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Leichhardt and Marrickville Councils

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Attention: Kendall Banfield

19 October 2015

Ref: 4358RepLet02.odt

Dear Kendal

RE: INDEPENDENT PEER REVIEW - APPENDIX H, AIR QUALITY ASSESSMENT, WESTCONNEX M4 EAST AIR QUALITY ASSESSMENT

This letter report presents the outcome of an independent expert review of the Air Quality Impact Assessment (Appendix H) of the Westconnex M4 East Environmental Impact Assessment. The independent peer review represents an impartial, independent review that has been based on knowledge and experience of current practices, procedures and information. The views expressed in the report are those of the reviewer, hence may not represent those of the client, however both Marrickville and Leichhardt Council have had the opportunity to review and comment on the review prior to finalisation.

The expert review has considered all aspects of the Appendix H Air Quality Assessment. In particular, as per the brief provided by Marrickville and Leichhardt Councils and the scope of work agreed for this peer review, the following issues have been specifically commented on in this report:

- The adopted methodologies for the air quality assessment and their suitability in the context of the project information.
- The suitability of the inputs and assumptions underlying the air quality modelling and the traffic scenarios considered in the modelling. In particular, ventilation rates (efflux velocity) and temperature of emissions have been reviewed in the context of the influence on dispersion, and emission rates.

- The suitability of the meteorological datasets prepared for the atmospheric dispersion modelling.
- The adequacy of local background air quality data utilised in the assessment of cumulative (project plus background) impacts.
- The adopted air quality goals and health risk standards, and suitability for assessment of the risk of impacts.
- The suitability of the proposed in-tunnel and external monitoring methodologies for determining compliance with typical approval conditions (referencing the NorthConnex approval as a primary example) and external ambient air quality goals.
- Whether the assessment has been completed in a manner that is consistent with the analysis and recommendations of the Advisory Committee on Tunnel Air Quality.
- The suitability of the assessment methodologies adopted for the construction air quality assessment, including review of the modelling inputs and assumptions.
- The overall predicted cumulative impact from the project, in conjunction with existing background and emissions from future stages of the WestConnex project. A particular focus will be the proposed co-location of the eastern ventilation stack with the WestConnex Stage 3 ventilation stack.
- The expected impact on the Marrickville and Leichhardt Local Government Areas both for the overall cumulative project impacts.
- The overall conclusions of the assessment and how robust these conclusions are based on the review of the methodologies and assumptions.
- The appropriateness of proposed mitigation strategies, and identification of any additional mitigation measures or controls that could further reduce the potential exposure of the local population to air pollution emissions from the project.

The Peer Review Team

This peer review has been completed by Air Noise Environment personnel with extensive experience in completing air quality impact assessments of major infrastructure projects, and road tunnels in particular. The review team comprised the following personnel:

- Principal Consultant: Claire Richardson, BSc(Hons), MAAS.
- Technical Director: Craig Beyers, BEng(Env), MAAS.
- Senior Environmental Engineer: Samuel Wong, BEng(Chem), MAAS.

This team has been involved in air quality assessment of the majority of tunnel projects completed in Australia over the last 20 years, including the following:

- Clem7 Tunnel (Brisbane)
- Cross City Tunnel (Sydney)
- Lane Cove Tunnel (Sydney)

- West Connex Stage 2b (bid phase)
- M5 East duplication (bid phase)
- East-West Link (Melbourne)
- Airport Link Northern Busway (APLNB), Brisbane
- EastLink Motorway (Melbourne)
- M5 East Motorway (Sydney)

The ANE team, in conjunction with Holmes Air Sciences, was also responsible for leading the development of a guideline for the monitoring, modelling and assessment of air quality impacts for road and tunnel projects in NSW on behalf of the NSW RTA.

The project team has expertise in air quality and meteorological modelling, including the use of the GRAL model adopted for use in the M4 East Air Quality Assessment.

Structure of the Review

The review information is presented in three ways. Firstly, comments on the questions identified in the scope of work are addressed in Attachment A. Secondly, specific comments are tabulated in Attachment B in a format that will allow cross-referencing with the relevant sections/pages in the Environmental Impact Assessment documentation. Finally, overall analysis and conclusions are presented in the main body of this letter report, based on a broader synthesis of the more detailed information presented in Attachment B.

Overall Analysis and Comment

Overall, it is considered that the Air Quality Assessment presented in Appendix H of the West Connex M4 East Environmental Impact Assessment presents an in depth, high quality analysis of the air quality issues associated with this major project. As with any project of this complexity, there are numerous uncertainties associated with the analysis of potential impacts, and the Air Quality Assessment has sought to address these in a thorough, scientifically sound manner.

The additional analyses has included further developing current methodologies in an attempt to improve the assessment of specific aspects, particularly where approaches used in the past have been less than ideal. Whilst these attempts to develop improved methodologies are an important step in developing our understanding of the impacts of complex infrastructure projects, there are inherent risks in the application of methodologies that have had limited application to tunnel projects in the past. This has resulted in some specific issues that have not been satisfactorily addressed in the Air Quality Assessment. These issues relate primarily to the inability of the dispersion modelling methodology (GRAM/GRAL model) to consider:

- building downwash effects;
- data from multiple meteorological stations;
- hourly time varying emission rates;
- time varying emission temperatures; and

- limitations on the number of receptors where predicted impacts can be considered in detail.

The assessment report has sought to address these limitations through sensitivity analysis and verification of the datasets used. However, these factors combine to introduce significant uncertainty to the predicted concentrations for the predicted short term nitrogen dioxide concentrations.

These effects are likely to be most apparent for the dispersion of emissions from the ventilation stations. The estimates for variability presented in the assessment confirm +/- 50 % variability each for building downwash and emission temperature for 24 hour average predicted concentrations. Additional uncertainty would be added to the predicted impacts of the ventilation stations as a result of the smoothing of hourly emission rates, as these uncertainties relate to 24 hour average data. This could result in predicted non-compliances at a number of additional receptors in close proximity to the ventilation outlets. There is also variability introduced due to the use of a single meteorological station that is located in the centre of the overall WestConnex modelling domain, as opposed to stations in closer proximity to the M4 East, for the prediction of the meteorological data used in the GRAL modelling.

The overall uncertainty associated with the modelling predictions is considered to be significantly reduced for the road related emissions. It is important to recognise that road traffic emissions are the overwhelmingly dominant source in the modelling domain. Similarly, the additional uncertainties are likely to be reduced for the pollutants with longer averaging times (CO, PM_{10} and $PM_{2.5}$) and are most significant for predicted 1-hour average nitrogen dioxide concentrations.

The adopted methodology does not satisfy all of the requirements of the 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW' however, the Air Quality Assessment report does not confirm that the NSW EPA has approved the alternative assessment methodology that has been adopted. Confirmation should be sought from NSW EPA to confirm that the GRAM/GRAL modelling methodology is acceptable.

One of the issues identified in the review relates to a factor that is unique to this assessment. This is the co-location of two ventilation outlets with differing characteristics – height, volumetric flow, temperature and emission concentrations. Combining the two ventilation outlets is an option that would address these issues and could yield savings in terms of energy costs and routine emission monitoring. However, assuming that this option has already been considered and rejected, it is recommended that computational fluid dynamics of the interaction of the two ventilation outlets is completed to accurately assess the dispersion of pollutants from the two ventilation outlets.

A further area of significant relevance to the air quality outcomes of this project relates to the potential for the traffic volumes for the project to differ markedly from those considered in the Air Quality Assessment. As noted in the EIS, history demonstrates that operational traffic volumes through road tunnels can differ markedly from those projected at the design phase. In many cases traffic volumes are lower (Cross City Tunnel, Clem7, Airport Link, for example). In some cases, traffic volumes are higher and the traffic mix differs significantly from the original projects. The M5 East Motorway tunnel is an example of this issue. The EIS has attempted to address this by considering a worst case scenario, whereby it is assumed that the emission concentrations from the tunnel ventilation outlet are equivalent to the licence limits imposed on the NorthConnex ventilation outlets.

However, the 'worst case' assessment presented in the Air Quality Assessment does not consider the maximum emission rates (in g/s), hence the worst case scenario is not in fact considered. Furthermore, a peak congested scenario has not been considered in the air quality assessment. It is considered that these scenarios should be modelled/remodelled.

Additional specific issues that have been identified in the review, and warrant further consideration, are as follows:

- completion of a quantitative construction air quality assessment, focussing on the risk of particulate impacts and including the potential for release of crystalline silica;
- low efflux velocity for ventilation outlets at night, with potential for stack tip and building downwash issues to be enhanced;
- necessity of incorporating portal emission monitoring if a condition requiring no portal emissions is imposed;
- provision of dampers in the western ventilation outlet to allow for varying outlet diameters.

Overall Conclusions

The Air Quality Assessment predicts compliance with the air quality goals for the majority of pollutants. The short term predicted non-compliances are related principally to road traffic emissions, and these impacts are also present for the existing environment. Overall reductions in pollutant impacts are predicted for the majority of receptors.

Providing the issues identified in this review are addressed, and the conclusions of the Air Quality Assessment do not change significantly as a result, it is concluded that the local and regional air quality as a result of the Westconnex M4 East project is not likely to be detrimentally affected to a significant degree.

Disclaimer

Where site inspections, testing or fieldwork have taken place, the report is based on the information made available by the client or their nominees during the visit, visual observations and any subsequent discussions with regulatory authorities. The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Air Noise Environment Pty Ltd is both complete and accurate. It is further assumed that normal activities were being undertaken at the site on the day of the site visit(s).

Yours sincerely

for Air Noise Environment Pty Ltd

Claire Richardson BSc(Hons), MAAS

Principal Consultant

Attachment A

Response to Questions Raised in Brief and Scope of Work

Issue	Peer Review Comments
The adopted methodologies for the air quality assessment and their suitability in the context of the project information.	The adoption of an alternative meteorological and dispersion modelling package (GRAM and GRAL) has introduced some limitations in the assessment methodology, relative to the current approved regulatory models. Whilst the NSW EPA Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales does not preclude the use of alternative air quality models, the Air Quality Assessment does not confirm that the NSW EPA were approached regarding the suitability of the model for this assessment. The GRAM/GRAL model does not contain features necessary for addressing a number of the requirements of the NSW Approved Methods for the M4 East project. These include building downwash, prediction of hourly cumulative receptor concentrations (this has been completed for averaged emissions over 3 periods a day only, not be hour, due to computational limitations), and consideration of site specific meteorology (a single meteorological dataset has been incorporated to represent the overall WestConnex project area). The GRAM/GRAL model provides an approach that allows consideration of road emissions and ventilation emissions in a single model. The latest version of the approved regulatory model CALPUFF/CALMET (V7 released in June 2015) provides this feature, however prior to release of V7 summation of predictions from two different models (for example, CALINE4 and CALPUFF) would have been required to complete analysis of the roads and ventilation outlets. Due to computational limitations, use of the GRAL model for the M4 East assessment also limits the number of discrete receptors that can be considered in detail.

Issue	Peer Review Comments
	Specific comments on the modelling approach are provided in Attachment B.
The suitability of the inputs and assumptions underlying the air quality modelling and the traffic scenarios considered in the modelling. In particular, ventilation rates (efflux velocity) and temperature of emissions will be reviewed in the context of the influence on dispersion, and emission rates.	Specific comments are provided in Attachment B.
The suitability of the meteorological datasets prepared for the atmospheric dispersion modelling.	The meteorological dataset has been prepared to represent the WestConnex project as a whole, and is based on Bureau of Meteorology data for Canterbury Racecourse. This approach results in the meteorological dataset poorly representing the specific meteorological conditions for the M4 East project (as indicated by the relatively poor correlation between the predicted meteorology at Sydney Olympic Park and Rozelle) although the broader annual trends at these locations appears to be well represented (as demonstrated by the cumulative frequency comparisons in Appendix H – Meteorological data analysis and model evaluation). The adoption of the GRAM and GRAL model for the meteorological and dispersion modelling is the reason for the assimilation of only a single observational meteorological dataset. Had one of the currently approved regulatory models, such as CALMET and CALPUFF, been adopted in the assessment, numerous meteorological dataset could have been incorporated. This may have improved the performance of the meteorological modelling, possibly to a significant degree.
The adequacy of local background air quality data utilised in the assessment of cumulative (project	Background air quality data has been compiled from existing ambient monitoring stations operated by the NSW EPA in the vicinity of the project. The data has been analysed and compared, and the approach adopted for

Issue	Peer Review Comments
plus background) impacts.	selection of the background air quality monitoring dataset for use in the cumulative assessment is considered acceptable. It is noted that the cumulative impact assessment has summed the contributions of the local roads, the ventilation outlets and existing background air quality. This introduces conservatism, as the existing background air quality will be largely defined by the existing road traffic emissions. In addition, background contributions in the 'fresh' air drawn into the tunnel for maintenance of in-tunnel air quality is considered in the ventilation calculations. This adds conservatism to the vent outlet modelling, as the existing background concentrations are added again as part of the cumulative impact assessment. These approaches are likely to over estimate the influence of existing background concentrations, hence it is concluded that a conservative approach has been adopted with respect to the influence of existing background concentrations on the cumulative predictions.
The adopted air quality goals and health risk standards, and suitability for assessment of the risk of impacts.	The air quality goals and criteria adopted in the Appendix H Air Quality Assessment are consistent with the current requirements in NSW and the Commonwealth. In addition, proposed national standards for particulates have been considered. The authors of the Air Quality Assessment have also discussed the issue of ultra fine particles and the use of particulate numbers as an assessment approach. Due to the absence of criteria and goals, and the fact that ultrafines are considered in the Air Quality Assessment as $PM_{2.5}$ includes this size fractions, the Air Quality Assessment has not assessed this issue further. This approach is considered acceptable given the current lack of defined air quality goals and standards for ultra fine particles measured by particle number.
The suitability of the proposed in-tunnel and external monitoring methodologies for determining compliance with typical approval conditions	The proposed monitoring methodologies have not been identified in the air quality assessment. The methodologies would generally be identified in a condition of approval (for example, refer to NorthConnex Instrument of Approval E10). Therefore, the fact that the monitoring requirements are not defined in the Air

Issue	Peer Review Comments
(referencing the NorthConnex approval as a primary example) and external ambient air quality goals.	Quality Assessment is not considered to be a significant omission. It is noted that, if zero portal emissions is to be a condition of approval, this would require monitoring in the outbound portals.
Whether the assessment has been completed in a manner that is consistent with the analysis and recommendations of the Advisory Committee on Tunnel Air Quality.	The Advisory Committee on Tunnel Air Quality made three recommendations in the Interim Report published in July 2014. These relate to completion of further research and assessment of the following key issues: - portal emissions - in-tunnel nitrogen dioxide limits - in-tunnel nitrogen dioxide monitoring The air quality assessment does not consider portal emissions, and assumes that there will be a requirement for no portal emissions as per previous tunnel projects in Sydney. The air quality assessment makes reference to existing in-tunnel nitrogen dioxide goals. Monitoring methods are not specified, however, this would generally be defined in the conditions of approval and not necessarily at the EIS stage. Eleven Technical Papers were prepared to support the Interim Report of the Advisory Committee on Tunnel Air Quality. These present that state of knowledge relating to tunnel related air quality, and do not make specific recommendations.
The suitability of the assessment methodologies adopted for the construction air quality assessment, including review of the modelling inputs and	The construction air quality assessment has not adopted a quantitative approach, and has not included air dispersion modelling of potential impacts.

Issue	Peer Review Comments
assumptions.	
The overall predicted cumulative impact from the project, in conjunction with existing background and emissions from future stages of the WestConnex project. A particular focus will be the proposed co-location of the eastern ventilation stack with the WestConnex Stage 3 ventilation stack.	Specific comments on the approaches adopted in the modelling are presented in Attachment B.
The expected impact on the Marrickville and Leichhardt Local Government Areas both for the overall cumulative project impacts.	The predicted air quality impacts for the Western portion of the M4 East project are most relevant for the Marrickville and Leichhardt Council areas. In particular, the proposed co-location of the M4 East eastern and the M4 – M5 western vent stations are of relevance. The air quality assessment has identified air quality non-compliances may be occurring for the 'do minimum' scenario, and are likely to occur in the future. The modelling of the ventilation stations has considered the two proposed outlets and concluded there will be negligible impacts from the ventilation emissions. Due to the method adopted for the modelling of the ventilation emissions, there is considerable uncertainty associated with the predicted emissions from the ventilation outlets. These concerns are identified in more detail in Attachment B.
The overall conclusions of the assessment and how robust these conclusions are based on the review of the methodologies and assumptions.	Atmospheric dispersion modelling is a complex process that attempts to apply, in a scientific way, estimation and calculation methods to predict extremely complex temporal and spatial processes. Inevitably, assumptions must be adopted and the uncertainty associated with these assumptions is considered by applying validation and sensitivity analysis techniques. The Air Quality Assessment has sought to address specific uncertainties posed by the modelling approaches that have been adopted through analysis of this type. However, there are

Issue	Peer Review Comments
	some aspects of the modelling where it is considered that specific assumptions and approaches have not been fully justified and the uncertainties associated with the method considered. These include the meteorological data inputs, building downwash and emission temperature for the ventilation outlets, averaging of emissions rates across periods of many hours rather than completing hourly cumulative assessments, and the generic meteorological dataset that has been adopted. These variables could significantly affect the outcomes of the dispersion modelling for project specific emissions only, hence would not necessarily result in significant increases in the predicted cumulative concentrations at specific receptors. It is important to recognise that the existing background pollution concentrations (defined by current road traffic emissions) are the dominant feature of the current air quality climate. These emissions are predicted to result in non-compliances for a number of existing near road receptors as well as the same types of receptor for the future modelling scenarios.
The appropriateness of proposed mitigation strategies, and identification of any additional mitigation measures or controls that could further reduce the potential exposure of the local population to air pollution emissions from the project.	Mitigation measures are not proposed for the construction or operational phases of the project. For the construction phase, mitigation is likely to be required with respect to management of dust emissions. As a quantitative assessment has not been completed, there has been no quantification of risk, or development of mitigation solutions. For the operational phase non-compliances are predicted for a number of near road receptors. This is also predicted for the 'do minimum' (ie, the status quo) scenario. Therefore, the mitigation tool of primary relevance will be management of vehicle emissions in the region. This is consistent with the conclusions of the Advisory Committee on Tunnel Air Quality.

Attachment B
Detailed Comments on Appendix H – Air Quality Assessment

Section/Page	**Issue**	**Comment**
Section 2.4.1, Page 19 Figure 2.3, Page 20, Figure 2-4 Page 21, Figure 2-6, Page 22 Section 8.3.6 Page 109 Section 8.7.3, Page 179	'back-to-back' ventilation outlets for M4 East and M4-M5 link projects. Building downwash Interaction of the plumes from the two outlets	The location and indicative layouts are provided for the two ventilation stacks. Elevations showing the heights of the proposed ventilation buildings are not provided. Buildings attached to stacks and vents can cause significant impacts on the effective dispersion of plumes due to turbulence (plume downwash impacts). The height of the ventilation buildings, and other buildings and structures in close proximity to the ventilation outlets (eg, fire water tanks, electrical plant rooms, tunnel operations buildings) are an essential consideration in atmospheric dispersion modelling from tunnel ventilation outlets. This downwash has not been satisfactorily addressed in the EIS Appendix H. As identified in Section 8.3.6 of the Air Quality Assessment, it was impractical to incorporate the building downwash effects in the GRAL model due to run times and the ability to assess the data at an appropriate resolution. A sensitivity analysis of the issue of building downwash is presented in Section 8.7.3 however only the potential influence of existing buildings in the vicinity of the project are considered. The sensitivity analysis identifies a possible increase in predicted concentrations of 50 % based on 24 hour and annual average calculations. The likely difference for 1 hour predictions is not provided, and this is significant for NO_2 which has a 1 hour average and has predicted non-compliances for some RWR receptors. Furthermore, the sensitivity analysis does not consider the proposed ventilation buildings and other project related buildings. This omission is critical for the assessment of the dispersion of emissions from the ventilation outlet – it is the ventilation building that houses the ventilation fans that has the most significant influence on

Section/Page	Issue	Comment
		building downwash. The Air Quality Assessment identifies that the eastern M4 East ventilation outlet and the western M4-M5 ventilation outlet will be located 'back-to-back'. The ventilation outlets are proposed to be different heights – 30.5 m for the M4 East vent and 25.0 m for the M4-M5 vent. The diurnal emission profiles for the vents will also differ. Maximum emissions will occur during the morning for the M4 East vent, and in the afternoon for the M4-M5 vent – this is because the two vents service traffic travelling in different directions. These issues cause additional complexities surrounding the effective dispersion of emissions from the two vents. There is uncertainty surrounding the maintenance of effective dispersion where the two plumes interact, particularly due to the different heights of the emission points, the differing velocities, the potential downwash and, potentially, the slightly different temperatures involved. True co-location of the emissions in a single vent would resolve these issues, and potentially improve dispersion and reduce energy costs for the operation of these tunnels. Operating costs associated with emissions monitoring and management would also be reduced. If co-location of the emission points in a single ventilation outlet is not possible, it is recommended that Computational Fluid Dynamics modelling is completed to assess the issues surrounding the mixing of the two tunnel vent plumes.
Section 2.4.2 Page 23, Section 4.5 Page 35	Portal Emissions	Prevention of emissions of tunnel air via the outbound portals requires operation of jet fans to reverse the flow of air against the traffic. This increases energy costs, and needs to be considered in the context of the overall environmental impact of the project. Portal emission are permitted for some tunnel projects (eg, City Link Melbourne) for off peak periods. However, where there are sensitive receptors in close proximity to tunnel portals, portal emissions can result in elevated pollutant concentrations in the vicinity of the portals.

Section/Page	Issue	Comment
		Therefore, the potential for portal emissions must be considered on a case by case basis. If a zero portal emission condition is included in the approval for the project, in-portal monitoring will be necessary to demonstrate compliance with this requirement.
Section 5.5, Page 42 and Section 7.4 Page 70	Particulate Emissions, construction	Where silica is present in the material being bored, there is potential for crystalline silica emissions to occur during tunnel boring due to the high temperatures caused at the boring face. The potential for crystalline silica to be released is primarily relevant to occupational exposure, however it is considered appropriate to consider this issue in the construction environmental management plan if sensitive receptors are located in close proximity to tunnelling shafts and air extracts.
Section 7	Construction Assessment	The construction assessment does not quantify air quality impacts in terms of predicted concentrations of air pollution. The approach that has been adopted is a risk based semi-quantitative method. It is acknowledged that the specific detailed information relating to the construction works necessary for completing accurate dispersion modelling may not available at the time of preparing an EIS and, even when it is, there are likely to be significant changes during the construction phase as different site constraints are addressed. Previous tunnel EIS (eg, Northconnex) have attempted to quantify the air quality impacts during the construction phase, however, such analyses are reliant on the data available at the time. As a result, the predictions must be considered indicative. For many sensitive receptors, the primary impacts of a major infrastructure project are during the construction phase. Therefore, it is important that the assessment process ensures that, as and when the relevant construction information becomes available, there is an opportunity for assessment by the regulatory authorities and those that may be potentially affected by these impacts. The absence of more detailed construction information in the Air Quality Assessment limits the opportunity for local authorities, regulatory agencies and

Section/Page	Issue	Comment
		potentially affected receptors to consider and comment on this aspect of the project. For the Westconnex M4 East EIS the Noise Impact Assessment (Appendix I) does consider in detail the potential impact of construction noise. This indicates that sufficient data is available to complete an indicative quantitative assessment of the construction air quality impacts.
Section 8.2, Appendix I	Emission rates	Hourly emission rates have not been adopted in the Air Quality Assessment, due to the limitations of the GRAL model. The approach has been to consider average emissions from three time periods in the day (Hours 00 -05, 06 – 17, 18 – 23). The effect of this is to smooth out the variability in the data, with lower emission rates assumed for peak hours, and higher for off-peak hours, within the three time periods adopted. This is not strictly in accordance with the requirements of the NSW EPA 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW' document, for a Level 2 air dispersion modelling assessment. This requires addition of hourly predicted emissions from the source to the corresponding hourly background concentration. The use of averaged emission rates smooths out the variability in the predicted hourly concentrations. This is not considered to be a significant issue where 24 hour average criteria are relevant (eg, for PM_{10} and $PM_{2.5}$). For pollutants with criteria referenced to averaging periods that are less than 24 hours, such as NO_2 and to a lesser extent CO, the smoothing of emissions is likely to result in an underestimate of peak predicted impacts. This variability has not been quantified in the assessment.
Section 6.4, Section 8.3.5, Page 105	Meteorological Data	The model domain for the GRAMM meteorological analysis encompassed the entire WestConnex project area. The reason for this was to allow for consistency with air quality assessments for future sections of the WestConnex project. A single meteorological station is included in the GRAL model due to model limitations.

Section/Page	Issue	Comment
		The GRAMM modelling has adopted 2014 meteorological data from the Canterbury Racecourse AWS station, which is in the centre of the adopted model domain. The Sydney Olympic Park BOM and Rozelle stations are located in closer proximity to the western and eastern ventilation outlets respectively. The low predicted vs measured correlation at the Sydney Olympic Park and Rozelle stations (R^2 = 0.6 and R^2 = 0.45 respectively) introduces additional uncertainty into the modelling predictions for sensitive receivers for the M4 East project due to the use of the Canterbury Race Course meteorological data as opposed to the local datasets.
Section 8.2.3, Table 8-3, Page 90	Road widths	Table 8-3 indicates that the road widths are narrower for Motorways than Highways and Regional Arterials. This appears unusual, and may be a typographic error. However, this is likely to only have a marginal influence on the modelling results unless receptors are in close proximity to the modelled road.
Section 8.3.6, Page 109	Receptors	Both gridded (RWR) and discrete receptors have been considered, as is standard practice for an air quality assessment. However, due to limitations in GRAL, only 31 discrete receptors have been considered in the assessment. These receptors have been selected on the basis of landuses. Detailed analysis of predicted concentrations has been presented in the Air Quality Assessment report for these 31 receptors. Review of the location of the 31 receptors confirms that these represent a range of near road receptors, and specific sensitive receptors that are more remote from the Project. Few receptors are within the 500 m of the ventilation outlets although a number of RWR receptors are included in these areas. Because of this, the 31 discrete receptors are not likely to be representative of the worst case impacts from the ventilation outlets, although the RWR receptors are likely to represent these impacts.

Section/Page	Issue	Comment
Section 8.3.6, Page 116	Outlet Diameters	The eastern VSO and the M4-M5 eastern VSO are identified as having a single outlet diameter. The western VSO is identified as having three outlet diameters. This will require provision of two dampers in the stack however this is not confirmed in Appendix L (Ventilation Report) of the Air Quality Assessment so this design requirement cannot be verified.
Section 8.3.6, Page 116	Vent emission temperatures	Average temperatures were adopted in the modelling for summer and winter. This is an over simplification of reality. Data for currently operating tunnels confirms that there are periods when the tunnel emission temperature is higher than the external ambient air, eg at night in the winter. Conversely, there are significant periods when the emission temperature is lower than the ambient air, eg peak morning periods in the summer. Where the emission temperature is assumed to be higher than the external ambient air, initial plume rise due to buoyancy is accounted for in the model. Where temperature averaging results in specific hours of the day where the temperature should be lower than ambient, but the model adopts a higher than ambient temperature, the predictions may overestimate plume dispersion. The effect of this is to underestimate receptor concentrations. The sensitivity analysis suggests a variability of +/- 50 %, with predicted receptor concentrations 1.5 times higher where the emission temperature is 10 degrees lower than that adopted in the modelling. Again, the loss of resolution in the input data due to the averaging of emission rates and temperatures across 3 periods a day could introduce a higher variability for this parameter.
Section 8.3..6, Table 18	Efflux Velocity	Table 18 confirms that relatively low efflux velocities have been modelled for some periods of the day (as low as 3.3 m/s at night for the M4 East). Both stack tip downwash and building downwash can significantly increase predicted receptor concentrations where the vertical efflux velocity is insufficient to overcome the effect of cross wind conditions above a specific velocity.

Section/Page	Issue	Comment
		As building downwash caused by the ventilation building and other project buildings has not been considered in the modelling, there is considerable uncertainty associated with adoption of the low efflux velocities for the night time period in particular, and much higher predicted receptor concentrations (ventilation outlet only) could be expected as a result.
Section 8.3.7, Table 8-2, Page 117	M5 East Ventilation Outlet Temperature	A constant temperature of 30 degrees has been adopted based on the annual average of the data reviewed for the purposes of the Air Quality Assessment. As noted previously, application of an average temperature will over estimate dispersion for some periods, and underestimate dispersion for others. The sensitivity analysis suggests a variability of +/- 50 %. It is noted that the M5 East ventilation outlet is somewhat unusual, as the emissions from the tunnel are transported via an underground duct over a distance of a few hundred metres prior to discharge via the stack. This may result in differing temperature variability than compared to other tunnels in Sydney.
Section 8.3.7 and Table 8-21 and 8-22, Page 118	Regulatory worst case scenario emission rates	The regulatory worst case scenario has not presented the results for the maximum permitted emission rates in g/s, as only a 'medium case scenario' is presented. The assessment notes that an alternative 'high' and 'low' emission scenario were tested and gave 'very similar' results. If the high emission rate scenario was adopted, the mass emission rates presented in Table 8-22 would be significantly higher. The higher volumetric flow rates would be expected to result in improved dispersion of emissions, however presentation of the modelling results for the worst case “polluting to the limit” scenario is considered appropriate from a transparency perspective. If the NorthConnex licence conditions are mirrored in the approval for the M4 East project, there will need to be continuous monitoring of emissions via a process control system. When emissions from the ventilation outlet approach the licence limits, traffic management measures will need to be implemented to prevent emissions

Section/Page	Issue	Comment
		exceeding the licence limits.
Section 8.3.7, Table 8-22, Page 118	Outlet temperature	A constant temperature of 25 degrees has been adopted based on the annual average of the data reviewed for the purposes of the Air Quality Assessment. As noted previously, application of an average temperature will over estimate dispersion for some periods, and underestimate dispersion for others. The sensitivity analysis suggests a variability of +/- 50 %.
Section 8.4.4, Pages 138 - 140	One hour NO_2 predictions	The one hour predicted NO_2 results are presented for the 31 community receptors; the cumulative predicted concentrations are within the overall limit of 246 µg/m^3, but at or above 200 µg/m^3 in all cases. The surface roads were the biggest contribution. For the RWR receptors, there are predicted exceedances of the 1-hour NO_2 criterion for a significant number of near road receptors. The NO_x/NO_2 conversion rates adopted in the assessment are based on an empirical formula developed specifically for the WestConnex project area. Different conversion rates were adopted for prediction of hourly and annual average concentrations. The adoption of alternative methods is permitted in the NSW EPA 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW', subject to appropriate detailed scientific assessment. The method adopted in the Air Quality Assessment appears valid, however it is noted that the approach is likely to be more accurate for the emissions from the road based sources than the ventilation outlets, as the monitoring data used to determine the empirical relationship is primarily defined by vehicle emissions. As the road based emission sources are the dominant source in the project area, this assumption is considered reasonable.
Section 8.5, Table 8-27,	Regulatory Worst Case	The predicted 1-hour NO_2 concentrations, ventilation outlets only, are likely to result in exceedance of the

Section/Page	Issue	Comment
Page 171	Scenarios	criterion of 246 µg/m^3 when combined with background and surface road emissions for the regulatory worst case scenarios. The extent of this has not been quantified. This is of particular relevance if operational traffic is significantly higher than projected, and the tunnel emissions routinely approach the expected licence limits. In simple terms, based on this modelling, the project as proposed could result in regular and extensive exceedance of the 1-hour NO_2 criteria if the project operates at significantly higher traffic flows than have been considered as the normal operating scenario.
Section 8.7.1, Page 178	Outlet Temperatures	The sensitivity analysis identifies a factor difference of around 1.5 if the temperature is 10 degrees lower than the average of 25 degrees assumed in the modelling. Therefore, for peak morning periods in the summer when the external temperature could be 10 degrees higher than the tunnel emissions, predicted one hour concentrations could be 50 % higher for the tunnel ventilation emissions. The analysis presented in the assessment considers the impact of temperature changes on 24 hour average predictions only. The differences on 1 hour predictions for NO_2 are not presented. The predictions for this pollutant exceed the assessment criteria for some RWR receptors, and the pollutant that is closest to the regulatory limit for the discrete receptors. Therefore, analysis of the impact on 1-hour predicted concentrations is considered essential to determine the sensitivity of the modelling to this assumption.