Initial peer review of

Air Quality Analysis of NSW Tunnel Data — DRAFT, 7 Nov 2024

The aim of the Tunnel Data report is "to consider the impacts of tunnel vents on nearby air quality". The report's conclusion is "Overall, there is very little evidence that tunnel vent stacks have an appreciable impact on nearby air quality …" and "At the Jackson site, the isolation of the signal that is potentially associated with the tunnel vents indicates a contribution to NOx concentrations of only a few percent (<1 μg m^{-3})".

An equally important question not addressed in the report is: what is the maximum possible size of any tunnel-vent signal for it not to be detected in the ambient air quality data.

The report presents an analysis of vast quantities of air quality data collected around Sydney motorway tunnel projects. It uses several different polar plot formats to show the dependence of concentration on wind direction and speed, some of which would benefit from clearer explanations so that informed community members could understand how to "read" them. (Potential pollution from tunnel vent stacks is an issue that causes a lot of community angst.)

There is detailed exploration of a potential contribution at the Jackson site (section 2.1). Puzzlingly, the report does not show difference plots for M5 East sites other than Jackson. Although the report notes that because of reductions in vehicle emissions, "it might be expected to be easier to detect tunnel vent impacts for data more than several years ago than data collected in the past few years", a rigorous analysis is warranted for the Gipps site because Hibberd (2019) detected a contribution there in 2009-2013 data.

In all other regions, the search for possible tunnel vent contributions is based on differences from a single background site. I suggest a more targeted approach of calculating the difference between pairs of sites close to the tunnel vents. More use of conditional bivariate probability function plots like Figure 9 could also be warranted. If no other signals are detected, these plots would be useful in answering the question about an upper bound on the size of possible tunnel vent impacts in ambient monitoring data. I note that given the very poor siting (from a dispersion point of view) of the M5 East stack in the bottom of a valley, it would not be surprising for any tunnel-vent impact from the newer stacks to be much smaller.

Some consideration should also be given the possible misalignment of directional information from the polar plots due to use of the airport meteorological data at sites that are up to 25 km from the airport.

Detailed comments

1. *Compare pairs of sites close to the tunnel vents*. For all except one region in the report, a representative background site was selected with polar plot differences from it shown for all other sites. Puzzlingly, the exception was M5 East, where only the Jackson-Wavell difference is shown. Since Hibberd (2019) detected a contribution at the Gipps site, it is important that this report also consider the differences at Gipps.
   Given that the focus of the report is the potential impact of tunnel vent emissions, it could be more effective and relevant to show the differences between pairs of sites near the vents (see Table A below) rather than using a single representative background site.

Because these sites are closer to each other than the background site, the differences would tend to be dominated by very local emissions, which could make it easier to interpret these difference plots and give greater confidence in findings of the presence or absence of a tunnel vent signal. See dot point 3 below about also using CBPF plots.

Motorway region	**Pairs of sites close to vent stacks**
M5 East	Jackson and Wavell (done) Jackson and Gipps – opposite directions from the vent stack, vent stack contribution identified at Gipps by Hibberd (2019)
North Connex	Carden Park and James Park Hornsby Ashley Ave and Larchmont Place
M8	Kingsgrove 1 and Kingsgrove 2 Arncliffe 1 and Arncliffe 2 St Peters 2 and St Peters 3
M4 East	Allen St and Powells Creek (but note very similar downwind directions for both sites) Ramsay St and Haberfield Public School
Rozelle	Chapman Rd and Quirk St
M4-M5 Link	Albert St and Campbell St

Table A Suggested site pairs for investigating tunnel vent contributions

2. *Choice of meteorological data*. Section 1.2 discusses the reasons for using the meteorological data from Sydney International Airport in all the analyses. It mentions that local on-site data were/could also be used and that "similar conclusions would be drawn using local meteorological data at most sites". Were there sites where the conclusions were different? As an indication of differences across the Sydney basin, Figure A shows wind roses from three air quality monitoring sites – Randwick (~5 km from the airport), Rozelle (~10 km), and Lindfield (~20 km). An important consideration is whether the wind directions at the airport are representative for sites up to 25 km away, e.g. NorthConnex. If not, then directional information from the polar plots could be misaligned with respect to local sources. Has this been taken into account in assessing the plots for possible tunnel vent signals?

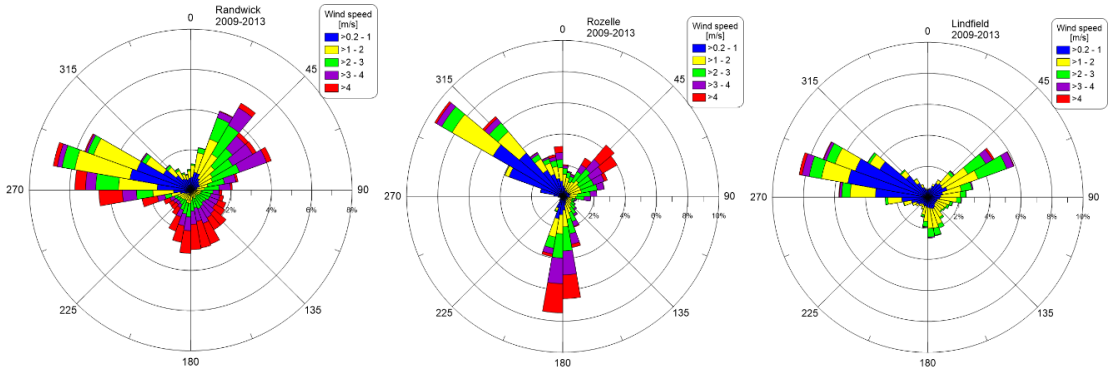

Figure A Wind roses from three air quality monitoring sites across Sydney, from Hibberd (2019)

3. *More extensive use of conditional bivariate probability function (CBPF) plots like Figure 9*. Using the example of the Jackson site, Figure B shows that the basic polar plot of concentrations (left) only gives a hint of a tunnel vent signal. How well it stands out is quite sensitive to the colour scale used. In contrast, the middle and right-hand plots clearly show a signal. Uria-Tellaetxe and Carslaw (2014) discuss the sensitivity of CBPF plots and how different concentration ranges can be used to discriminate between potential sources. The right-hand plot shows the differences in concentration between Jackson and Wavell. It is only these difference polar plots that are shown in the rest of the report to assess the presence/absence of a tunnel vent signal. However, the ability of the CBPF plots to distinguish between surface and elevated sources could prove useful for the regions where the tunnel vents are located close to major road emissions. Whether or not they reveal contributions from the tunnel vents, the results would strengthen the conclusions from this report about the impacts of tunnel vents on nearby air quality and assist in setting an upper bound on the size of possible tunnel vent impacts in ambient monitoring data.

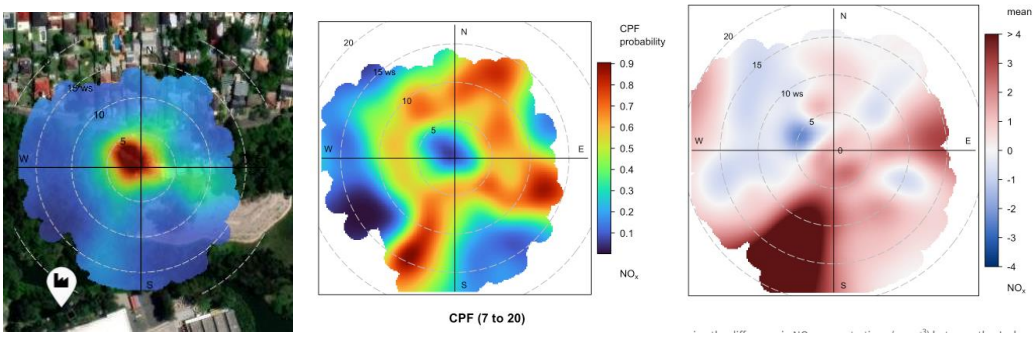

Figure B Polar plots of Jackson site data from Figures 3, 9, 11. The right-hand figure is Jackson-Wavell differences.

4. *Better explanations of how to interpret the various polar plots*. Several different types of plots are used in the report. The Percentile Rose is described in section 1.2 and an example given in Figure 1: I suggest adding a sentence to explain what the reader is meant to see in this example. I suggest it would also be useful to describe the concentration polar plots using an example figure, so that specific features can described more easily than using a polar plot in one of the maps. For the probability polar plot, Figure 9 could be used to explain, for example, what does a probability of 0.9 for the dark red region in the SSW mean.

5. *Section 2.1*. It is not clear why the concentration interval of 7 to 20 µg m^{-3} was selected for Figure 9. Was it based on the findings in Uria-Tellaexte and Carslaw (2014) [U&C] about stack impacts? Or was it based on looking at a range of concentration intervals for the Jackson site data in a similar fashion to that done in Figure 4 of the U&C paper?
The second paragraph presents the conclusion from the cluster analysis, but the cluster approach is barely explained. There is reference to Carslaw and Beevers (2013) but this article is behind a paywall. I suggest adding a sentence or two to explain it.
I don't understand how you get from a 6.3% to a 3% contribution. I think this paragraph, which includes a key finding of the report, needs reworking – currently the result of the cluster analysis is presented before describing the clustering figure.

6. *Hourly-average versus annual-average contributions*. Does the analysis in the CBPF plots enable you to estimate the maximum contribution of vent stack emissions to

hourly-averaged concentrations at Jackson? The estimates in Table 2 are the contributions of the clusters to annual average NOx concentrations. This question is relevant because both short and long-term air quality averages are important in design criteria for these tunnel projects.

Other comments/suggestions

7. *Wind directions averages*. Tables with the summary site information (Tables 1, 3, 4, 5, 6, 7) list the average wind direction for the meteorology used for analysing each site. This parameter should not be included in these tables. It is not an informative parameter for the analysis undertaken in this report because the wind rarely blows from the "average" direction. This is demonstrated by typical wind roses for the region shown in Figure A.

8. For all the motorways except M5 East, the available data covers a time span including both before and after opening of the tunnels. These total time periods are listed in Tables 3 to 7. Was all this data used in the main NO_x polar plots (e.g. Figure 13) or just the data after tunnel opening. This needs to be clarified in the report. The report should state the opening dates for regions where After-Before plots are presented.

9. Do seasonal differences in wind directions/speeds have an impact when comparing After and Before concentrations for Rozelle when there are only 5 months of After data compared to 12 months of Before data?
   Why are there no After-Before difference plots for M4 East even though there are more than 12 months of data for both periods?

10. Distance scale missing on most figures (2, 12-19, etc).

11. The colours in the NOx concentration colour scales in Figure 3, etc and for nox_inc (increment?) in Figure 14, etc are washed out compared to the colours in the polar plots. This makes it difficult to estimate concentrations from the figures.

12. There are no colour scales for concentrations in the polar plots of PM_{10} and CO (Figures 4, 5).

13. Section 1.2, second paragraph. At the end, add a sentence to explain how the reader is meant to interpret the pollution rose example in Figure 1.

14. Section 2, paragraph 4, The first sentence says "slightly enhanced concentration of NOx from the direction of the vent stack over a range of wind speeds … is the behaviour seen by stack emissions". Add a brief explanation of why this is the case.

15. Last sentence before section 2.1 says that the polar plots for CO are "broadly similar" to those for NO_x and do not show clear directional impacts of the vent stacks. The plots are copied in Figure C below; some aspects look quite different. Please be more specific than "broadly similar".

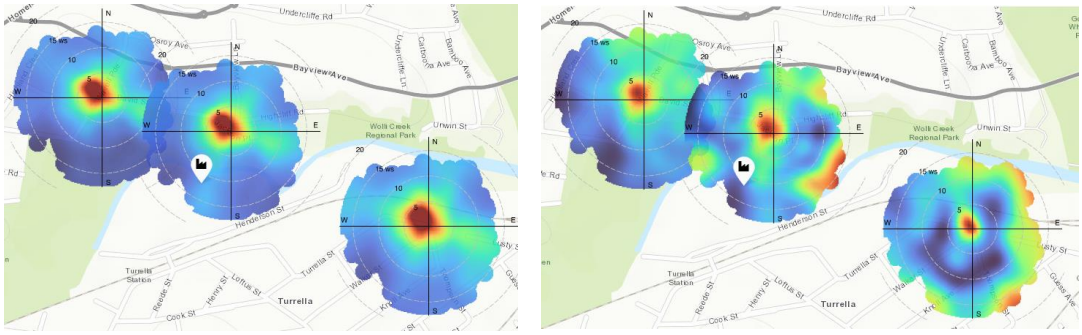

Figure C Extracts from the Report's Figure 3 for NO_x (left) and Figure 5 for CO (right)

16. The caption for Table 2 says "The cluster associated with the tunnel vent is highlighted in light blue." This is correct but I found it confusing because this is not the colour of this cluster in Figure 10.

17. Figure 10. Rather than a legend for the cluster colours, it would be clearer if the cluster numbers were included within the figure written on the coloured regions.

18. In Figure 11, the colour scale needs to be adjusted to distinguish concentrations in the saturated dark red/brown region with concentrations >4 µg m^{-3}. Many of the plots of concentrations with the background removed also show colour saturation making it impossible to see any features within these areas.

19. When viewing the html document, the names of the sites can be revealed by clicking on individual polar plots or percentile roses. This is first mentioned in the text in relation to Figure 19. It should be mentioned with the first plot that has this feature.

20. Scrolling through the html document on a touch-screen device is frustrating because the embedded maps capture the swipe and pan the map instead of scrolling the document. The same thing happens for a device with a mouse device. Is it possible to implement a feature to require two-finger touch gestures to pan and zoom the maps?

21. I was unable to produce a useable pdf version of the document – the maps were all small segments of the map without any polar plots. This is a comment from a reviewer who prefers hard copy 😊.

Corrections

22. There are no Figures 6, 7, 8, 15, 20, 25, 28. None of these, except 25, are cited in the text. It looks like they've been deleted but the figure numbering has not been refreshed.

23. Executive Summary, paragraph 5, line 3. Correct "a contributions" to "a contribution".

24. Introduction, 2nd paragraph. Correct "4. M4-M8 link (previously called the M4-M5 link)" to "4. WestConnex M4 East".

25. Section 1, second paragraph. The numbering of the motorway areas from 1 to 6 is slightly confusing because it not consistent with the numbering of the report sections which run from 2 to 7.

26. Table 1. The average CO concentration at Gipps in negative. The mean temperature at Thompson is listed as 36.0°C, almost 20° higher than the other 4 sites. Have the data been checked for anomalous readings?
27. Figure 2 shows the Flatrock site but no data from this site is presented in the following figures and it's not included in Table 1.
28. Section 2.1, second paragraph, line 8. Delete repetition of "would be below".
29. Section 2.1, second last paragraph, line 6. Delete the first "to". The line currently starts "to most likely to be the tunnel stack."
30. In Tables 4, 5, 6, and 7 the average temperatures appear to be in units of Kelvin but the table header says they are °C.
31. St Peters 1 site location listed in Table 4 as NaN. No plots of data from this site are shown in any of the figures.
32. Table 5. Correct the heading in the table from "M5" to "M4".
33. Figure 16, 21, 29. The captions for these figures need to describe that they're After-Before differences. Currently the captions are incomplete, e.g. "Figure 16: Polar difference plots for NO_x (in µg m^{-3}) for North Connex".
34. Include links to the Longley (2018) and Hibberd (2019) reports which are on the chiefscientist.nsw.gov.au website.