West Gate Tunnel Project

Report of Dr Jackie Wright

1 Introduction

Environmental Risk Sciences Pty Ltd (enRiskS) prepared the technical report titled West Gate Tunnel Project: Technical Report J – Human Health Impact Assessment (**Technical Report**) which is included as Technical Report **J** to the Environment Effects Statement (**EES**) for the West Gate Tunnel Project (**Project**)

The role that I had in preparing the Technical Report was as the author.

I adopt the Technical Report, in combination with this document, as my written expert evidence for the purposes of the West Gate Tunnel Project Inquiry and Advisory Committee's review of the EES, draft planning scheme amendment and works approval application.

2 Qualifications and experience

Appendix A contains a statement setting out my qualifications and experience, and the other matters raised by Planning Panels Victoria 'Guide to Expert Evidence'.

A copy of my curriculum vitae is provided in Appendix B.

3 Further work since preparation of the Technical Report

Since the Technical Report was finalised, I have not undertaken any further work in relation to the matters addressed in the Technical Report relevant to the Project.

4 Written Submissions

4.1 Submissions Received

I have read the public submissions to the EES, draft planning scheme amendment and works approval application and identified those that are relevant to the Technical Report and my area of expertise. These include the following submissions:

3, 4, 7, 23, 34, 45, 52, 56, 57, 62, 65, 71, 73, 81, 82, 83, 86, 88, 93, 95, 96, 98, 101, 104, 105, 111, 119, 122, 124, 129, 134, 139, 143, 144, 147, 151, 152, 155, 156, 157, 158, 162, 165, 166, 168, 169, 171, 175, 178, 182, 183, 190, 192, 198, 201, 202, 205, 213, 215, 217, 218, 220, 221, 225, 226, 228, 229, 230, 232, 233, 245, 249, 250, 251, 256, 268, 270, 277, 278, 279, 286, 288, 289, 293, 297, 298, 301, 305, 307, 314, 319, 326, 334, 336, 337, 339, 340, 343, 346, 348, 349, 351, 352, 353, 359, 362, 364, 366, 372, 374, 375, 378, 380, 385, 390, 399, 400, 401, 403, 404, 405, 406, 407, 408, 409, 412, 413, 416, 418, 428, 432, 434, 439, 443, 449, 450, 453, 454, 455, 457, 458, 465, 467, 470, 475, 477, 478, 480, 481, 482, 483, 484, 485, 488, 490, 491, 492, 493, 494, 496

4.2 Summary of Issues Raised

The submissions have raised the following issues relevant to my area of expertise (also refer to Section 4.3 for additional details on these isses):

Issues raised:	**Submissions**
Adequacy of human health methodology and modelling, including: • Assessing impacts close to the freeway and tunnels • Focus of conclusions on positive impacts • Use of qualitative and quantitative measures • Consideration of other health outcomes • Assessment of hospital data for children aged 0-5 years • Conservative assessment for lung cancer • Currency of population data and health studies considered in the assessment • Consideration of ozone and ultrafine particulates • In-tunnel assessment of particulates • Assessment of "road-side" asthma • Concerns the risks to human health have been underestimated No assessment of tunnel filtration, cost benefits, measures to mitigate existing air quality, noise issues or health impacts	71, 83, 158, 169, 190, 270, 278, 326, 340, 346, 349, 351, 364, 378, 401, 403, 405, 432, 449, 458, 477
Concerned about health impacts during construction, in relation to concerns about respiratory health and mental health	124, 182, 339
Concerns about air quality impacts at sensitive locations such as schools, kindergartens, recreational areas and aged care facilities. In addition, concerns were also raised in relation to not assessing precautionary measures or risk reduction measures.	4, 57, 65, 95, 98, 105, 119, 139, 143, 151, 171, 183, 192, 213, 215, 217, 225, 230, 268, 270, 279, 286, 288, 297, 305, 307, 314, 326, 336, 339, 340, 346, 348, 349, 351, 352, 353, 372, 374, 399, 400, 401, 403, 406, 407, 409, 428, 432, 439, 458, 470, 478, 496
Concerns about health and safety of children due to trucks on suburban streets	56, 293, 406, 408, 432
Concerns about predicted change in health risks, specifically in relation to the following: • Changes in traffic and particulate matter exposures • Impact on individual or family members with pre-existing health conditions • Assessment of a wider range of health effects	3, 7, 23, 52, 57, 62, 65, 73, 81, 82, 88, 96, 98, 104, 111, 119, 129, 143, 144, 147, 151, 152, 155, 156, 157, 166, 168, 169, 171, 175, 215, 226, 229, 245, 256, 279, 288, 293, 326, 337, 340, 346, 348, 349, 351, 362, 366, 372, 375, 378, 380, 385, 390, 406, 412, 413, 416, 432, 434, 443, 450, 458, 467, 475

Issues raised:	Submissions
• Psychological effects of changes in green space • Impacts on the health of workers Impacts on health care costs	
Concerns about the existing impact of the project on health and livelihood, particularly in relation to children	192, 228, 232, 233, 343
Concerns about types of population impacted, including children, the elderly and those with pre-existing health conditions, or from low-socioeconomic areas.	4, 34, 57, 62, 65, 86, 98, 122, 134, 139, 151, 168, 171, 198, 215, 225, 249, 288, 293, 319, 334, 337, 339, 340, 351, 352, 353, 359, 399, 400, 406, 432, 454, 470, 478, 496
Existing human health (prevalence of existing health conditions such as respiratory conditions and lung cancer) and concern about impacts on these health conditions.	34, 45, 81, 88, 93, 101, 105, 162, 165, 178, 183, 198, 201, 202, 205, 215, 218, 220, 221, 230, 249, 250, 251, 277, 279, 288, 289, 298, 301, 314, 319, 339, 340, 343, 346, 349, 351, 362, 366, 374, 375, 403, 404, 418, 432, 453, 454, 455, 457, 458, 465, 467, 470, 475, 480, 481, 482, 483, 484, 485, 488, 490, 491, 492, 493, 494
Request for compensation due to healthcare costs from increase in respiratory disease and asthma	166

4.3 Response to Issues Raised

Set out below are my comments and response to the issues raised by the written submissions relevant to the area of my expertise.

Issues raised	Submissions	Response
Adequacy of human health methodology and modelling		
General concern about the adequacy of the human health methodology and modelling, including the need to assess impacts close to the freeway and in tunnels	158, 278, 349, 401	The methodology adopted for the assessment of health impacts from the project follows on from and has adopted the methodology used to assess health impacts from similar projects in Sydney, specifically NorthConnex and WestConnex (M4 East and New M5), as well as the Moorebank Intermodal Terminal. In relation to impacts associated with changes in air quality, the methodology was developed for the above projects in direct consultation with key health professionals in NSW Health and Dr Patrick Harris, author of the CHETRE (2007) guidelines for conducting Health Impact Assessments in Australia. The methodology developed through this process in NSW, specifically relates to assessment health impacts from transport infrastructure projects. There is no detailed guidance on the conduct of similar health impact assessment in Victoria. As the vehicle fleet (and hence air emissions and noise sources) is expected to be consistent in Sydney and Melbourne, as well as the general population present in urban areas, the methodology developed in NSW for these transport infrastructure projects is considered to be relevant and applicable to this project. In Victoria. The report has been reviewed by Dr Andrew Buroni as part of WDA report checking process. Dr Andrew Buroni is an international expert on the assessment of health impacts, who has considerable experience with the assessment of health impacts from a wide range of transport projects. The report has considered health impacts that specifically include impacts at properties located directly adjacent to the freeway as well as inside the tunnel (refer to Section 6 of the report).
Concern about focus of assessment conclusion on positive impacts	158	The purpose of a Health Impact Assessment is to assess both positive and negative health impacts associated with the project (refer to Section 3.2 of the report). In addition, where all impacts on community health are considered, particularly for noise, the project results in some overall benefits to health (albeit small). The negative impacts have also been assessed in detail and constitute much of the assessment presented.
Qualitative and quantitative measures should be applied to assess impacts on human health	378	The report has used both quantitative and qualitative methods for the assessment of health impacts, as is outlined in Section 3.2 of the report.
A number of health outcomes have been omitted, including strokes, respiratory emergency admissions, cognitive impairments, birth outcomes and diabetes. There are meta-analyses that provide risk estimates	326, 378, 405, 432	The quantitative assessment of health impacts has considered changes in air quality (Section 6 of the report) and noise (Section 7 of the report). For the assessment of health impacts from changes in air quality, the health endpoints considered were based on the use of robust studies and relationships (refer to Sections 6.8 and 6.9 of the report). These were identified through detailed discussions with NSW Health for road projects in NSW. The health endpoints considered were grouped as primary

Issues raised	Submissions	Response
		indicators and secondary indicators in line with health authorities. Primary indicators are based on the most robust studies that are encompassing of a wide range of health effects that affect mortality (all causes) and hospitalisations for cardiovascular and respiratory disease. The secondary health effects are subsets of the primary health indicators, but include more specific aspects such as asthma. Other studies are available that look at more specific health effects. Not all of these are considered to be robust or suitable for consideration in a quantitative assessment (despite study authors developing exposure-response relationships) by health authorities. Health effects like stroke are already captured in the health endpoints considered in the report. The health endpoints for aspects such as diabetes, cognitive impairments and birth weights are not sufficiently robust at this stage. It should also be noted that it is not appropriate to include quantification of risks for all health effects evaluated in the literature. Many of these types of publications evaluate a range of potential associations and relationships without consideration of causation, and without ensuring effects may be relevant for road traffic emissions so they are not considered suitable. The assessment of health impacts from changes in noise (refer to Section 7.4 of the report) has considered a range of cardiovascular and mortality health effects, that includes stroke. As discussed above, these health effects were selected based on robust studies where causation between road noise and these health effects was proven. All the health effects considered\quantified have been reviewed and considered appropriate, by Dr Andrew Burtoni (the international independent reviewer for the report) during the development of the report.
No consideration of data from hospital admissions for children 0-5 years or pre-schoolers	405, 432	The quantitative relationships used to assess health impacts in the community did not use any relationships that specifically related to children aged 0-5 years (refer to Sections 6.8 and 6.9 of the report). The relationships for this age-group are less robust and not suitable for use. Health effects for this age-group are included in the assessment of health effects over all ages.
Risk estimate for lung cancer is too conservative	378	It is agreed that the approach adopted for the assessment of lung cancer risk as discussed in Appendix D of the report is highly conservative (i.e. has overestimated the risk). However insufficient detail is available from the air modelling to determine what proportion of all the $PM_{2.5}$ emissions modelled from all the vehicles would be diesel particulates (the measure that is associated with lung cancer). As a result, the assessment of risk could not be further refined. The submission implies that the assessment used risk estimates from 1996. This is not correct as the assessment has calculated lung cancer risks based on modelled changes in $PM_{2.5}$ specific for the project. The inhalation unit risk adopted for the assessment is discussed further in Appendix D of the report. Thee inhalation unit risk was published by the WHO in 1996, however, as discussed in Appendix D of the report it remains relevant and suitable for the quantification of lung cancer risks.

Issues raised	Submissions	Response
Population data used is not the most recent or best available	378	The population data included in Section 5 the report was the data that was publicly available at the time the assessment was undertaken (2016-2017). Additional data was requested from various Victorian departments to supplement publicly available information, however no additional data was provided. The data used in the report was discussed with the EPA and DHHS and was considered the most current publicly available data.
Health Atlas data for air quality and asthma should be considered	458	Data from the Health Atlas has been included in the report, as referenced in Section 5 of the report.
Ground level ozone not included	326, 378	Ozone was not considered, as it is not considered to be a key local air pollutant relevant to the project. As ozone is a secondary pollutant (formed from precursors NOx and volatile organic compounds) it is a regional issue that cannot be predicted in a local area from localised sources. Assessment of the precursors, namely NOx and volatile organic compounds is of most relevance to local health and these have been assessed in this report.
No consideration of ultrafines. One submission (378) recognises that a quantitative assessment is not possible but wanting consideration of mitigation	169, 270, 378, 405	The report has provided discussion on the assessment of ultrafine particulates (including PM_1) and health (refer to Section 6.9.1 of the report). It is agreed that health effects associated with ultrafine particulates is a growing area of research. However, health effects related to all particulates from vehicle and truck emissions are already incorporated in the epidemiology studies that underlie the exposure-effects relationships used to quantify health impacts. The measure of $PM_{2.5}$ is used as an indicator of the level of community exposure from these urban sources. As this is a growing area of research, there are no guidelines for the assessment of ultrafines in the community (as air quality guidelines or as health based guidelines), and as a result there is no basis for making decisions on whether mitigation measures to address ultrafines should or should not be considered.
In-tunnel only considers CO and NO_2 Health impacts for particulates in-tunnel not assessed	378, 405	The in-tunnel assessment of health is presented in Section 6.10 of the report. As the amount of time spent in the tunnel is short, it is important the assessment of potential health effects relates to very short duration exposures. The available health studies allow an assessment of these very short duration exposures to CO and NO_2. However, there is no quantitative data available to enable establish guidelines for very short duration exposures to particulates inside the tunnel. The report presents a qualitative discussion on the health effects associated with short-duration exposures to particulates relevant to exposure in the tunnel.
No consideration of "road side asthma" – there is evidence of this both domestic and international	340, 351, 378	Asthma is included in the report as a key health effect where risks to community health have been quantified (refer to Section 6.9.5 of the report). The assessment has also considered changes in air pollution adjacent to key roadways, where impacts to health (including asthma) have been evaluated.
Concern that human health impacts have been underestimated. A specialist health literature review	340, 351, 346	The methodology adopted for the assessment of health impacts from the project follows on from and has adopted the methodology used to assess health impacts from similar projects in Sydney, specifically NorthConnex and

Issues raised	Submissions	Response
should be undertaken by relevant professionals. One submission (346) indicates the review should focus on the health of children attending the Emma McLean Kindergarten and Donald McLean Reserve		WestConnex (M4 East and New M5), as well as the Moorebank Intermodal Terminal. In relation to impacts associated with changes in air quality, the methodology was developed for the above projects in direct consultation with key health professionals in NSW Health and Dr Patrick Harris, author of the CHETRE (2007) guidelines for conducting Health Impact Assessments in Australia. The methodology developed through this process in NSW, specifically relates to assessment health impacts from transport infrastructure projects. There is no detailed guidance on the conduct of similar health impact assessment in Victoria. As the vehicle fleet (and hence air emissions and noise sources) is expected to be consistent in Sydney and Melbourne, as well as the general population present in urban areas, the methodology developed in NSW for these transport infrastructure projects is considered to be relevant and applicable to this project. In Victoria. The report has been reviewed by Dr Andrew Buroni as part of WDA report checking process. Dr Andrew Buroni is an international expert on the assessment of health impacts who has considerable experience with the assessment of health impacts from a wide range of transport projects. The report does not include a detailed literature review of all available publications, as this was outside the scope of works and was not considered to be necessary as the methodology and approach adopted (as described above) was considered to be appropriate and had been reviewed by appropriate experts. The approach adopted in the report has considered health impacts relevant to all members of the community, including children at the Emma McLean Kindergarten and Donald McLean Reserve. It should also be noted that there are a range of other factors inherent in the characterisation of risk that are highly conservative as outlined in Section 9 of the report.
No consideration of most recent studies or any evidence or data published since 2012	340, 349, 351, 326	The quantitative assessment of health impacts has considered changes in air quality (Section 6 of the report) and noise (Section 7 of the report). For the assessment of health impacts from changes in air quality, the exposure-response relationships considered were based on those from robust studies and relationships (refer to Sections 6.8 and 6.9 of the report). These are referenced in the report. While many of these relate to studies that were undertaken up to 2013, this does not mean that more recent studies were not evaluated. No more recent studies provide more robust exposure-response relationships and have therefore not been included. The report does not present a detailed literature review of all published studies as this was not in the scope of works, nor was it considered necessary. The report does include discussion of other reviews conducted in Australia to 2016. In relation to the assessment of health impacts from noise, this has included references to key studies relevant to the quantification of these impacts (refer to Section 7.4 of the report). The studies include a number published in 2014 and 2015 and are considered to be robust and current.
Lack of consideration of	326	The assessment of health impacts associated with changes in

Issues raised	Submissions	Response
tunnel filtration or pollution barriers, and lack of cost benefit analysis for these aspects to offset health costs		air quality is presented in Section 6 of the report. This includes changes in air quality as a result of vehicles and trucks using the tunnel, and these emissions being discharged to air through the ventilation facilities. This assessment did not identify any health impacts of concern for any member of the community. Hence there is no need to consider any mitigation measures such as tunnel filtration. In addition, there is no trigger (i.e. the potential for unacceptable health risks) to conduct any detailed cost benefit analysis of any mitigation measures.
Lack of cost benefit analysis for installing filtration Should consider cost benefit analysis of the project and similar projects	326, 71, 83 449	
Use of outdated air quality data	326, 340, 351	The air quality data presented and considered in the report is based on information and data provided in the EES Technical Report G Air Quality.
Concern no epidemiological study has been mandated	364	The report did not identify any health impacts of concern and hence there is no need to undertake any more detailed health evaluations. The conduct of epidemiology studies is complex and these studies are challenging to interpret. They also require a very large population to be exposed to enable statistically valid outcomes to be evaluated/determined. The population in the local community, relevant to the project, is very small, and would make such a study more complex. It would not be suitable to recommend such studies where no measurable health impacts are identified.
EES does not examine solutions to mitigate health impacts	270, 403	The report did not identify any health impacts of concern and hence there is no need to consider any mitigation measures.
Outcomes that the project will not contribute to already bad air and noise pollution is not reassuring	349	The report addresses impacts associated with the project and has focuses on changes in air quality (Section 6 of the report) and noise (Section 7 of the report), related to the project. The existing air and noise environment are also discussed. However, the focus of the report relates to impacts from the project.
Health assessment conflicts with evidence that additional road capacity results in increased usage of private vehicles, which will exacerbate deterioration in health	190	The report is based on traffic modelling that includes consideration of the increased number of vehicles that may use the project, once completed, due to the increased capacity. These traffic predictions are incorporated in the modelling of changes in air quality (Section 6 of the report) and noise (Section 7 of the report). The changes in air quality and noise have then been evaluated in the report, in terms of impacts to community health. As a result, the change in traffic, associated with increased capacity, has been considered in the report.
Modelling underestimates health risks	432	The submission discusses the assessment of health risks from exposure to $PM_{2.5}$ and PM_{10}. There is no disagreement that exposure to $PM_{2.5}$ and PM_{10} causes a range of adverse health outcomes within the community. The submission provides a range of other published studies that show a range of different exposure-response relationships, for the health endpoints address in the report. In addition, the submission provides relationships for other health endpoints. For the assessment of potential health impacts from one specific project, it is not appropriate to use all published exposure response relationships. Specifically, exposure-response relationships from small studies like those listed are subject to high levels of bias. Many of the relationships suggested in the submission relate to studies undertaken on

Issues raised	Submissions	Response
		very small populations. The focus of the report has been to adopt robust relationships that address a range of key/primary health effects and selected secondary effects. Robust studies are those where: • the population size considered is high enough to provide statistically sound data (a minimum of a few hundred thousand people is generally required); • the study has appropriately identified and adjusted for confounding factors (such as socioeconomic factors, lifestyle factors and choices such as smoking, and presence of localised industrial type emissions); • do not involved bias in the selection and evaluation of the population and data; and • the relationships identified can be considered to be causal, where measures such as the Bradford Hill criteria (for assessing causation) are applied. The methodology adopted for the assessment of health impacts from the project follows on from and has adopted the methodology used to assess health impacts from similar projects in Sydney, specifically NorthConnex and WestConnex (M4 East and New M5), as well as the Moorebank Intermodal Terminal. In relation to impacts associated with changes in air quality, the methodology was developed for the above projects in direct consultation with key health professionals in NSW Health and Dr Patrick Harris, author of the CHETRE (2007) guidelines for conducting Health Impact Assessments in Australia. The methodology developed through this process in NSW, specifically relates to assessment health impacts from transport infrastructure projects. There is no detailed guidance on the conduct of similar health impact assessment in Victoria. As the vehicle fleet (and hence air emissions and noise sources) is expected to be consistent in Sydney and Melbourne, as well as the general population present in urban areas, the methodology developed in NSW for these transport infrastructure projects is considered to be relevant and applicable to this project. In Victoria. The report has been reviewed by Dr Andrew Buroni as part of WDA report checking process. Dr Andrew Buroni is an international expert on the assessment of health impacts who has considerable experience with the assessment of health impacts from a wide range of transport projects. Regardless of the above, the following should be considered: • the report (refer to Section 6.9.5 of the report) has calculated low incremental risks associated with changes in air quality as a result of the project. • If more conservative exposure-response relationships were adopted for the assessment of the health effects presented, this would result in increased risks for both positive (benefits) and negative (disbenefits). • Even if the relative risks adopted in the report were doubled, i.e. 200% of those considered in the report, the calculated maximum incremental risk remains acceptable. Hence where robust studies are considered

Issues raised	Submissions	Response
		(not associated with small populations and bias) the small differences in relative risks that come from these studies (where the difference is much less than 200%) does not change the outcomes of the assessment presented in the report for exposures to $PM_{2.5}$ and PM_{10}. It should also be noted that there are a range of other factors inherent in the characterisation of risk that are highly conservative as outlined in Section 9 of the report. It should also be emphasised that the report relates to health impacts from changes in air quality for a road project. The changes in air quality relate to the re-distribution of vehicle and truck emissions that occur as a result of the project. The emission sources already exist in the community, and would continue to be present regardless of the project.
Concerned about health impacts during construction		
General concern, concerns expressed in relation to increased particulate matter, concerns about respiratory health and mental health impacts if people play less sport or are less socially engaged	124, 182, 339	The concerns raised in these submissions, in relation to impacts during construction works on community health, have been addressed within the report, as follows: • Sections 6.4 and 6.5 of the report has addressed air quality impacts • Section 7.3.1 of the report has addressed impacts from noise and vibration • Section 8 of the report has addressed impacts on the community from changes in traffic, green space and community cohesion.
Concerns about air quality impacts at sensitive locations such as schools and kindergartens		
General concerns expressed in relation to air quality and impacts to health at sensitive receptors including schools, kindergartens, recreational areas and aged care facilities. Some submissions have identified specific premises that include: • Shine Early Learning Kindergarten • Annunciation Primary School • Clare Court Children's Services • Emmanuel College • Marina Aged Care • Schools and play areas in Brooklyn • Emma McLean Kindergarten • Spotswood Primary School • Donald McLean Reserve • Westgate Golf Club • Planned children's	4, 57, 65, 98, 105, 119, 139, 143, 151, 171, 183, 192, 213, 215, 217, 225, 268, 270, 286, 288, 297, 305, 307, 314, 326, 336, 339, 340, 346, 348, 349, 351, 352, 353, 372, 374, 399, 400, 401, 403, 406, 407, 428, 439, 458, 470, 478, 496	The assessment of health impacts associated with changes in air quality is presented in Section 6 of the report. This assessment has included the assessment of health impacts at a large number of representative sensitive receptors that include schools, childcare centres, recreational areas and aged care facilities. The full list of sensitive receptors evaluated is included in Section 5.1 and Appendices F and G of the report. In addition to all of these individual sensitive receptors, the assessment of health impacts has considered the locations where the greatest increase in air quality is predicted to occur across the whole study area. The assessment of maximum impacts has assumed that any member of the community, including sensitive groups such as children or the elderly, are at that worst-case location 24 hours per day, every day of the year. Health impacts at all other locations (including all other residential, childcare, school, aged care and recreational areas) are lower than the maximum. To assess health impacts close to major roadways, changes in air quality next to a number of major roadways have also been assessed. This assessment has also assumed that any member of the community, including sensitive groups such as children or the elderly, are at these locations 24 hours per day, every day of the year. This approach is specifically designed to ensure that all health impacts, by all members of the community including sensitive groups, regardless of land use or changes in land use are addressed in a conservative manner.

Issues raised	Submissions	Response
centre at Francis Street and Williamstown Road • Yarraville West Primary School • Brooklyn Reserve • The Avenue in Spotswood		Following this approach, the report did not identify any health impacts of concern for any members of the community.
Concerns about an increase in air pollution for local residents, schools, childcare and aged care facilities where $PM_{2.5}$ and PM_{10} have been linked with reduced lung function, asthma, cancer and reduced life expectancy.	279	The report (refer to Section 6.9 in the report) has addressed these specific health effects associated with exposures to $PM_{2.5}$ and PM_{10}, for the whole community including sensitive groups.
West Gate Tunnel Project needs to take a precautionary approach and actively reduce impacts on communities in the project area, particularly the impacts on children	95	The report has presented a detailed assessment of health impacts relevant to all members of the community including children. The assessment conducted has adopted a range of conservative assumptions to ensure that the health impacts assessed are overestimated (refer to discussion in Section 9 of the report). There are no health impacts of concern identified in the report and hence there is no need to further consider precautionary measures or any other specific risk reduction measures including air filtration on specific buildings or buffer distances.
Suggest adopting policies from California EPA regarding protecting children.	432	
Install air filters and other protection measures in affected childcare, kindergartens and schools.	230	
Should be a buffer distance for trucks near childcare sentences and Donald McLean Reserve and Emma McLean Kindergarten	409	
Concerns about health and safety of children due to trucks on suburban streets		
General concerns raised in relation to the health and safety of children due to the presence of truck on suburban streets, including children walking to school.	56, 293, 406, 408, 432	The report includes a short discussion of public safety in Section 8.2 of the report. A more detailed assessment of traffic safety issues is addressed within the EES Technical Report A Transport.
Concerns about predicted change in health risks		
General concerns raised in relation health impacts from the proposed project, in particular changes in traffic (particularly trucks) and air quality, specifically $PM_{2.5}$ and PM_{10}. Some submissions have identified specific areas of concern	3, 23, 52, 57, 62, 65, 73, 81, 82, 88, 96, 98, 104, 111, 119, 129, 143, 144, 147, 151, 152, 155, 156, 157, 166, 168, 169, 171, 175, 215, 226, 245, 288, 293, 326, 337, 346, 348,	The assessment of health impacts associated with changes in air quality is presented in Section 6 of the report. This assessment is based on the predicted change in traffic, including changes on key local roadways. The project results in a redistribution of traffic in the area. This redistribution of traffic results in a redistribution of the emissions from these vehicles and trucks and changes in air quality. There are no new sources of particulates being introduced by this project. The report has assessed the changes in air quality, including

Issues raised	Submissions	Response
including Millers Road in Brooklyn, Melbourne Road Spotswood, Williamstown Road, Geelong Road and Hyde Street	349, 358, 372, 378, 380, 385, 390, 406, 416, 434, 450, 458, 467, 475	$PM_{2.5}$ and PM_{10}, and the potential for these changes to adversely affect the health of the community. The assessment of health impacts associated with changes in air quality has considered a large number of sensitive receptors (childcare centres, schools, aged care and recreational facilities) as listed in Section 5.1. In addition to these sensitive receptors, the assessment of health impacts has considered the locations where the greatest increase in air quality is predicted to occur across the whole study area. The assessment of maximum impacts has assumed that any member of the community, including sensitive groups such as children or the elderly, are at that worst-case location 24 hours per day, every day of the year. Health impacts at all other locations (including all other residential, childcare, school, aged care and recreational areas) are lower than the maximum. To assess health impacts close to/adjacent to major roadways, changes in air quality next to a number of major roadways have also been assessed (refer to Tables 6.9, 6.14 and 6.15 in the report). This has included Millers Road in Brooklyn, Williamstown Road, Geelong Road and Hyde Street, Identified in specific submissions. Melbourne Road was not specifically addressed in relation to changes in air quality and as a result no changes in health risk have been presented in the report. Other key roadways assessed include the West Gate Freeway, Francis Street, Whitehall Street, Footscray Road, Dynon Road, Moore Street, Buckley Street and Blackshaws Road. This assessment has also assumed that any member of the community, including sensitive groups such as children or the elderly, are at these locations 24 hours per day, every day of the year. This approach is specifically designed to ensure that all health impacts, by all members of the community including sensitive groups, regardless of land use or changes in land use are addressed in a conservative manner. Following this approach, the report did not identify any health impacts of concern for any members of the community.
Specific concerns in relation to the impact of the project on an individual's health or the health of their family	443, 256	
Specific health concerns raised in relation to exposures to particulate matter including cancer, reduced life expectancy, development of asthma, increased asthma risks, thunder asthma, respiratory illness, cognitive impairment, type 2 diabetes, developmental and reproductive effects	229, 340, 351, 375, 362, 412, 413, 432	The assessment of health impacts presented in the report has addressed a wide range of health effects related to changes in air quality (Section 6 of the report) and noise (Section 7 of the report). The assessment has included detailed calculations of risk for health effects where robust, peer-reviewed, studies are available that show a causal link between exposure and a specific health effect. Not all published studies that show some association between exposure to air pollution or noise and health effects are robust or suitable for use in quantifying risk. An association is not the same as causation. It is important that studies that show that exposure to the air pollutant evaluated causes the health effect are used, and that the study is large enough and robust enough to provide a way of quantifying these health effects. The assessment of changes in air quality (refer to Section 6 of the report) has considered reduced life expectancy, cancer, respiratory and cardiovascular effects and asthma. The assessment of changes in noise (refer to Section 7 of the report) has considered cardiovascular effects, reduced life

Issues raised	Submissions	Response
		expectancy, annoyance and sleep disturbance. Other effects such as cognitive effects have been discussed in relation to road traffic noise.
Psychological effects of the removal of trees adjacent to West Gate Bridge	337	The report has included a qualitative discussion on the effects of changes in green space on the community, including changes in stress and anxiety, refer to Section 8.4 of the report.
Impacts on workers and employees and the need to undertake baseline worker health tests and compensate for impacts on worker health from changes in air quality and noise	7	The assessment of health impacts associated with changes in air quality (Section 6 of the report) and noise (Section 7 of the report) on the community is presented in the report. The assessment has focused on the more sensitive receptors including residential, childcare, schools, aged care and recreational areas. This assessment provides a conservative assessment of health impacts for workers. Based on the assessment undertaken there are no health impacts of concern and hence there would be no health impacts that would be measurable in any population including workers.
Concerns about increases to public health expenditure and future health problems as a result of increased pollution	279	The assessment of health impacts included an assessment of changes in air quality (Section 6 of the report) and noise (Section 7 of the report) throughout the community and if these changes may result in any measurable increase in the incidence (number of people) of the health effects evaluated. Within the community, the changes in air quality (refer to Section 6 of the report) does not result in any measurable increase in the incidence of health problems in the community. The changes in noise (refer to Section 7 of the report) result in small decrease in the incidence of health problems. As a result, no significant or measurable health care costs are expected to be associated with the project.
Concerns about the existing impact of the project on health and livelihood		
General concerns have been raised in relation to health impacts of the project. More specifically these concerns relate to health effects on children in the inner west, carcinogenic effects from diesel exhaust, asthma and emotional stress and hardship.	192, 228, 232, 233, 343	The report has assessed impacts of the project on the health of the community, including sensitive groups such as children (refer to Section 5.1 of the report). The report has considered a wide range of health effects that include asthma and carcinogenic effects from diesel exhaust (refer to Section 6 of the report). In addition, the report has considered how the project may affect the wellbeing of the community, including issues that affect stress and anxiety levels (refer to Section 8 of the report). The report did not identify any health impacts of concern within the community. In addition, the assessment did not identify any measurable impacts on the incidence of health problems within the community. As a result, no significant or measurable health care costs are expected to be associated with the project
Concerns about types of population impacted		
General concerns raised about the populations who may be impacted by the project, with children (including families and those at childcare centres and in schools), the elderly and those with pre-existing health conditions	4, 57, 65, 86, 98, 112, 134, 139, 151, 168, 171, 225, 249, 288, 293, 319, 334, 339, 340, 351, 352, 353, 359, 399, 400, 406, 432, 470, 478, 496,	The assessment of health impacts associated with changes in air quality is presented in Section 6 of the report. This assessment has included the assessment of health impacts at a large number of representative sensitive receptors that include schools, childcare centres, recreational areas and aged care facilities. The full list of sensitive receptors evaluated is included in Appendices F and G of the report. In addition to these sensitive receptors, the assessment of

Issues raised	Submissions	Response
highlighted as particular populations of concern.		health impacts has considered the locations where the greatest increase in air quality is predicted to occur across the whole study area. The assessment of maximum impacts has assumed that any member of the community, including sensitive groups such as children or the elderly, are at that location 24 hours per day, every day of the year. Health impacts at all other locations (including all other residential, childcare, school, aged care and recreational areas) are lower than the maximum. To assess health impacts close to major roadways, changes in air quality next to a number of major roadways have also been assessed. This assessment has also assumed that any member of the community, including sensitive groups such as children or the elderly, are at these locations 24 hours per day, every day of the year. This approach is specifically designed to ensure that all health impacts, by all members of the community including sensitive groups, regardless of land use or changes in land use are addressed in a conservative manner. Following this approach, the report did not identify any health impacts of concern for any members of the community.
Effects of nitrogen dioxide on children's cognition	337	The assessment of health impacts presented in the report has addressed a wide range of health effects related to changes in air quality and noise. The assessment has included detailed calculations of risk for health effects where robust, peer-reviewed, studies are available that show a causal link between exposure and a specific health effect. Not all published studies that show some association between exposure to air pollution or noise and health effects are robust or suitable for use in quantifying risk. An association is not the same as causation. It is important that studies that show that exposure to the air pollutant evaluated causes the health effect are used, and that the study is large enough and robust enough to provide a way of quantifying these health effects. Some studies have been published that look at nitrogen dioxide exposures and cognitive effects in children. These are small studies where some limited associations have been identified but these studies are not adequately robust to demonstrate that exposure to nitrogen dioxide alone causes these effects or that these effects can be quantified in a population. It is not appropriate to use such information in the report. In relation to other effects in children from air pollution, the assessment of health effects associated with exposure to volatile organic compounds, polycyclic aromatic hydrocarbons are based on the use of guidelines that are protective of the most sensitive health effects (refer to Section 6.6 of the report). Where developmental effects are relevant to these chemicals, it has been included in establishing the guidelines adopted. Studies are available that have generally evaluated the physiological/ biological changes associated with exposure to air pollution and potential effects of child brain development. This is a growing area of research and there is currently no data available to enable such effects to be adequately quantified. Hence it is not appropriate to use such information in the report.
Effects of air pollution on early childhood and children's brains	215	
Project disadvantages the west and entrenches	34, 62, 198	The report has considered the socioeconomic status of the community evaluated and potential equity issues, refer to

Issues raised	Submissions	Response
disadvantage Effects on those of low-socioeconomic status Generational issues with children living in areas where they cannot perform to the best of their ability due to asthma and general poor health		Section 8.6 in the report. This evaluation relies on available data on the socioeconomic status of the community, which is only available for suburbs, not any smaller groups within these suburbs. The report did not identify any health impacts of concern in the community, regardless of socio-economic status, sensitivity (including childcare schools and aged care) or where impacts from both air quality and noise are considered. Hence no equity, or generational issues are of significance.
Effects from heatwaves caused by increased urban heat island effects	454	These effects were not addressed in the report. However, it is noted that the project is in a significantly urbanised area where heat island effects would already be present.
Existing human health (prevalence of key conditions such as respiratory conditions) and concern about impact on these health conditions		
General concerns raised about the impact of the project on individuals, family members or communities with pre-existing health conditions that include asthma, respiratory conditions, cancer, allergies, cardiovascular (heart) conditions and stroke	34, 45, 81, 88, 93, 101, 105, 162, 165, 178, 183, 198, 201, 205, 215, 218, 220, 221, 249, 251, 277, 279, 288, 289, 298, 301, 314, 319, 339, 340, 346, 351, 362, 366, 374, 375, 403, 418, 432, 455, 457, 458, 465, 467, 470, 475	It is acknowledged that the existing community has a wide range of existing health conditions. The existing health of the community has been characterised in the report in Section 5.4, based on health data that were publicly available. This data relates to larger community groups than specific individuals. The report has assessed the impact of the project on the health of these communities, where the existing health of the community has been considered. In addition, the way the health impacts have been quantified uses studies and relationships relevant to the whole community that includes those with pre-existing health conditions.
Concern the community already lives with high levels of noise and pollution. Existing health problems in Maribyrnong would not be solved without truck ban on Williamstown Road and tunnel air filtration.	349 230	The existing air and noise environments have been described in the report (refer to Sections 6.2, 6.3 and 7.1). The existing noise and air environments would already contribute (along with many other factors) to the existing health of the community, which has been considered in the report (refer to Section 5.4). The report only relates to the project impacts, and as a result has focused on changes in air quality and noise (and other factors) within the community, and the effect of these changes on health.
Concern over existing health where there are no existing noise/pollution barriers	404	
Concerns about ultrafine diesel particulates being the most damaging to human health	453	Diesel particulate matter has been specifically included in the report (refer to Section 6.9.5 and Appendix D of the report). This assessment has assumed that 100% of the $PM_{2.5}$ comprises diesel particulate matter which is highly conservative. The focus of the assessment of diesel particulate matter relates to lung cancer. The report has also addressed community exposures to other carcinogens, namely benzene, 1,3-butadiene and carcinogenic polycyclic aromatic hydrocarbons (PAHs) (refer to Section 6.6 of the report). The assessment of these as well as assuming that 100% of $PM_{2.5}$ is diesel particulates will result in some double counting of carcinogenic risks from diesel exhaust. The report has not identified any unacceptable carcinogenic risks posed to the community from exposure to diesel particulate matter or other carcinogens.
Risks on bad asthma days from carcinogenic pollutants such as PM1	343	

Issues raised	Submissions	Response
		The report has also provided discussion on the assessment of ultrafine particulates (including PM_1) and health (refer to Section 6.9.1 of the report). It is agreed that health effects associated with ultrafine particulates is a growing area of research. However, health effects related to all particulates from vehicle and truck emissions are already incorporated in the epidemiology studies that underlie the exposure-effects relationships used to quantify health impacts. The measure of $PM_{2.5}$ is used as an indicator of the level of community exposure from these urban sources.
Concerns about lung cancer effects	480, 481, 482, 483, 484, 485, 488, 490, 491, 492, 493, 494	The report has specifically included an assessment of carcinogenic effects associated with diesel particulate matter (refer to Section 6.9.5 and Appendix D of the report). The key health effect evaluated for community exposures to diesel particulate matter is lung cancer. This assessment has assumed that 100% of the $PM_{2.5}$ comprises diesel particulate matter which is highly conservative. The report has also addressed community exposures to other carcinogens, namely benzene, 1,3-butadiene and carcinogenic polycyclic aromatic hydrocarbons (PAHs) (refer to Section 6.6 of the report). The assessment of these as well as assuming that 100% of PM2.5 is diesel particulates will result in some double counting of carcinogenic risks from diesel exhaust. The report has not identified any unacceptable carcinogenic risks posed to the community from exposure to diesel particulate matter or other carcinogens.
Concern about heatwaves and effects on the elderly with chronic health issues and infants	454	Heatwave effects were not addressed in the report. However, it is noted that the project is in a significantly urbanised area where heat island effects would already be present.
Cycling should be encouraged, rather than car driving to reduce costs on the health system, improve wellbeing and reduce suicide	450	The report has considered benefits of improved cycle access on the community (refer to Section 8.2 of the report).
Reduced quality of sleep and overall mental health	404	The report has addressed changes in sleep disturbance and noise annoyance and the health impacts that may occur as a result, from changes in noise from the project, within the community (refer to Section 7.4 of the report). The report has not identified any measurable impacts to sleep disturbance or noise annoyance, and hence no measurable health effects, within the community.
Others		
Request for compensation due to healthcare costs from increase in respiratory disease and asthma	166	The assessment of health impacts included an assessment of changes in air quality (Section 6 of the report) and noise (Section 7 of the report) throughout the community and if these changes may result in any measurable increase in the incidence (number of people) of the health effects evaluated (including respiratory disease and asthma). Within the community, the changes in air quality (refer to Section 6 of the report) does not result in any measurable increase in the incidence of health problems in the community. The changes in noise (refer to Section 7 of the report) result in small decrease in the incidence of health problems. As a result, no

Issues raised	Submissions	Response
		significant or measurable health care costs are expected to be associated with the project.

5 Response to the Preliminary Matters and Further Information Request issued by the West Gate Tunnel Project Inquiry and Advisory Committee

The following provides Reponses to the Preliminary Matters and Further Information Request issued by the West Gate Tunnel Project Inquiry and Advisory Committee (IAC) dated 18 July 2017. Specifically, the following addresses the key issues and requests for information as outlined in Appendix C, LD1-A to LD1-T.

The following also provides comment on the Project Note dated 31 July 2017 issued in response to IAC requestion #19.

Issues raised/Information Requested	Response
LD1-A and LD1-K: Further information on the requirements of the enHealth and CHETRE guidance and how they have been met in the HIA is required. This includes the Level of HIA as set out on the above guidance for a project of this type and how the HIA has met those requirements.	As stated at the start of Section 3.2 of the report, the health impact assessment was conducted as a desk-top assessment. This is the level of assessment provided consistent with the wording for this level of assessment as outlined in the CHETRE (2007) guidance. The enHealth (2001) and CHETRE (2007) guidance provide a framework for the conduct of health impact assessments in Australia. As a framework, these documents do not provide prescriptive guidance. Both frameworks require the following: • Assessment of the broader definition of health, that includes both health and wellbeing, that includes consideration of social aspects. The assessment includes consideration of both direct and indirect effects. This is included in the scope of this HIA (refer to Section 3.2 of the report) • A screening step is included to focus the assessment on the key issues, where there are likely to be impacts. This was undertaken through the scope of works (as outlined in Section 1.5 of the report), with consideration of community concerns and perceptions (as outlined in Section 5.5 of the report) • Both positive and negative impacts on health should be considered (this is included throughout the report) • Providing a profile of the community (included in Section 5 of the report) • Community and stakeholder consultation (as outlined in Section 3.4 of the report) • Assessing the health risks and impacts using both qualitative and quantitative methods (addressed in the report) It is noted that the methodology adopted for the assessment of health impacts from the project follows on from and has adopted the methodology used to assess health impacts from similar projects in Sydney, specifically NorthConnex and WestConnex (M4 East and New M5), as well as the Moorebank Intermodal Terminal. The methodology for the above projects was developed in direct consultation with key health professionals in NSW Health and Dr Patrick Harris, author of the CHETRE (2007) guidelines for conducting Health Impact Assessments in Australia.

Issues raised/Information Requested	Response
LD1-B and LD1-L: An assessment should be conducted on the impact of both noise and air pollution on the low SES areas within the project area is required. This can be qualitative or quantitative if possible to enable an assessment on these more vulnerable groups.	The report has addressed health impacts from changes in air quality and noise throughout all areas within the community. This includes consideration of equity issues associated with those changes (refer to Section 8.6 of the report). The assessment of equity issues includes consideration of whether the changes impact on lower socioeconomic areas or receptors. This assessment is qualitative and very much limited by the very coarse data available on socioeconomic status, which is only available on a suburb level.
LD1-C and LD1-M: Further justification is required on the health effects assessed in the NO_2 health risk assessment and why it differs from the health outcomes assessed by Golder (2013). The Golder report assesses short-term all-cause mortality for all ages consistent with the epidemiological studies from which the dose response relationships have been derived but the HIA only considers the 30+ age group. This difference needs to be clarified and justified as required. Recent recommendations from WHO (2013) and COMEAP (2015) recommend assessment of long-term all-cause mortality of NO_2 this should be included or justification as to why it is excluded is required. The health risk assessment should be expanded to include a quantitative assessment of the impact of NO_2 from the project on the more sensitive health indicators – hospital admissions for respiratory disease in people 65+ years of age and 15-64 years of age and hospital admissions for cardiovascular disease in people 65 + years of age should be undertaken.	The methodology adopted for the assessment of health impacts from the project follows on from and has adopted the methodology used to assess health impacts from similar projects in Sydney, specifically NorthConnex and WestConnex (M4 East and New M5), as well as the Moorebank Intermodal Terminal. In relation to impacts associated with changes in air quality including NO_2, the methodology was developed in direct consultation with key health professionals in NSW Health. The methodology developed through this process in NSW, specifically relates to assessment health impacts from transport infrastructure projects. There is no detailed guidance on the conduct of similar health impact assessment in Victoria. As the vehicle fleet (and hence air emissions and noise sources) is expected to be consistent in Sydney and Melbourne, as well as the general population present in urban areas, the methodology developed in NSW for these transport infrastructure projects is considered to be relevant and applicable to this project. In Victoria. The report has been reviewed by Dr Andrew Buroni as part of WDA report checking process. Dr Andrew Buroni is an international expert on the assessment of health impacts who has considerable experience with the assessment of health impacts from a wide range of transport projects. More specifically the assessment has addressed key health effects and population groups that are based on robust/large published studies. This assessment relates to exposures from vehicle emissions already present in the project area that are being re-distributed in a localised area. It does not relate to a new source of emissions that affect a regional area, nor does it relate to changes that affect a whole urban population (e.g. the whole population of Melbourne). The assessment is being used to identify localised changes in a small population, to which the application of any exposure-response functions from large population studies is challenging. As a result, it is not possible, or reasonable to address all health effects and all age groups using exposure-response functions that are less robust than those from large studies. This is why the specific exposure-response relationships to be used were agreed with NSW Health as part of the Sydney road projects (NorthConnex and WestConnex) to ensure the relationships were considered appropriately indicative for identifying health impacts of concern. These exposure-response relationships were provided to and reviewed by Victoria EPA and DHHS throughout this project. In relation to mortality all-causes for NO_2 (refer to Section 6.8 of the report), the report applied this calculation to the population aged 30 years and over. It is noted that the application of this exposure-response function by Golder and as detailed by the Woolcock Institute (Jalaludin & Cowie 2012) is for all ages. It is noted that the key difference in the calculation of risk for the different age groups is the baseline incidence. The baseline incidence of mortality all causes (all ages) is lower than for all causes (ages 30+) (refer to Table 5.4 in the report) so the calculations would provide a lower risk if mortality all causes (all ages) was used. Providing risk calculations for ages 30+ will have overestimated (by a very small amount) the risk for mortality all-causes over all ages. The

Issues raised/Information Requested	Response
	conclusions from the report do not change where all ages are considered. In relation to long-term all-cause mortality, the reviewer comment differs from the outcomes of the review by the Woolcock Institute in 2012 (Jalaludin & Cowie 2012), where no exposure-response relationship was recommended. As there is inconsistent evidence that such a relationship should be considered, it was not included in the report.
LD1-D and LD1-N: Justification on using overseas dose response data for PM_{10} and $PM_{2.5}$ rather than more Australian data is required. A sensitivity analysis for the short-term effects using the Australian data, which includes studies conducted in Melbourne, should be included.	The methodology adopted for the assessment of health impacts from the project follows on from and has adopted the methodology used to assess health impacts from similar projects in Sydney, specifically NorthConnex and WestConnex (M4 East and New M5), as well as the Moorebank Intermodal Terminal. In relation to impacts associated with changes in air quality including PM_{10} and $PM_{2.5}$, the methodology and the exposure-response functions adopted, as presented in Table 6.13 of the report, were developed in direct consultation with key health professionals in NSW Health. The exposure-response functions adopted were considered to be the most robust for the assessment of the health effects evaluated, even where the small Australian studies were taken into consideration. These exposure-response relationships were also provided to and reviewed by Victoria EPA and DHHS throughout this project. It is agreed that other studies are available, including those from Australia, where there are small differences in the relative risk. This issue is discussed in Section 9.3 of the report. Where differences in the relative risk are considered the following should be noted: • If more conservative exposure-response relationships were adopted for the assessment of the health effects presented, this would result in higher levels of increased risk as well as greater decreases in risk, where there is an improvement in air quality • Even if the relative risks adopted in the report for the most significant health effects were doubled, i.e. 200% of those considered in the report, the calculated maximum incremental risk remains acceptable. For many other, less sensitive health effects, the relative risk can increase by significantly more than 2 fold before risks would be considered unacceptable. • Review of the data from Australian studies (Jalaludin & Cowie 2012; Simpson et al. 2005) does not result in increases in risk that would be considered unacceptable. It should also be noted that there are a range of other factors inherent in the characterisation of risk that are highly conservative as outlined in Section 9 of the report.
LD1-E and LD1-O: The short-term effects of NO_2, PM_{10} and $PM_{2.5}$ need to be assessed using the daily changes in air pollution data not the annual averages. The impacts of using the long-term data to assess short term daily changes in health needs further assessment.	The assessment presented in the report has considered changes in the annual risk for exposure to NO_2, PM_{10} and $PM_{2.5}$ at each individual receptor, based on short-term and long-term health effects. Any daily change in risk from short-term changes in air quality are significantly smaller than those calculated for the year. The approach adopted to assess short-term effects is outlined further in Appendix C (Section C3) of the report and follows on from the approach and discussion presented by the WHO (Ostro 2004). WHO notes that when calculating the annual risk from short-term changes, mathematically the calculation is the same if the risk is calculated for the sum of every 24-hour average change for every day of the year at an individual receptor location or if the risks are calculated using the annual average. When developing the methodology for calculating risks for short-term effects, the calculations were checked to determine if the comment by WHO was correct. This check involved

Issues raised/Information Requested	Response
	calculating the daily change in risk from short-term changes in air quality (with PM2.5 specifically addressed), over every day of the year, and summing those risks individually for each receptor location. This resulted in the same annual risk as those calculated using the annual average concentration and applying the relative risk over the year. Since that initial check calculating the risk based on the annual averaged has been adopted at each individual receptor.
LD1-F and LD1-P: Further clarification on what air quality scenario data is required. If the worst case – maximum capacity – has not been used then the analysis should be repeated with this data or a discussion on the potential impact on the predicted health outcomes using this data is required. (Sections 6.8 and 6.9)	The primary focus of the assessment presented in Section 6.8 and 6.9 of the report is on changes in air quality in 2022 and 2031 with predicted traffic, that varies throughout the day, as this provides an estimate of community exposures that may occur throughout this period, during peak hour and other times of the day. One part of the assessment includes a maximum scenario (refer to the text after Table 6.17) where it is assumed that the tunnels are operating at maximum traffic capacity for all hours of the day, for the whole year. This is a highly unrealistic worst-case, however, no unacceptable risks have been identified, even under this scenario.
LD1-G and LD1-Q: Further clarification on how population growth has been included in the predicted health risk is required.	Population growth has been taken into account in the development of the traffic numbers that are then included in the air quality and noise modelling, used in the assessment of health impacts. Additional discussion on changes in population size and demographics is included in Section 9.8 of the report.
LD1-H and LD1-R: Justification of the health outcomes that have been used in the noise HIA is required. This should be based on the recommendations of WHO and the recent published studies on the health effects of road traffic noise. The assessment should include the most vulnerable groups or justification as to why this is not appropriate for this Project.	A number of jurisdictions in Australia and many international jurisdictions have noise guidelines that are based on the protection of health. This is not the case in Victoria. The guidelines published in Victoria do not specifically consider the protection of health. Hence the assessment presented in this HIA has included a quantitative assessment of health impacts from the proposed changes in noise, associated with the project. There are very few health impact assessments where such calculations are required or are presented, and hence the identification of appropriate and robust exposure-response relationships was undertaken in consultation with the international peer-reviewer, Dr Andrew Burtoni. He recommended the use of some recent studies where the quantification of health effects from changes in noise from major infrastructure projects has been required. Section 7.4 of the report provides discussion on the health effects of noise, where evidence as presented by the WHO and other recent studies is discussed and presented. This discussion has specifically addressed the health effects that have been clearly linked with road noise, as this is particularly relevant to the project. This discussion includes consideration of evidence for more vulnerable groups including children. The health effects evaluated/quantified in this HIA include annoyance, sleep disturbance, hypertension, ischaemic heart disease, stroke and mortality (all causes), as listed in Table 7.1 in the report. These are based on relationships that are considered to be current and based on robust studies that are relevant to road traffic noise.
LD1-I and LD1-S: Justification of the use of the NSW Road Traffic Guidelines over the WHO Community Noise Guidelines for the assessment of health impacts is required.	The NSW Road Traffic Guidelines have not been used to quantify health impacts in the report. The NSW Road Traffic Guidelines adopt the WHO guidelines and are based on the protection of health, and, as a result, they are referenced a number of times in the report, particularly in relation to the relevance of various WHO health outcomes that relate to road traffic noise. The guidelines also provide insight into how the WHO information has been used to interpret the significance of changes in noise annoyance and sleep disturbance within the community. The assessment of health impacts from noise, presented in Section 7 of the report, has not used threshold values from the WHO or any other jurisdiction.

Issues raised/Information Requested	Response
	The assessment has used exposure-response relationships relevant to road-traffic noise, and calculated changes in risk and incidence as a result of changes in noise from the project. This is discussed in Section 7.4.2 of the report, and these specifically address annoyance, sleep disturbance, the incidence of hypertension, ischaemic heart disease (hospitalisations), stroke (hospitalisations) and mortality (all causes). Some of these relationships have been used by the WHO in the development of their guidelines. Others come from more recent studies, that are more specifically relevant to road noise.
LD1-J and LD1-T: Clarification of the noise metric used in the assessment of sleep disturbance is required. If the annual average Lnight value has not been used then the impact on the HRA outcomes needs discussion.	The assessment of sleep disturbance has used the exposure-response relationships outlined in Table 7.1 of the report. This requires the use of the metric, Lnight. This metric is determined from the modelled noise data provided for this project as outlined in Section 7.4.3 of the report. Lnight is calculated from the $L_{A10,18hour}$ modelled noise level as Lnight = $L_{A10,18\text{-}hour} - 5$ (dB). The Lnight value (or change in Lnight) is what is used in the quantification of sleep disturbance. This can be clearly seen in the noise calculations presented in Appendix H of the report.
Additional comments	
Project Note dated 31 July 2017, responding to IAC request #19	The Project Note has evaluated the impact on traffic volumes on key local roads where the tolling structure is changed to a single toll point. The health impact assessment report has not directly used the traffic volume predictions, however the traffic volumes on local roads affects the change in predicted air quality and noise. The change in air quality and noise is directly addressed in the health impact assessment report. While the changes in air quality and noise associated with the single toll point scenario have not been calculated, for the predicted change in traffic volumes, the following can be noted: • Any reduction in traffic volumes (including trucks) as predicted on Millers Road and Blackshaws Road will result in smaller changes in air quality and noise, which will result in lower levels of health risk (when compared with the risk presented in the report). • An increase in traffic volumes (including trucks) as predicted on the West Gate Freeway and Williamstown Road will result in larger changes in air quality and noise, which will result in higher levels of health risk (when compared with the risk presented in the report). • It is not possible to quantify what the changes in health risk would be in relation to the changes in traffic/truck volumes identified.

Declaration

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the Inquiry and Advisory Committee.

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Signed

Date: 2 August 2017

Additional References:

Jalaludin, B & Cowie, C 2012, *Health Risk Assessment - Preliminary Work to Identify Concentration-Response Functions for Selected Ambient Air Pollutants*, Respiratory and Environmental Epidemiology, Woolcock Institute of Medical Research, Report prepared for EPA Victoria

Ostro, B 2004, *Outdoor Air Pollution: Assessing the environmental burden of disease at national and local levels.*, World Health Organisation.

Simpson, R, Williams, G, Petroeschevsky, A, Best, T, Morgan, G, Denison, L, Hinwood, A, Neville, G & Neller, A 2005, 'The short-term effects of air pollution on daily mortality in four Australian cities', *Australian and New Zealand Journal of Public Health*, vol. 29, no. 3, Jun, pp. 205-212.

Appendix A Matters Raised by PPV Guide to Expert Evidence

(a) the name and address of the expert;

Dr Jackie Wright

6 Wilshire Ave

Carlingford NSW 2118

(b) the expert's qualifications and experience;

Dr Jackie Wright has over 25 years' experience in the assessment of exposures and risks to human health and the environment, relevant to a wide range of contaminants, pollutants and stressors. She holds a PhD in Public Health and is a Fellow with the Australasian College of Toxicology and Risk Assessment. A more detailed CV is included in **Appendix B**.

(c) a statement identifying the expert's area of expertise to make the report;

Dr Jackie Wright's area of expertise includes the assessment of exposures and risks to public health associated with a wide range of pollutants and stressors. More specifically she has been involved in the development of Health Impact Assessments (HIA) for a number of large infrastructure projects in NSW, with significant consultation with NSW Health and Dr Patrick Harris, author of the CHETRE (2007) guideline "*Health Impact Assessment, A Practical Guide*" for these NSW projects. A more detailed CV is included in **Appendix B**.

(d) a statement identifying all other significant contributors to the report and where necessary outlining their expertise;

Therese Manning, a Principal within enRiskS, reviewed the report and assisted in responding to some reviewer comments throughout the development of the report.

(e) all instructions that define the scope of the report (original and supplementary and whether in writing or oral);

The scope of the report was defined by the Minister for Planning, where draft evaluation objectives were set out. The scope was also defined through discussions with the Victorian EPA and the Department of Health and Human Services (DHHS).

The scope of this Expert Report is in accordance with the letter of instructions provided by Clayton Utz dated 6 July 2017. In relation to this Expert Report, the following was required to be undertaken:

- Review the public submissions and identify those relevant to my area of expertise. Respond to these submissions.
- Review my previous report (West Gate Tunnel Project: Technical Report J – Human Health Impact Assessment (May 2017)) and identify whether there are changes to the conclusions arising from the issues raised by public submissions or as a consequence of another relevant matter.

The scope of this Expert Report also includes the request by Clayton Utz to review and provide responses to the IAC's Preliminary Matters and Further Information Request dated 18 July 2017, for matters that relate to my area of expertise.

(f) the identity of the person who carried out any tests or experiments upon which the expert relied in making this report and the qualifications of that person;

No tests or experiments were conducted for the purpose of this report.

(g) a statement setting out the key assumptions made in preparing the report;

The key assumptions made in preparing the report are as follows:

The report was prepared on the basis of assessments and information provided from other Technical Reports prepared for the EES. Specifically, this relates to Technical reports prepared for the assessment of air quality, noise and vibration, traffic, economic impacts, contamination and social impacts. It was assumed that the assessments and information provided for use in the report was correct.

It was assumed that the available health statistics available from publicly available sources, and used within the report were correct and apply to the populations as evaluated in the report.

(h) a statement setting out any questions falling outside the expert's expertise and also a statement indicating whether the report is incomplete or inaccurate in any respect.

Questions that fall outside my area of expertise relate to traffic modelling, air quality impact assessment and public policy.

The report and this statement (Expert Report) are complete and is not known to contain inaccuracies.

Appendix B CV

Dr Jackie Wright

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Director/Principal
Environmental Risk Sciences Pty Ltd
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Professional Profile

Jackie Wright has more than 25 years' experience in human health and ecological risk assessment in Australia. Experience includes leading and developing a national risk practice group for a major consultancy, training of staff, providing technical (and toxicological) direction, developing internal technical standards, participating in the development on industry guidance and standards, developing appropriate risk models and providing peer-review.

Areas of expertise include human and eco-toxicological review and evaluation of chemicals in line with Australian regulatory requirements, human health and ecological risk assessment, exposure modelling, indoor air quality assessment, fate and transport assessment, air dispersion modeling, environmental chemistry, environmental monitoring, and the assessment of air emissions and air toxics. Human health assessments have included a wide range of sites that involve the evaluation of emissions to air, waste sites, residential and recreation areas, operating industrial plants as well as other industrial plants that have been closed and are in the process of property sales or redevelopment and remediation. Ecological assessments have included screening level and detailed assessments of contamination, potential for contamination and remediation of contamination in soil and the aquatic environment. Risk assessments, ecological and human health, have been conducted for review by regulatory agencies (including Contaminated Land Auditors), with Jackie also providing expert support on both human health and ecological risk assessments (including detailed aquatic eco-toxicological assessments) for a number of Auditors in NSW, Victoria, South Australia, Western Australia and Queensland.

Jackie has been heavily involved in the development of national guidance and investigation levels as presented in the National Environment Protection Measure (NEPM) for Site Contamination (2013) and Australian Crime Commission Assessment and Remediation of Clandestine Drug Laboratories (2011).

In addition, she has extensive experience in the assessment of vapour migration and intrusion, detailed evaluation of exposure by occupational, residential and recreational groups including the application of probability distributions to human health risk assessments. Jackie also been involved in a number of key projects that require regular risk communication with interest groups, including resident action groups.

- Toxicological (human and ecological) Review and Assessment
- Human Health Risk Assessment
- Environmental Risk Assessment
- Exposure Assessment and Modelling
- Occupational Exposure Assessment
- Clandestine Drug Laboratories
- Health Impact Assessment
- Environmental Chemistry, Fate and Transport
- Vapour Intrusion
- Indoor Air
- Risk Communication
- Air Dispersion Modelling

Dr Jackie Wright jackie@enrisks.com.au

Professional Accomplishments

Toxicology and Risk Assessment

- 2014-2015 – conducting detailed toxicological review of TCE, particularly in relation to the quantification of inhalation dose-response.
- 2009 to 2013 – provided detailed toxicological review, determination of appropriate dose-response values, and derivation of proposed 2013 NEPM Soil Health Investigation Levels (HILs), including the interim soil gas HILs, and input into the petroleum Health Screening Levels (HSLs). The review included significant update and revision to Schedules B4 and B7 and involved incorporation of all comments from regulators, industry and the public.
- 2010 – provided detailed review of toxicological interactions, biomonitoring data and human exposure to metals (and metal mixtures) for a site in Tasmania.
- 2005 to 2016 (ongoing process of development and revision) - Prepared over 50 toxicity summaries for a range of chemicals relevant to the inclusion and assessment of these chemicals within human health and ecological risk assessments in accordance with Australian guidance. Toxicity summaries prepared provide detail on the chemical use, sources, exposures, chemical properties, ecotoxicity (terrestrial and aquatic), environmental fate and transport, health effects, review and identification of appropriate data relevant to acute and chronic exposures by the inhalation, oral and dermal routes, including assessment of carcinogenicity and genotoxicity. Range of compounds assessed includes particulate matter, petroleum compounds, chlorinated compounds, metals and more obscure industry-specific compounds. More specific, detailed review of arsenic dose-response has been undertaken based on current studies.
- 2006 to 2016 (and ongoing) - Presentation and collaboration with regulatory bodies in Australia (New South Wales Environmental Protection Authority [EPA], New South Wales Department of Health and Victorian EPA) with regards to the approach adopted and information presented with toxicity summaries (addressing human health and aquatic toxicity where required) for key, high profile assessments.

Exposure and Risk Assessment (Human Health and General Environmental)

- 1992 to 2016 (ongoing) - Project management and evaluation of human health and environmental risks associated with over 350 contaminated sites in all states of Australia utilising national guidance that include NEPM, enHealth, ANZECC and NH&MRC guidance. Sites include operational sites as well as other industrial areas proposed for redevelopment for industrial, recreational or residential use. Most of the sites assessed are associated with petroleum contamination, chlorinated hydrocarbons, polycyclic aromatic hydrocarbons (PAHs) and metals. Other sites include those impacted with dioxins, phthalates, PCBs and PFOS/PFOA.
- 1995 to 2016 (ongoing) - Detailed assessment and ongoing evaluation of risks to human health associated with contamination issues derived from the Orica Botany site in Sydney. A number of assessments have been undertaken over a period of 17 years and has involved detailed review of risks to residents (including groundwater extraction and use), workers and recreational users of a large area affected by the discharge of contamination in shallow and deep groundwater to surface water within a drain and an estuary, historically deposited sediments and volatile

chlorinated compounds in air. The assessment of risk has been tied closely with ongoing monitoring with detailed exposure reviews, including the collection of additional data and ongoing review of methods, being undertaken for many key aspects of the project. The process required evaluation within context of the NEPM (1999) and enHealth (2002) guidance with regular liaison with the NSW OEH, NSW Department of Health and independent reviewers.

- 2009 to 2015 - Derivation of national guidelines for the investigation and remediation of clandestine drug laboratories in Australia. The work involved the derivation of investigation levels, protective human health and the environment (terrestrial and aquatic), associated with former clandestine drug laboratories in Australia. Project required identification of key indicator compounds from over 200 base, intermediate and waste products that may be associated with over 20 different drug manufacturing methods. This required consideration of human health and environmental toxicity, behaviour/fate and transport in the environment and manufacturing methods. Guidelines were derived for indoor surface residues, indoor air, outdoor soil and the environment (local waterways and soil) for residential, commercial and recreational areas. The guidelines developed have been published by the Australian Government in April 2011. Further development of state guidelines, such as those from NSW Health have been undertaken to 2015.
- 2010 to 2016 – Detailed evaluation of community exposures and risks to PM10 and PM2.5 derived from urban (combustion) sources as well as crustal (mining) sources. A number of urban projects have been completed, including major road infrastructure projects such as NorthConnex, WestConnex M4 East and WestConnex New M5 in NSW and Western Distributor in Victoria and rail infrastructure projects including the Moorebank Intermodal Terminal. These infrastructure projects have considered community exposures and risks to particulate matter as well as other criteria pollutants that include ozone, nitrogen oxides, sulphur dioxide, particulate matter and other combustion products. Projects have involved detailed review of current literature in relation to the health effects and the use of appropriate dose-response relationships relevant to the quantification of relevant health endpoints, with consultation conducted with stakeholders, including state health departments and the community.
- 2015 and 2016 – conduct of detailed human health and ecological risk assessments for a range of sites (in particular airport sites) where PFAS issues are of potential concern both on the site and in relation to offsite migration, discharge and exposure. Work has involved detailed evaluations and the development of site-specific guidelines and management measures within the context of a moving regulatory environment.
- 2008 to 2014 - Detailed evaluation of human health and environmental issues associated with a former chlor-alkali plant. The assessment involved detailed evaluation of mercury fate and transport with use of specialised data collected and analysed by CSIRO and liaison with experts on mercury issues from the CSIRO. Assessment considered environmental issues associated with the presence of mercury in groundwater and discharge to an urban (highly modified) environment, as well as issues associated with mercury (elemental and inorganic) in soil and groundwater with respect to fate and transport, human health and environmental issues.
- 2010 to 2015 – Conduct of a detailed Health Impact Assessment in relation to major rail infrastructure development proposal at Moorebank. The HIA involved consultation with stakeholders, in particular local councils, NSW

Health and the community, with all aspects of the proposal being address in relation to health impacts, both positive and negative. The HIA was peer reviewed by the University of NSW and an international expert.

- 2011 – Quantitative assessment of risks to human health associated with the placement of remediated soil that contains residual levels of radiological contamination, beneath a proposed commercial/industrial development in South Australia.
- 2011 to 2016 – Detailed evaluation and development of chemical risk assessments for a range of products/compounds utilised during coal seam gas operations in NSW and Queensland.
- 2011 – Development of a detailed scope of works for the assessment and remediation of an abandoned asbestos mine in NSW. The works required collaboration between key stakeholders including NSW Health and the NSW EPA with the focus of the works on the protection of off-site community health.
- 2011 to 2014 – Assessment of risk issues associated with the presence of friable and bonded asbestos materials on a range of sites, proposed to be used for residential or commercial/industrial purposes. The assessments include consideration of risk management measures required, monitoring requirements and establishing site specific criteria relevant for the protection of construction workers and off-site residents (as required).
- 2010 – Detailed assessment of risks (including detailed assessment of toxicity of individual compounds and mixtures) to human health associated with the presence of nitrate, nitrite and perchlorate contamination in drinking water (international project).
- 2009 to 2016 (and ongoing) – Expert support for contaminated land Auditors located in New South Wales, Victoria, Queensland, South Australia and Western Australia. Expert support has included review of human health and ecological risk assessments for a range of projects and issues.
- 2000 to 2011 - Detailed evaluation of risks to human health and the environment associated with redevelopment of large a number of gasworks sites in New South Wales and Victoria. Projects have involved the evaluation of the vapour migration pathway, including the collection of relevant soil gas and vapour emissions data to quantify exposure consistent with the proposed developments. The process required liaison with relevant site auditors, Vic EPA, SA EPA, NSW EPA and NSW Department of Health as required.
- 1995 to 2008 - Detailed evaluation, modelling and risk assessment of a number of landfill and waste depots in Australia (in New South Wales, Australian Capital Territory, Queensland and Victoria). This includes proposed waste destruction technologies, proposed waste depots and landfills, operational landfills, composting operations and closed landfills with assessments considering workers, residents and recreational users of the site and surrounding areas. Assessments undertaken have considered issues associated with the presence of a wide range of chemicals, landfill gas emissions, bioaerosols and other pathogens and bacteria.
- 1995 to 2016 (ongoing process as vapour issues are relevant for many projects) - Evaluation of vapour migration (and vapour intrusion) from numerous sources including contaminated soils and groundwater (dissolved phase and free phase) for many different chemicals, and subsequent assessment of human health risks associated with the estimated vapour concentrations. In addition, Jackie has developed and managed various techniques for the direct measurement of vapour

migration in residential, recreational and industrial settings as part of the risk assessment process.

- 2009 - Detailed evaluation of public health issues associated with recreational exposures to arsenic and PAHs in surface soil in sporting areas and children's playgrounds. Provision of technical advice along with appropriate general advice relevant for presentation to the public and responses to questions from the general public.
- 1995 to 2000 - Evaluation of human health risks associated with potential exposure to emissions from coal mining activities, including the assessment of potential risks and health effects associated with exposure to fine particulates.
- 1998 to 2009 - Evaluation of human health risks associated with the existence of and potential remediation of encapsulated scheduled waste materials located near residential and recreational areas. The assessment has involved ongoing monitoring, review of toxicity and exposures on an ongoing basis, review of remediation options and risks derived from the application of preferred remediation options. The encapsulation has now been remediated.
- 2007 to 2013 – Assessment of risks to human health and the environment associated with the re-use of water (including irrigation uses) from a groundwater treatment plant located in Sydney.
- 2000 to 2005 - Evaluation of human health risks associated with a number of contaminated sites located in Abu Dhabi, Spain and Azerbaijan. These risk assessments involved assessment of human health risks using USEPA guidance as well as WHO guidance.
- 2005 - Project management of large human health risk assessment associated with the redevelopment of explosives and munitions factories and firing ranges within various areas of NSW.
- 1995 to 1998 - Evaluation of human health risks associated with off-site accumulation of lead from historical deposition associated with a former operating lead paint site located within a residential area in Sydney. Project involved the review of lead exposure and toxicity, identification and agreement to lead action levels relevant for residential properties located close to and further away from the former source.
- 1995 - Evaluation and coordination of a multi-pathway health risk analysis for a large contaminated site in Sydney involving the use of probabilistic risk assessment methodology.
- 2000 to 2005 - Conducting a feasibility assessment for a waste destruction facility in Sydney, using a probabilistic risk assessment methodology. Conduct of a detailed health risk assessment associated with the operation of the selected technology, including presentation to the Commission of Enquiry. Subsequent review of the process and exposures in relation to placing the facility within a rural area (as opposed to an urban area) and consideration of other multi-pathway exposures.
- 1993 - Assessment of risks to human health and the environment associated with sewage sludge incinerators at North Head and Malabar Sewage Treatment Plants.
- 1992 to 2016 (and ongoing) - Determination of preliminary remediation goals for numerous contaminated sites based on risk criteria.
- 1995 to 2016 (and ongoing) - Development of air sampling procedures and techniques to collect air data relevant to the further assessment of vapour migration pathways in a range of areas. This includes the collection of ambient air, soil gas data (active and passive and sub slab) and flux emissions.

Ecological Risk Assessment

- 1998 to 2016 (ongoing) - Derivation of risk-based criteria for a range of projects that are based on the protection of the aquatic environment. Evaluations have considered the potential for physical parameters (turbidity, pH, dissolved oxygen) and contaminants (principally metals, polycyclic aromatic hydrocarbons [PAHs], PFAS, petroleum compounds and chlorinated compounds). The evaluations include the potential for contaminants to leach from soil, migrate to groundwater and potentially discharge to a receiving environment (considered both marine and freshwater [including ephemeral] systems). Some of the assessments have required review and consideration of fate and transport modelling.
- 2009 to 2016 (ongoing) – Identification and derivation of investigation levels protective the terrestrial and aquatic environments associated with former clandestine drug laboratories in Australia. Ecological Tier 1 levels (based on available ecotoxicological data primarily from overseas studies) were identified and proposed for use in remediation guidelines with additional guidance provided in relation to sites where more detailed assessments of environmental risk issues needs to be conducted.
- 2010, 2011 and 2012 – Conduct (co-presenter) of lectures at the University of Sydney for the Risk Assessment (Human Health and Ecological) module for undergraduates, School of Geosciences. Ecological risk assessment lectures addressed basic principles and frameworks, stressors, fate and transport, bioaccumulation, uptake, derivation of ANZECC Guidelines, reviewing available ecotoxicological studies and conduct of statistical analysis using the CSIRO Burrlioz software for establishing water guidelines.
- 2010 to 2011 – Expert witness in relation to ecotoxicological impacts of initial works proposed for the Barangaroo site in NSW.
- 2010 - Assessment and derivation of water criteria for petroleum hydrocarbons relevant to the protection of the terrestrial and aquatic environments from the reuse of urban run-off for irrigation or a public park and associated runoff into a lake. Assessment required a detailed assessment of not only phytotoxicity, but levels at which grass growth would be affected to the extent by which grass cover on an important AFL playing field would be affected.
- 2009 to 2011 – Detailed review of screening level risk ecological assessment (supporting studies and outcomes) for the discharge of contaminated groundwater into a sensitive marine environment in South Australia. Review required detailed consideration of the local environment, consideration that appropriate ecological indicator species have been selected, consideration of the range of urbanisation stressors within the environmental and potential for groundwater discharges to result in adverse effects to the aquatic environment, over and above those from urbanisation.
- 2008 to 2010 - Detailed evaluation of environmental fate and transport issues associated with a former chlor-alkali plant. The assessment involved detailed evaluation of mercury fate and transport with use of specialised data collected and analysed by CSIRO and liaison with experts on mercury issues from the CSIRO. Assessment considered ecotoxicological risks associated with the presence of mercury in groundwater and discharge to an urban (highly modified) environment.
- 1992 to 2016 (and ongoing) - Determination of preliminary remediation goals for numerous contaminated sites based on risk criteria. In relation to

environmental risk issues, this has included the identification of appropriate and screening level criteria that are protective of fresh and marine environments and phytotoxic effects. Where necessary more detailed evaluations of ecotoxicological effects have been considered. This has included the design of suitable surveys and sampling programs (including microtox, microalgae, fish, crustacean, amphipod (sediments), plant and earthworm), interpretation of information and data from these studies, discussion of results with relevant regulatory parties, uncertainty analysis and reporting. These studies have been conducted for the assessment of petroleum hydrocarbon, cyanide, inorganics, ammonia, chloride, phosphorous and nitrate concentrations in soil and discharges from groundwater.

- 2000 to 2008 - Detailed evaluation of risks to human health and the environment (particularly aquatic species and sediments) associated with redevelopment of large a number of gasworks sites in New South Wales and Victoria. The project in NSW involved collaboration with sediment experts to determine the nature and extent of sediment contamination, potential for adverse ecotoxicological effects and requirements for remediation. The process required liaison with relevant site auditors and the DECCW (formerly NSW EPA) as required.
- 2007 - Assessment of risks to terrestrial and aquatic (marine water) environments associated with the re-use of water from a groundwater treatment plant located in Sydney. Water is proposed to be reused for a range of proposes that include industrial water (where it may be directly discarded to the marine environment) and irrigation where the water may affect terrestrial species and runoff may enter local water ways. The assessment considered available ecotoxicological data and guidelines available from Australian and International studies (where relevant to Australian species).

Contaminant Transport

- All of the projects listed above have involved the assessment of contaminant transport in at least one media. More specific examples are listed below:
- Vapour partitioning and transport assessed for petroleum compounds, including the development of a national database of petroleum vapour data, related to over 300 petroleum impacted sites, and detailed review of the database in conjunction with technical specialists from the USEPA. The database developed has been peer-reviewed by the USEPA and has been incorporated into the USEPA technical review of data from both the US and Australia for the purpose of determining screening distances;
- Vapour partitioning and transport assessed for chlorinated compounds at numerous contaminated sites, including the assessment of vapour risk issues at the Orica Botany site from 1994 to 2015;
- Review and use of groundwater fate and transport modelling conducted in support of numerous detailed risk assessment outcomes. Reviews have been conducted for the purpose of ensuring these models adequately address the potential movement of contaminants from a source to a point of discharge, utilising appropriate inputs and site data;
- 2008 to 2014 - Detailed evaluation of mercury fate and transport in groundwater and air (mercury vapour) with use of specialised data collected and analysed by CSIRO and liaison with experts on mercury issues from the CSIRO. Assessment considered environmental issues

associated with the presence of mercury in groundwater and discharge to an urban (highly modified) environment, as well as issues associated with mercury (elemental and inorganic) in soil and groundwater with respect to fate and transport, human health and environmental issues.

- 2010 to 2016 - Air dispersion modelling conducted for the assessment of exposures (and risks to human health) to grain fumigants, timber fumigants, hydrogen sulphide, chlorinated compounds, silica and dust (particulate) emissions from a range of facilities. Modelling has been conducted using Screening level and mode detailed Ausplume and Calpuff dispersion modelling packages.

Air Emissions and Vapour Assessment

- Jackie Wright is experienced in all aspects of determining air quality, including monitoring, assessing and modelling soil gas, vapour emissions and emissions from stacks and other fugitive sources. Projects include analysing dust emissions from a number of quarries and coal mines, motor vehicle emissions; modelling vapour emissions from motor vehicles and sources such as creeks, ponds and waste areas; and assessing odour emissions from sewage treatment plants.
- 2012 to 2013 – Development of petroleum vapour intrusion guidance for Australia in conjunction with CRC CARE. The project has involved the development of clear, prescriptive guidance that incorporates current science on the assessment of petroleum vapour intrusion. The guidelines being developed have been presented at a series of PVI training workshops (supported by ALGA and CRC CARE) run in Sydney, Melbourne and Perth.
- 2009 to 2016 (ongoing) - Development of a petroleum vapour database to assist in the interpretation and understanding of the behaviour of petroleum vapours in the subsurface environment. The database is unfunded and independent and has been interpreted by Jackie as well as industry experts in Australia and the US. The database has been peer-reviewed by the USEPA, and incorporated into the USEPA publication on the use of field data (from the US, Canada and Australia) to support and develop vertical exclusion/separation distances (refer to the following website for the USEPA review and access to the database developed: http://www.epa.gov/oust/cat/pvi/). This data is being used to support the development of screening distances that are being incorporated into guidance being developed in Australia and the US.
- 2005 to 2016 (ongoing) - Preparation of conceptual site models and completing screening level modelling (using published models such as Johnson & Ettinger) for the assessment of vapour migration and intrusion issues on a wide range of sites (over 200) affected by petroleum and chlorinated hydrocarbons.
- 2010 to 2016 – Detailed evaluation of community exposures and risks to PM10 and PM2.5 derived from urban (combustion – associated with road and rail infrastructure) sources as well as crustal (mining) sources. A number of urban projects have also considered community exposures and risks to other criteria pollutants that include ozone, nitrogen oxides and sulphur dioxide. Projects have involved detailed review of current literature in relation to the health effects and appropriate dose-response relationships relevant to the quantification of relevant health endpoints, with consultation conducted with stakeholders, including state health departments.

- 1995 to 2016 (ongoing) - Development of methods and approaches for the sampling and assessment of vapour (e.g. soil gas, flux emissions, indoor and ambient air). Works conducted has involved the conduct of field activities for the purpose of collecting this data.
- 1995 to 2016 (ongoing) - Interpretation and assessment of vapour data for the purpose of characterising inhalation exposures in a range of scenarios. These include existing buildings and proposed developments.

Risk Communication

- 2000 to 2016 (ongoing) - Jackie Wright has experience in the preparation and presentation (communication) of risk outcomes from a number of key projects across Australia to a range of community groups. These groups include workers and unions, residents and community action groups. Successful communication with stakeholders and the community on controversial projects including infrastructure, coal seam gas and other mining projects has been required.

Air Quality Assessment

- 1990 to 1995 – Air dispersion modelling and air quality impact assessment conducted for various mining (coal mining and quarry activities) and transport (major roadways) in NSW and Victoria. Projects included the development of emissions inventories, setting up and running air dispersion models and reporting.
- 2011 to 2015 - Air dispersion modelling conducted for the assessment of exposures (and risks to human health) to crop, grain and timber fumigants. The assessment have been undertaken based on trial data, with scaling to address commercial application.
- 2010 to 2012 – Air dispersion modelling undertaken to evaluate community exposures to hydrogen sulfide (from accidental releases), chlorinated hydrocarbons (from remediation plant) and silica and dust (particulate) emissions from a range of facilities. Modelling has been conducted using Screening level and more detailed Ausplume and Calpuff dispersion modelling packages.
- 2010 to 2016 - Review of air dispersion modelling undertaken for a range of projects. The reviews have been undertaken to determine if the assessments are adequate for the purpose of understanding and characterising community health impacts. In some cases the review has been undertaken as part of a larger assessment of public health impacts. Projects have included communication of the air quality assessment and health impact assessment to community groups.

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Teaching

- 2010 to 2012 – Conduct of lectures at the University of Sydney for the Risk Assessment (Human Health and Ecological) module for undergraduates, School of Geosciences.
- 2009, 2010, 2012, 2013 to 2016 – Conduct of lectures at the University of Technology Sydney as part of the Contaminated Site Assessment and Management (CSARM) Professional Development Short Course, Risk Based Site Assessment.
- 2014 – ACLCA (Qld) Training Course on Vapour Intrusion and Landfill Gas Assessment (organising and teaching) – May 2014
- 2014 – ACLCA (SA and VIC) Training Course on Vapour Intrusion (teaching) – June 2014.
- 2013 and 2015 – Vapour Intrusion Short Course. Training Course conducted at CleanUp 2013 and 2015, CRC CARE (teaching).

Work History

Principal/Director/ Owner	Environmental Risk Sciences Pty Ltd	2008 (current)
Adjunct Lecturer	Flinders University	2016 (current)
Principal Environmental Scientist	URS Australia, North Sydney, NSW (formerly Woodward-Clyde)	1992 to 2008
Project Engineer	Sydney Water, Sydney, NSW	1991-1992
Environmental Scientist	Nigel Holmes & Associates, Sydney NSW	1990-1992
Assistant	Dames & Moore, Crows Nest, NSW	1988-1990

Education

BE (Hons)	University of Sydney, Bachelor of Engineering (Hons)	1989
PhD	Public Health, Health and Environment, Flinders University	2016

Professional Accreditation

Fellow of the Australasian College of Toxicology and Risk Assessment (ACTRA)

Professional Development

Clandestine laboratory safety and investigator training and synthesis run by the Clandestine Laboratory Investigators Association (8-hour course, 2011)

Ecological Risk Assessment Course run through AEHS and credited by University of Massachusetts Boston (2010)

Mid-America Toxicology Course (35 hours, 2010)

Dose-Response Boot Camp run by Toxicology Excellence for Risk Assessment (TERA) (5

day course, 35 hours, 2008)

Vapor Intrusion Assessment and Mitigation Short Course run by Air & Waste Management Association (4 hours, 2006)

USEPA Human Health Risk Assessment Short Course (24 hours, 1995)

Affiliations

Member (former committee member, remains co-opted committee member), Australasian College of Toxicology and Risk Assessment (since 2007).

Member, Australian Land and Groundwater Association (since 2010).

Clean Air Society of Australia and New Zealand (re-joined 2015)

Member, Environmental Health Australia (since 2011).

Member, SETAC (Asia Pacific) (since 2011).

Member, Air & Waste Management Association (since 2006).

Member, Society for Risk Analysis (since 1997).

Member, Association for Environmental Health and Sciences Foundation (since 1997).

Publications

Journal Articles:

Wright, J., Kenneally, M. E., Edwards, J.W. and Walker, S., 2017. Adverse Health Effects Associated with Living in a Former Methamphetamine Drug Laboratory — Victoria, Australia, 2015. Morbidity and Mortality Weekly Report (MMWR) January 6, Vol.65, No. 52, p1470-1473

Wright, J., Edwards, J. and Walker, S., 2016. Exposures associated with clandestine methamphetamine drug laboratories in Australia. Reviews on Environmental Health.

Lahvis, M.A., Hers I., Davis, R.V., Wright, J. and DeVaull G.E., 2013. Vapor Intrusion Screening at Petroleum UST Sites. Groundwater Monitoring & Remediation.

Wright J. and Howell M., 2003. “Volatile Air Emissions from Soil or Groundwater – Are They as Significant as Model Say They Are?”. In Contaminated Soils, Volume 8, Edited by Edward J. Calabrese, Paul T. Kostecki and James Dragun, p375-393.

Gorman J., Mival K., Wright J. and Howell M., 2003, “Developing Risk-Based Screening Guidelines for Dioxin Management at a Melbourne Sewage Treatment Plant”. Water, Science and Technology, Vol 47 No 10, pp 1-7.

Wright J., and Howell M., 1995, “Health Risk Assessment - Practical Applications Related to Air Quality Issues”. Clean Air, Volume 29, No. 2, May 1995.

Government and Industry Publications:

Wright J., 2013. Petroleum Vapour Intrusion (PVI) Guidance. CRC Care Technical Report No 23, CRC for Contamination Assessment and remediation of the Environment, Adelaide, Australia (in publication).

NEPM 2013 Revision (released in 2013), Schedule B4 (Guideline on Site-Specific Health Risk Assessment Methodology) and Schedule B7 (Guideline on Derivation of Health-Based Investigation Levels). Primary author of toxicological evaluations and derivation of health investigation levels and contributing author to the Schedules (conducting full revision/rework of both Schedules, including responding to public comments and comments from state health agencies).

Australian Government, 2011. Guidelines for Environmental Investigations, Remediation and Validation of former Clandestine Drug Laboratory Sites [Guidelines], April 2011. Primary author of toxicological evaluations and derivation of remeidation guidelines using risk based approach and listed contributor to main document.

Davis G.B., Wright J. and Patterson B.M., 2009. Field Assessment of Vapours, CRC CARE Technical Report no. 13, CRC for Contamination Assessment and remediation of the Environment, Adelaide, Australia.

Invited Lectures

Wright, J., 2013. Petroleum Vapour Intrusion Guidance in Australia. AEHS 23rd Annual International Conference on Soil, Water, Energy, and Air and AEHS Foundation Annual Meeting, March 18-21, 2013, Mission Valley Marriott, San Diego, California. Invited lecture

Wright, J., 2012. Evaluation of the Australia Hydrocarbon VI Data Base: Exclusion Criteria. AEHS 22nd Annual International Conference on Soil, Water, Energy, and Air and AEHS Foundation Annual Meeting, March 19-22, 2012, Mission Valley Marriott, San Diego, California. Invited lecture.

Conference Proceedings (Oral Presentations):

Wright J., 2014. Particulate Risk Assessments – Issues and Challenges. ACTRA Annual Scientific Meeting, Sydney October 9-10 2014.

Wright J. and Manning T., 2014. Health Impact Assessment – Role in EIS. Keynote presentation. Ecoforum, 29-31 October 2014, Gold Coast.

Wright J. and Manning T., 2014. Addressing Risk Perceptions through Risk Assessment. Ecoforum, 29-31 October 2014, Gold Coast.

Wright J. and Manning T., 2014. Vapour Assessment for TCE. Ecoforum, 29-31 October 2014, Gold Coast.

Wright J., Howell J. and Newell P., 2014. Assessment and Remediation of Illegal Drug Laboratories. Ecoforum, 29-31 October 2014, Gold Coast.

Wright, J., 2014. Clandestine Drug Laboratories – Understanding Exposures and Public Health. The Second International Conference on Law Enforcement and Public Health, Amsterdam 5-8 October 2014.

Wright, J. 2014. ASC NEPM – Implementation. AEBN (Australian Environment Business Network) Conference on Managing Contaminated Land, September 2014.

Wright, J. 2014. Managing Vapours – The Issues to Consider for Developers and Councils. AEBN (Australian Environment Business Network) Conference on Managing Contaminated Land, September 2014.

Wright, J., 2012. Exposure and Risk Issues associated with Clandestine Drug Laboratories – development of guidelines. British Occupational Hygiene Society (BOHS), Occupational Hygiene 2012 Conference, 24-26 April 2012, Mercure Holland House Hotel, Cardiff.

Wright, J., 2012. Risks of Not remediating Clandestine Drug Laboratories. 66th Annual Western Australian Environmental Health Australia (WA) State Conference Environmental Health: Imagine Life Without Us, 28-30 March 2012.

Wright, J, 2011. Establishing exclusion criteria from empirical data for assessing petroleum hydrocarbon vapour intrusion. CleanUp 2011: Proceedings of the 4th International Contaminated Site Remediation Conference, 11-15 September, Adelaide, Australia.

Wright, J., 2010. Review of Petroleum Vapour Data from Australia. Abstract presented at Ecoforum 2010, 3rd ALGA Annual Conference 23-24 February 2010.

Wright, J., 2010. Interpretation and Use of Soil Gas and other Vapour Data. Abstract presented at Ecoforum 2010, 3rd ALGA Annual Conference 23-24 February 2010.

Weaver T., Hassell T., Wright J., Stening J. and Apte S., 2009. Speciation and Geochemical Modelling as a Tool to Refine a Risk Assessment for Mercury in Groundwater. Presented at EcoForum, Sydney 28-30 April 2009.

Wright J. and Robinson C., 2009. The Reality of Sampling and Assessing Vapour Intrusion on Petroleum Sites. Presented at Air &Waste Management Association's Vapor Intrusion 2009, January 27-29 2009, San Diego CA.

Wright J., Lee A. and Howell M., 2008. Role of Risk-Based Concentrations in Assessment and remediation of Contaminated Sites. Presented at EcoForum, Gold Coast, 27-29 February 2008.

Wright J., Howell M. and Barnes J., 2006. Risk Assessment – Important Tool for Managing Issues on Contaminated Sites or Just a Task. Presented at Enviro06, Melbourne 2006.

Hall, A, Wright J. and Calabrese N, 2006. Ray Street Landfill – Audit Acceptance Levels for CO_2 in Redeemed Soils. Presented at Enviro06, Melbourne 2006.

Wright J. and Howell M., 2004. "Evaluation of Vapour Migration Modelling in Quantifying Exposure". Presented at Enviro04, Sydney March 2004.

Lee A., Howell M., and Wright J. 2004. "TPH – Analysis, Guidelines and Risk Assessment" Presented at Enviro04, Sydney March 2004.

Pershke D., van Merwyk T., Graham-Taylor S., Wright J., Mitchell T., and Elliot P., 2004. "Health Risk Assessment: Broadening the Horizons of the Traditional Health and Safety Approach", Presented at Enviro04, Sydney March 2004.

Wright J., Buchanan V., and Howell M., "Health Risk Assessment using Probability Density Functions". Presented at the AWWA Waste and Wastewater Conference, Brisbane 1998.

Wright J. and Buchanan V., 1996, “Uptake of Organics and Inorganics into Edible Fruit and Vegetable Crops”. Presented at Intersect-96 International Symposium on Environmental Chemistry and Toxicology, Royal Australian Chemical Institute and the Australian Society for Ecotoxicology, 14-16 July 1996.

Wright J. and Howell M., 1995, “Risk Based Approach to Assessment and Management of Air Quality Issues Associated with Contaminated Sites and Hazardous Waste”. Presented at Waste Management Institute (New Zealand) Inc., 7th Annual Conference and Exhibition, 31 October - 3 November, 1995.

Harrington J F, Clark L T and Wright J, 1994, “The Incineration of Sludge and its Effect on Ambient Air Quality in the Evaluation of Risk Factors for Primary School Children”. Presented at Australia and New Zealand Clean Air Conference, Perth 1994.

Royston D, Clark L T and Wright J, 1993, “Chlorinated Dioxins and Furans from Combustion Sources: A review”. Poster presented at the Sixth Conference of Asia Pacific Confederation of Chemical Engineering, Melbourne, 1993.