NE Link Air Quality

Expert Evidence

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15 August 2019
Outline

- Items remaining in contention
  - Assessment criteria
  - Accuracy of emission estimates
  - Inclusion of gradients for surface roads
  - Dust resuspension
  - Influence of the introduction of electric vehicles to the fleet on dust emission levels
  - Importance of conversion of NO to NO₂
  - Assessment indicates potential for exceedance of in-tunnel air quality standards
  - Requirement for space within the design for retrofitting of mitigation technology
Assessment Approach

- Assessment has adopted:
  - Criteria from Schedule A of the SEPP(AQM) for assessment of impacts from ventilation structures to provide a cumulative impact including background
  - An incremental assessment only for the surface road network, which has then been used by the human health risk assessment
  - An incremental assessment for the ventilation structures plus the surface road network at a limited number of receptors determined to be the most exposed
Current Legislation

NEPM (AAQ)

Sets acceptable air quality standards for all Australians agreed to by all States and Territories, but must be promulgated into State legislation.

Environment Act, 1970

SEPP(AAQ)

Implements requirements for measurement and reporting against the NEPM (AAQ)

SEPP(AQM)

Sets requirements for emissions to air from all sources to ensure ‘beneficial uses’ of the atmosphere are protected

Mining PEM

Stationary Sources PEM

GHG & Ozone PEM
SEPP (AQM)

- Relevant sections of the SEPP (AQM):

28. Modelling of Emissions

(1) In addition to managing emissions in accordance with clauses 18, 19 and 20, the Authority may require a generator of emissions to:

(a) model the transport and dispersion in the air environment of emissions; and

(b) for new sources of emissions, demonstrate that the model predictions meet the relevant design criteria; or

(c) in the case of odorous emissions for which design criteria are not established, demonstrate that local amenity will not be adversely affected by offensive odours.

(2) Any modelling done under sub-clause (1) must be done in accordance with Schedule C or any relevant protocol for environmental management made under this policy for a particular industry or activity.

SCHEDULE C
Modelling Emissions to Air

PART C – Assessing the Impact of Emissions to Air

2. Assessment against design criteria for new or modified sources of emissions

(a) The predicted maximum concentration as defined in Part C1 of this schedule must not exceed the design criterion for the relevant pollutant listed in schedule A.
PART D – MODELLING OF EMISSIONS TO AIR FROM PROPOSED TRANSPORT CORRIDORS.

1. Proposed transport corridors such as roads must be assessed using one of the regulatory models for near-road modelling.

EXPLANATORY NOTES

Background to State environment protection policy (Air Quality Management)

SCHEDULE C – MODELLING EMISSIONS TO AIR.

This schedule applies to all new or modified sources of emissions to air from stationary industrial or commercial sources and proposed transport corridors.

Motor vehicles are a significant contributor to emissions to air in Melbourne. Emissions to air from large line sources such as new transport corridors should be modelled and assessed against the relevant design criteria using a regulatory model for near-road modelling.

Further information on the use of these models and assessment of the predicted impacts should be sought from the Authority. Additional protocols and guidance for modelling roads will be given in any future protocol for environmental management developed for the purpose.
The SEPP (AQM) requires:

- Modelling of the ventilation buildings and surface transport corridors
- Inclusion of background for both point sources and surface roads
- Assessment against the relevant design criteria for both point sources, surface roads and a combination of these.

This has not been completed in the assessment.
# SEPP (AQM) Design Criteria

<table>
<thead>
<tr>
<th>SUBSTANCE</th>
<th>REASON FOR CLASSIFICATION</th>
<th>AVERAGING TIME</th>
<th>DESIGN CRITERIA mg/m³</th>
<th>DESIGN CRITERIA ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Toxicity</td>
<td>1-hour</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>Toxicity</td>
<td>1-hour</td>
<td>0.19</td>
<td>0.1</td>
</tr>
<tr>
<td>¹Particles as PM₁₀</td>
<td>Toxicity</td>
<td>1-hour</td>
<td>0.080</td>
<td>–</td>
</tr>
<tr>
<td><strong>Class 2 (toxicity-based)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>¹Particles as PM₂₅</td>
<td>Toxicity</td>
<td>1-hour</td>
<td>0.050</td>
<td>–</td>
</tr>
<tr>
<td><strong>Class 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>IARC Group 1 carcinogen</td>
<td>3-minute</td>
<td>0.053</td>
<td>0.017</td>
</tr>
<tr>
<td><strong>Unclassified Indicators</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>¹TSP (nuisance dust)</td>
<td>Amenity (nuisance)</td>
<td>3-minute</td>
<td>0.33</td>
<td>–</td>
</tr>
</tbody>
</table>

¹ applies to point sources only. For area-based sources and roads, applicable criteria are specified in the relevant industry PEM.
Criteria for Particulate Matter

- Design criteria in Schedule A of the SEPP(AQM) for NO\textsubscript{2}, CO and air toxics are for all sources of emissions – roads and ventilation structures.

- Design Criteria in Schedule A of the SEPP(AQM) for TSP, PM\textsubscript{10} and PM\textsubscript{2.5} are for point sources only, and can only be used for the ventilation structures.

- Options for appropriate assessment criteria for particulate matter emissions from roads:
  - In the assessment of Westgate Tunnel, Eastlink and Tullamarine widening the intervention criteria in Schedule B were adopted for the assessment of both modelling predictions and monitoring data.
  - Protocol for Environmental Management for Mining and Extractive Industries adopts the intervention criteria in Schedule B of the SEPP(AQM) as modelling assessment criteria.
  - SEPP(AAQ) adopts criteria from NEPM (AAQ) under clause 7 of the SEPP(AAQ) are considered to apply to all ambient air.

<table>
<thead>
<tr>
<th>Species</th>
<th>Avg Period</th>
<th>SEPP(AQM) Intervention / Mining PEM (µg/m\textsuperscript{3})</th>
<th>NEPM (AAQ) 2025 (µg/m\textsuperscript{3})</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM\textsubscript{10}</td>
<td>24 hour</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Annual</td>
<td>-</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>PM\textsubscript{2.5}</td>
<td>24 hour</td>
<td>36</td>
<td>25</td>
</tr>
<tr>
<td>Annual</td>
<td>-</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
Future Directions of Air Quality Standards

- Proposed Variation to NEPM for Ambient Air Quality
  - Reduction of NO\textsubscript{2} 1 hour standard from 0.12 ppm (226 µg/m\textsuperscript{3}) to 0.09 ppm (169 µg/m\textsuperscript{3})
  - Reduction of NO\textsubscript{2} 1 year standard from 0.03 ppm (56 µg/m\textsuperscript{3}) to 0.019 ppm (36 µg/m\textsuperscript{3})
  - Further reduction of NO\textsubscript{2} 1 hour standard from 0.09 ppm (169 µg/m\textsuperscript{3}) to 0.08 ppm (150 µg/m\textsuperscript{3}) in 2025
  - Further reduction of NO\textsubscript{2} 1 year standard from 0.019 ppm (36 µg/m\textsuperscript{3}) to 0.015 ppm (28 µg/m\textsuperscript{3}) in 2025

- SEPP (AQM) design criteria are based on attaining SEPP(AAQ) and hence NEPM(AAQ) standards and are lower than those standards to allow for multiple sources
  - Current SEPP(AAQ) 1 hour standard - 226 µg/m\textsuperscript{3}
  - Current SEPP(AQM) 1 hour standard - 190 µg/m\textsuperscript{3}

- Using \( \frac{SEPP(AQM)}{SEPP(AAQ)} \) as a indication, revised design criteria for NO\textsubscript{2} 1 hour standard will be \( \sim 126 \) µg/m\textsuperscript{3} in the opening year
Future Directions of Air Quality Standards – Implication to Assessment Results

- Predictions of ventilation structures plus background indicate exceedances for:
  - Scenario A1 (Table 45) maximum concentration of 130 µg/m³
  - Scenario B1 (Table 47) maximum concentration of 130 µg/m³
  - Sensitivity Analysis Maximum Tunnel Capacity (Table 57) – maximum concentration of 140 µg/m³
  - Sensitivity Analysis In-Tunnel Air Quality Limits (Table 58) – maximum concentration of 130 µg/m³
  - Sensitivity Analysis Increased ratio of Diesel to Electric Vehicles (Table 59) – maximum concentration of 130 µg/m³
- Cumulative impact of surface roads unknown as background not included in assessment as required by the SEPP (AQM)
Accuracy of Emission Estimates
Accuracy of Emission Estimates

- COPERT Australia website states that: “COPERT Australia is based on thousands of Australian vehicle emission and fuel consumption tests over real-world Australian drive cycles. This ensures the model reflects the Australian on-road fleet, fuel composition, climate and driving conditions”.


- Estimates of:
  - NO\textsubscript{X} emissions are under-estimated by 26%
  - CO emissions are under-estimated by 37%
  - PM\textsubscript{2.5} emissions are between 52% over-predicted at lowest measured concentrations in a tunnel and 13% under predicted at the highest measured concentrations in the tunnel with an average under prediction of 7%
  - PM\textsubscript{10} emissions are between 32% over-predicted at lowest measured concentrations in a tunnel and 19% under predicted at the highest measured concentrations in the tunnel with an average under prediction of 14%
It is noted by the study that NO$_2$ to NO$_X$ ratios can be high at low concentrations especially at night and so model validation should not be completed at this time.

Nevertheless looking at times of the day when the NO$_X$ levels are elevated due to higher traffic levels there are periods when the NO$_2$ ratio is under predicted by COPERT.
Accuracy of Emission Estimates

- Compared to other emission estimation models for vehicle emissions COPERT Australia was found to perform well
  - Other emission estimation models for vehicle emissions underpredicted emissions by a factor of generally within a factor of 2 for NO\textsubscript{X} and within a factor of 3 for CO and PM, although differences as high as a factor of 5 have been reported

- COPERT Australia is the best available method of emission estimation but….
  - It underestimates NO\textsubscript{X} emissions by a 26%
  - It underestimates NO\textsubscript{2} percentages of NO\textsubscript{X} by an average of 13%
  - It underestimates CO emission by more than a 37%
  - It underestimates PM\textsubscript{2.5} emissions on average by 7%
  - It underestimates PM\textsubscript{10} emissions on average by 14%

- The results of the dispersion modelling therefore need to be considered in light of these potential inaccuracies
Inclusion of Gradients for Surface Roads
Road Gradients

- Estimation of emissions in the tunnels and in the cutting prior to the tunnels considers the impact of gradient on emissions.
- Estimation of emissions on the surface road considers the roads to be flat, even though it is acknowledged that the gradient in that area is up to 5%.

Factors of passenger car emissions for 5% Gradient compared to Flat from PIARC 2019

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Class</th>
<th>CO</th>
<th>NOx</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>40 kph</td>
<td>60 kph</td>
<td>80 kph</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 kph</td>
<td>60 kph</td>
<td>80 kph</td>
</tr>
<tr>
<td>Petrol</td>
<td>EURO 3</td>
<td>2.04</td>
<td>1.85</td>
<td>3.18</td>
</tr>
<tr>
<td></td>
<td>EURO 4</td>
<td>1.46</td>
<td>1.80</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>EURO 5</td>
<td>1.85</td>
<td>1.86</td>
<td>2.97</td>
</tr>
<tr>
<td>Diesel</td>
<td>EURO 3</td>
<td>1.03</td>
<td>1.00</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>EURO 4</td>
<td>1.11</td>
<td>1.31</td>
<td>1.27</td>
</tr>
<tr>
<td></td>
<td>EURO 5</td>
<td>1.19</td>
<td>1.57</td>
<td>1.28</td>
</tr>
</tbody>
</table>
Road Gradients

- Response from Golder on this issue is that this under estimation of emissions doesn’t matter because surface roads have been subject to an incremental assessment.

- SEPP(AQM) requires that a cumulative assessment in comparison to the design criteria is undertaken – not including road gradients would underpredict concentrations for comparison against design criteria.

- If you are only concerned about increment rather than total concentration and it’s impact, this approach is only correct where there is no chemical conversion occurring in the atmosphere (i.e. PM, CO) and where the dose response is linear – a question for the HHRA.

- Approach is not valid for NO₂ as:
  - Upon release NO₂ percentage of total NOₓ is approximately 15%.
  - NO is available for oxidation to NO₂, this process occurs fairly rapidly near the road (Smit et al., 2017).
  - Under low oxidant concentrations, the amount of NO converted to NO₂ is limited, whilst in high oxidant environments (>30ppb), the amount of NO that is converted to NO₂ is driven by the amount of NOₓ (Kimbrough et al. 2017, Atmospheric Environment 165 pp23-24).
  - Consideration of only primary NO₂ therefore underestimates the increase of NO₂ as a result of the new road.
Resuspension of Dust
Resuspension of Dust

- Assessment accounts for emissions from tailpipe and tyre and brake wear
- Assessment does not estimate emissions as a consequence of resuspension
Resuspension of Dust

- Multiple studies indicate that resuspension of road dust is an important source of emissions
  - Atmospheric Environment Volume 43, Issue 17 pp2770-2780, measured at a background site resuspension responsible for:
    - 37% PM$_{10}$ and 15% PM$_{2.5}$
  - Atmospheric Environment, 2014 Volume 99, pp 175-182, measured at kerbside resuspension responsible for:
    - 58% PM$_{10}$ and 54% PM$_{1}$
  - Concluded “The high abundance of resuspension particles underlines their significance for the observed adverse health effects of traffic emissions and for mitigation measures”

- Degree of resuspension is dependant on the percentages of heavy goods vehicles which contribute up to 20 times the amount of resuspension than passenger cars

- Resuspension on freeways tends to be lower than other roads due to the higher than average vehicle speed

- Nevertheless an important source which is missing from the emission estimates especially for surface roads leading from the freeway
Introduction of Electric Vehicles
Introduction of Electric Vehicles

- Electric vehicles will reduce at source tailpipe emissions
  - Greater draw on power generation, so only truly zero emissions if power is all renewable

- Electric vehicles continue particulate emissions due to:
  - Tyre wear – likely to be higher than current due to additional weight of vehicles;
  - Brake wear – likely to be less than current due to regeneration braking majority of the time; and
  - Resuspension – likely to be higher than current due to additional weight.

- Greencar Congress ([https://www.greencarcongress.com/2016/05/20160502-nonehaust.html](https://www.greencarcongress.com/2016/05/20160502-nonehaust.html)) reports on three studies:
  - University of Edinburgh concluded that non-exhaust PM$_{10}$ emissions from EV are equal to current ICEVs and non-exhaust PM$_{2.5}$ emissions are only slightly lower
  - Study in Rotterdam considered 10% reduction of private vehicles and 50% share of EV and concluded there is a marginal effects on air pollution compared to the already implemented policies
  - One study in Belgium suggests that EVs emit up to eight times less non-exhaust PM than diesel vehicles and two times less than gasoline vehicles
Introduction of Electric Vehicles - Policy

- Australia currently behind European nations, United States and New Zealand in terms of New Car Sales (2017 Sales)
  - Norway – 39.2%
  - UK – 1.8%
  - EU – 1.7%
  - US – 1.1%
  - New Zealand – 0.72%
  - Australia – 0.2%
- National Electric Vehicle Strategy – currently being developed
  - Looks like targets for replacement of ICV will not form part of strategy which forms the basis for uptake in other countries
- Uptake of electric vehicles will be slow unless there is significant intervention from Government
  - Noted that first investigations into the legislative requirements for EURO VI and EURO 6 technologies have been underway since 2010 with no indication on when this technology will be mandated
Conversion of NO to NO₂
Conversion of NO to NO₂

- Emissions from vehicles are roughly in the ratio of 15% NO₂ to 85% NO
- NO reacts with O₃ to produce NO₂
- NO₂ can react with hydrocarbon free radicals to produce smog
- NO₂ can break down by solar energy (sunlight) to produce NO and atomic oxygen
- Atomic oxygen reacts with oxygen to form O₃
- Oxidation of NO to form NO₂ is limited by the amount of oxidant in the atmosphere
- The reaction is rapid (Smit et al., 2017) and impacts near road and in-tunnel concentrations
Conversion of NO to NO₂

- Conversion of emitted NO to NO₂ not assessed as:
  - Incremental assessment for roads and assumption that conversion is linear – as discussed above this is incorrect
  - Draft Guidance for the use of AERMOD (EPA Publication 1551) says not to use the methods built within AERMOD to convert NO to NO₂ without specific EPA Approval
    - This does not mean that the conversion can be ignored, just that EPA requires consultation on the method
  - SEPP(AQM) Schedule C, Part B, Section 3c states:
    - “Proponents for new or modified sources of emissions adjacent to existing sources of the same pollutant must include emissions from the existing sources in the model”.

- It is well known that NO converts to NO₂ once in the environment, thus to not account for this conversion underestimates the impact.

- Assessment of conversion of NO to NO₂ is required under regulations in NSW, NZ, USA, UK, EU and is commonly completed in every air quality assessment for industrial and road sources throughout Australia
Conversion of NO to NO₂

- Westconnex, Western Harbour Tunnel and the Beaches Link studies in NSW modelled total NOₓ and based conversion rate on all measured NOₓ to NO₂ ratios in the Sydney airshed.

Estimated 1 hour average NO₂ concentration based on overall NOₓ concentration from Sydney data compared to NE Link NO₂ predictions:

<table>
<thead>
<tr>
<th>NOₓ Conc</th>
<th>Estimated NO₂ Conc</th>
<th>NO₂:NOₓ Factor</th>
<th>NE Link Assumed NO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;130</td>
<td>130</td>
<td>1</td>
<td>16.9</td>
</tr>
<tr>
<td>200</td>
<td>137.4</td>
<td>0.69</td>
<td>26</td>
</tr>
<tr>
<td>400</td>
<td>143.3</td>
<td>0.36</td>
<td>52</td>
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<tr>
<td>600</td>
<td>146.8</td>
<td>0.24</td>
<td>78</td>
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<tr>
<td>800</td>
<td>149.3</td>
<td>0.19</td>
<td>104</td>
</tr>
<tr>
<td>1000</td>
<td>151.4</td>
<td>0.15</td>
<td>130</td>
</tr>
<tr>
<td>1200</td>
<td>153.0</td>
<td>0.13</td>
<td>156</td>
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<tr>
<td>1400</td>
<td>154.4</td>
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<td>182</td>
</tr>
<tr>
<td>≥1555</td>
<td>155.5</td>
<td>0.10</td>
<td>202.15</td>
</tr>
</tbody>
</table>
Conversion of NO to NO₂

Near road studies around the world have shown that the NOₓ to NO₂ ratio is significantly higher close to the road than estimated for the tail pipe emissions indicating that consideration of NO to NO₂ conversion is an important consideration for surface roads:

  - “A regression of the NO₂/NOₓ ratios yielded on-road ratios ranging from 0.25 to 0.35, substantially higher than the anticipated tail-pipe emissions ratios.”

- New Method for NOₓ to NO₂ (https://uk-air.defra.gov.uk/assets/documents/reports/cat06/NewMethodforNOxtoNO2(Final).pdf)
  - “The best-fit relationship shows that the ratio of NO₂(road) to NOₓ(road) reduces from around 0.25 at 50 mg/m³ total NOx, tending towards 0.1 at higher concentrations.”

  - “Our findings from curbside monitoring, on-road experiments, and simulations imply the on-road oxidation of NO by ambient O₃ is a significant, but so far ignored, contributor to curbside and near-road NO₂.”
Potential for Exceedance of In-Tunnel Air Quality Standards
Potential for Exceedance of In-Tunnel Air Quality Standards

- In-Tunnel Air Quality limits Sensitivity Analysis (Table 42 in Technical Report B)

<table>
<thead>
<tr>
<th>Species</th>
<th>In Tunnel Air Quality Standard</th>
<th>Ventilation Structure</th>
<th>In Stack Concentration (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ppm</td>
<td>mg/m³ @25°C</td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>50</td>
<td>57.22</td>
<td>62.8</td>
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<td></td>
<td></td>
<td></td>
<td>Northern</td>
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<td></td>
<td></td>
<td></td>
<td>62.9</td>
</tr>
<tr>
<td>NO₂</td>
<td>0.5</td>
<td>0.94</td>
<td>1.01</td>
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<td></td>
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<td>Northern</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Southern</td>
</tr>
</tbody>
</table>

- Using minimum and maximum volumetric Flows from Table 42 in Technical Report B

<table>
<thead>
<tr>
<th>Species</th>
<th>In Tunnel Air Quality Standard</th>
<th>Time</th>
<th>In Stack Concentration (mg/m³)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ppm</td>
<td>mg/m³ @25°C</td>
<td></td>
</tr>
<tr>
<td>NO₂</td>
<td>0.5</td>
<td>0.94</td>
<td>1am to 5am 2.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8am 1.64</td>
</tr>
</tbody>
</table>

- Emission rates by time of day for Tunnel at 40 kph
Space for mitigation technology
Space for Mitigation Technology

- Project does not allow for the installation of mitigation technology, nor the space for future addition of technology
  - Discussion within assessment that very little tunnel mitigation technology installed around the world is used
  - Contribution from the tunnel is small
- Must be balanced against the:
  - Inclusion of mitigation technology in CityLink, Eastlink and Westgate
  - Reducing air quality standards within Australia
  - Likely under-estimation in the emission estimation and atmospheric chemical conversion
  - Uncertain timeline for adoption of future technologies
- Recommend allowing for the space for future retrofitting of mitigation technology to account for the uncertainty in the modelling, potential changes in air quality standards and consistency with other road tunnels in Victoria
Recommendations
Recommendations

- Recomplete the modelling in accordance with the requirements of the SEPP (AQM) and compare a cumulative assessment for both surface roads and ventilation facilities to demonstrate compliance with the relevant design criteria:
  - Accounting for gradients of surface roads
  - Accounting for conversion of NO to NO₂
  - Accounting for dust resuspension
  - Consider five consecutive years without using a screening analysis to isolate a single year
  - Consider time of maximum background with concurrent project contribution together with maximum project contribution and concurrent project contribution where exceedances of design criteria are predicted
  - Consider impacts at all identified sensitive receptors
- Consider potential for changes to legislation by the opening year of the project, to ensure that the project design is future proofed
- Where exceedances are predicted undertake a risk assessment on both the incremental risk and the overall risk of predicted concentrations to human health
- Require space for the retrofitting of mitigation technology should it be required in the ventilation facilities
Thank you

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The business of sustainability