traffic assessment without considering such effects, but better performance with these effects included.</td><td>-</td><td>N</td></tr>
<tr><td>6. Dispersion modelling</td><td></td><td></td><td></td></tr>
<tr><td>6.3 Advanced air dispersion models for specialist application</td><td>The GRAL/GRAMM model is not an Approved Methods. The proponent states that it discussed the use of the model with the EPA, but there is no direct evidence presented to confirm that the EPA approved the model for such use.</td><td>-</td><td>N (?)</td></tr>
<tr><td>2.4.3 Processing dispersion model output data</td><td>Predicted ground level concentrations (glc's) of all pollutants are in the same units and for the same averaging period as the relevant impact assessment criteria. A typo in one plot is corrected.</td><td>Section 8.4 and subsections and Section 8.5</td><td>Y</td></tr>
<tr><td>7. Interpretation of dispersion modelling results</td><td></td><td></td><td></td></tr>
<tr><td>7.1.2 Application of impact assessment criteria for SO_2, NO_2, O_3, Pb, PM_{10}, TSP, deposited dust, CO and HF. The Approved Methods states that the assessment criteria must be applied as follows:</td><td>It is noted that the Approved Methods applies to Stationary Sources, which does not include emissions from motor vehicles. Technically it would appear that the Approved Methods is not applicable to the Project, but the existing industry practice is to adopt the Approved Methods for the assessment of stack emissions and as a means of assessing the effects of a Project on road side pollutant concentrations.</td><td>-</td><td>-</td></tr>
</table>

Requirements per Approved Methods/ Contemporary Practice	Appendix G – Technical working paper: Air Quality (AQIA)	AQIA reference	Adequate? (Y/N)
a. At the nearest existing or likely future off-site sensitive receptor	The maximum predicted glcs at most the sensitive receptors were reported, with the exception of elevated receptors in the vicinity of the stacks. Some receptors near roads were omitted, and some non-existent receptors away from roads were included, however but it is not reasonable or expected that all receptors for such a Project be evaluated. A comprehensive cross-section of representative receptors was assessed, albeit with some bias in the number and location of receptors added / omitted. The bias would make the Project more conservative. It is necessary to evaluate the impacts at elevated receptors in the vicinity of the stacks	Section 8.3.6	N
b. The incremental impact (predicted impacts due to the pollutant source alone) for each pollutant must be reported in units and averaging periods consistent with the impact assessment criteria.	Incremental predicted glcs of all pollutants are in the same units and for the same averaging period as the relevant impact assessment criteria. Incremental impacts of rolling 8-hr mean CO concentrations for RWR receptors are not presented. The justification is that these would be "broadly similar to those obtained for maximum one-hour concentrations". The issue is not significant as the assessed CO levels would be well below any possible level that may cause impact, and this is certainly true for the 8-hour values also.	Section 8.4 and subsections and Section 8.5	N
c. Background concentrations must be included using the procedures specified in Section 5.	Refer to Requirement 5.1	Appendix F and Section 8.3.8.	N
d. Total impact (incremental impact plus background) must be reported as the 100th percentile in concentration or deposition units consistent with the impact assessment criteria and compared with the relevant impact assessment criteria.	Non-statistically determined cumulative impacts were reported as 100th percentiles and have units consistent with the relevant assessment criteria and compared against the relevant criteria. Total impacts of rolling 8-hr mean CO concentrations for RWR receptors are not presented Total impacts for the regulatory worst-case scenarios were not presented. Refer to Requirement 5.1	Section 8.3.8	N
7.2.2 Application of impact assessment criteria for individual toxic air pollutants. The Approved Methods states that the assessment criteria must be applied as follows:			
a. At and beyond the boundary of the facility.	The maximum predicted incremental glcs at all the community receptors (except elevated receptors) were reported.	Section 8.4.9	N

Requirements per Approved Methods/ Contemporary Practice	Appendix G – Technical working paper: Air Quality (AQIA)	AQIA reference	Adequate? (Y/N)
	The maximum predicted incremental glcs at the RWR receptors, which should include receptors at and beyond the boundary of the facility, were not reported. As stated in Section 8.4.9, "the largest increases for the community receptors were also representative of the largest increases for the RWR receptors." Limited evaluation of the impacts form the stacks is provided, but no convincing verification was presented to prove this statement.		
b. The incremental impact (predicted impacts due to the pollutant source alone) for each pollutant must be reported in concentration units consistent with the criteria (mg/m^3 or ppm), for an averaging period of 1 hour and as the: i. 100th percentile of dispersion model predictions for Level 1 impact assessments, or ii. 99.9th percentile of dispersion model predictions for Level 2 impact assessments	The 100th percentile of the predictions for the community receptors were presented. As stated above, the correct format for the results for RWR receptors were not presented.	Section 8.4.9	N
c. Polycyclic aromatic hydrocarbons (PAH) as benzo[a]pyrene (BaP) must be calculated using the potency equivalency factors for PAHs in Table 7.2c.	As stated in the notes below Table 8-23, the PAH was taken from the "PAH fraction of THC from NSW EPA (2012b) and the BaP fraction of PAH from Environment Australia (2003)". There is no explanation as to why only the BaP fraction of PAH from Environment Australia (2003) was used. There is also no statement about the calculation using the potency equivalency factors for the PAH fraction of THC from NSW EPA.	Table 8-23	N
d. Dioxins and furans as toxic equivalent must be calculated according to the requirements of clause 29 of the Regulation.	N/A	N/A	N/A
7.4 Individual odorous air pollutants	Individual odorous air pollutants were assessed and results are presented in Section 8.4.10.	Section 8.4.10	Y
8. Modelling pollutant transformations			
8.1 Nitrogen dioxide assessment	None of the methods in the Approved Methods was used in the assessment. An empirical conversion method was instead developed for Sydney. Whilst non-complaint, the method is considered to be technically sound, providing significant conservatism.	Section 4.2.11.1	N

Requirements per Approved Methods/ Contemporary Practice	Appendix G – Technical working paper: Air Quality (AQIA)	AQIA reference	Adequate? (Y/N)
9. Impact assessment report			
9.1 Site plan			
- Layout of the site clearly showing all unit operations	A site layout is shown however it does not show the existing ventilation outlets that were included in the assessment.	Figure 8-5	N
- All emission sources clearly identified	All emissions sources are clearly identified.	Figure 8-5	Y
- Plant boundary	N/A	N/A	N/A
- Sensitive receptors (e.g. nearest residences)	Sensitive receptors are shown in Figure 8-16.	Figure 8-16	Y
- Topography	Topography is presented in Figure 6-1.	Figure 6-1	Y
9.2 Description of the activities carried out on the site	Chapters 1 and 2 provide an overview of the Project. Description and emission parameters of various scenarios depicting the current, expected situations with and without the Project, and regulatory worst-case situation are presented in Sections 8.2 and 8.3.	Chapter 2 and Sections 8.2 and 8.3	Y
9.3 Emissions inventory	Emission inventories are presented in Sections 8.2 and 8.3 and Appendix I	Sections 8.2 and 8.3 and Appendix I	Y
9.4 Meteorological data	Section 6.4 and Appendix presents a discussion and analysis of available meteorological data from monitoring stations in the modelling domain.	Section 6.4 and Appendix H	Y
9.5 Background air quality data	Data from OEH and RMS monitoring sites were presented and analysed to determine background air quality data to be used for the assessment.	Appendix F	Y
9.6 Dispersion modelling			
- A detailed discussion and justification of all parameters used in the dispersion modelling and the manner in which topography, building wake effects and other site-specific peculiarities that may affect plume dispersion have been treated	Section 6.2 discusses the topography and how it would affect dispersion. Section 8.3.6 presents a discussion on the insignificance of including buildings in the assessment. This contradicts the model developer's evaluation of the model at predicting traffic emissions in an urban environment.	Sections 6.2 and 8.3.6	Y
- A detailed discussion of the methodology used to account for any atmospheric pollutant formation and chemistry	Section G.4 presents the methodology used in the assessment to consider the transformation of NO_x to NO_2.	Section G.4	Y
- A detailed discussion of air quality impacts for all relevant pollutants, based on predicted ground-level concentrations at the plant boundary	Sections 8.4 and 8.5 presents a discussion of air quality impacts for all relevant pollutants.	Sections 8.4 and 8.5	Y

Requirements per Approved Methods/ Contemporary Practice	Appendix G – Technical working paper: Air Quality (AQIA)	AQIA reference	Adequate? (Y/N)
and beyond, and at all sensitive receptors			
- Ground-level concentrations, hazard index and risk isopleths (contours) and tables summarising the predicted concentrations of all relevant pollutants at sensitive receptors	Ground-level concentrations isopleths and graphs are presented in Section 8.4. Maximum predictions presented in Sections 8.4.10 and 8.5 are presented in tables. Plots showing the ventilation outlet impacts are presented in the response to submissions report.	Sections 8.4 and 8.5	Y
- All input, output and meteorological files used in the dispersion modelling supplied in a *Microsoft* Windows-compatible format	N/A.	-	N/A