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11 July 2017

Dear Stewart,

Air Quality Monitoring in the tunnel, St Helier, June 2017

Ricardo Energy and Environment undertook a short study of air quality in St Helier, from 21 to 24 June 2017. The study encompassed a number of different assessments :

- To assess exposure of commuters traveling through the tunnel using different modes of transport
- To evaluate concentrations of nitrogen dioxide (NO_2) in the tunnel
- To evaluate concentrations of nitrogen dioxide for pedestrians using alternative routes to work.

A pair of experimental battery operated sensors were used for the NO_2 surveys: Electronic "Diffusion Tubes" were provided by Alphasense Ltd. These devices use electrochemical cells, capable of measuring and reporting NO_2 concentrations every minute. These sensors operate at lower levels of accuracy than conventional NOx analysers and NO_2 diffusion tubes. Nevertheless, they are estimated to carry a measurement uncertainty in the order of ±30-35%, compared to tubes at 25% and conventional NOx analysers at 15%.

For information, the relevant exposure guidelines (WHO) and limit values (for EC) for nitrogen dioxide are presented below:

Annual mean – 21ppb (40µg/m^3)

Hourly mean – 104.6ppb (200µg/m^3)

It should be noted that the tunnel environment is an unsuitable location for monitoring under the siting criteria requirements of the EC directive 2008/50/EC. It does not constitute a representative location for undertaking exposure measurements of the general population.

Prior to deployment, the performance of the two sensors was checked, to verify the level of agreement between them. These tests confirmed that the two sensors gave responses within 5% of each other, with a coefficient of linear correlation (r^2) of better than 1%. This excellent agreement will be useful for the study that looks at relative differences between locations reported later.

Prior to deploying the tubes at fixed locations, a short study was undertaken on 21 June to evaluate exposure of commuters travelling through the tunnel using different modes of transport. A qualitative assessment of air quality was undertaken during the morning rush hour for the following modes, together with an assessment of time taken to travel through the tunnel:

- Walking (approximately 3 minutes)
- Cycling (approximately 1 minute)
- Driving, windows open (approximately 1 minute)
- Driving, windows closed, ventilation off (approximately 1 minute)
- Driving, windows closed, air conditioning (approximately 1 minute)

During each of these assessments, measurements of NO_2 and PM_{10} Particulate Matter were recorded. PM_{10} was measured with a portable battery operated Alphasense OPC-N2 sensor. This device produces data that carry a measurement uncertainty in the order of ±40%, compared to ±25% for a conventional analyser. The results of these tests are presented in the table below:

Mode of transport	Average NO_2, ppb	Average PM_{10}, ug/m3
Walking	201.1	73.6
Cycling	268.8	74.3
Car, windows open	202.3	67.7
Car, windows closed, no ventilation	118.9	58.5
Car, windows closed, air conditioning	147.7	53.6

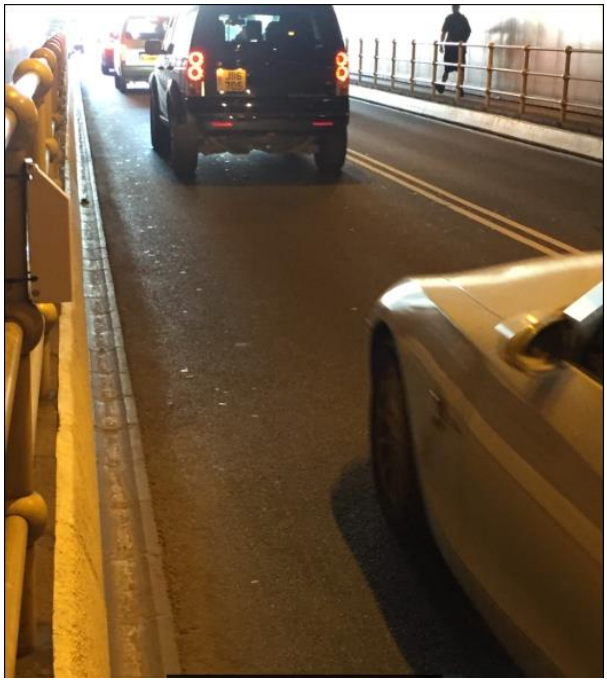
It should be noted that the measurements recorded will strongly depend on the vehicles present in the tunnel at the time of the survey. Nevertheless, the more vehicles are in the tunnel, the higher the exposure is likely to be. From this limited study, the following observations can be made:

- Cycling through the tunnel exposes the cyclist to the highest recorded concentrations. It is likely that this is a direct result of the closeness of the rider to vehicle exhausts.
- Driving through the tunnel with windows open gives very similar exposure to cycling and walking
- Driving through the tunnel with windows closed and ventilation turned off resulted in the lowest exposure.

Following this study, and after discussion with the Environment Team, the NO_2 sensors were fixed in two separate locations. Unfortunately, it was not possible to securely position the PM sensor at either location in such a way to prevent rain damage or vandalism. The first was 55m into the tunnel, while the second was located in the car park at Snow Hill. These locations are shown in the Google Earth image below:

The Snow Hill location was chosen to assess exposure for pedestrians if they were to walk on an alternative route, avoiding the tunnel. For information, the time taken to walk along Regent Road and Mulcaster Street, to arrive at Liberation Square was 8 minutes, compared to 3 minutes through the tunnel.

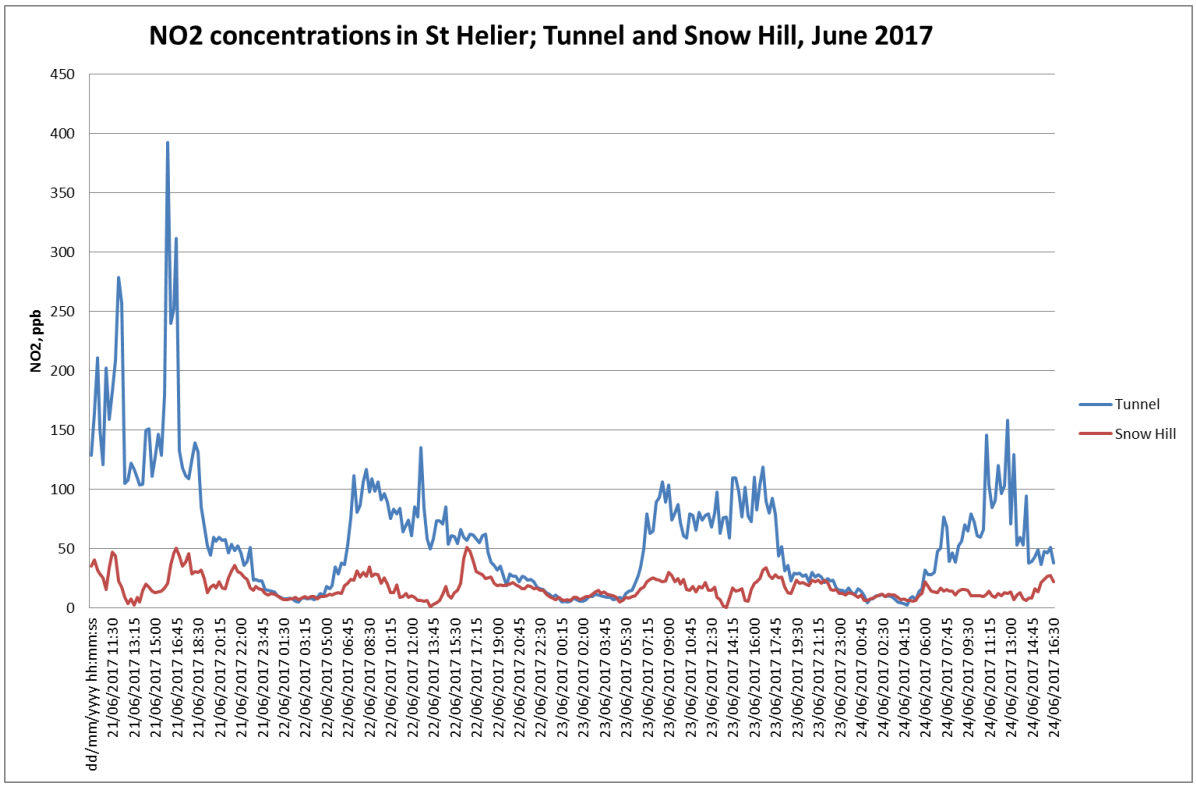
The sensors were operated from 10:00 on 21 June, through to 16:00 on 24 June 2017. Data was checked and downloaded daily from the sensors. The measurement locations are presented below:



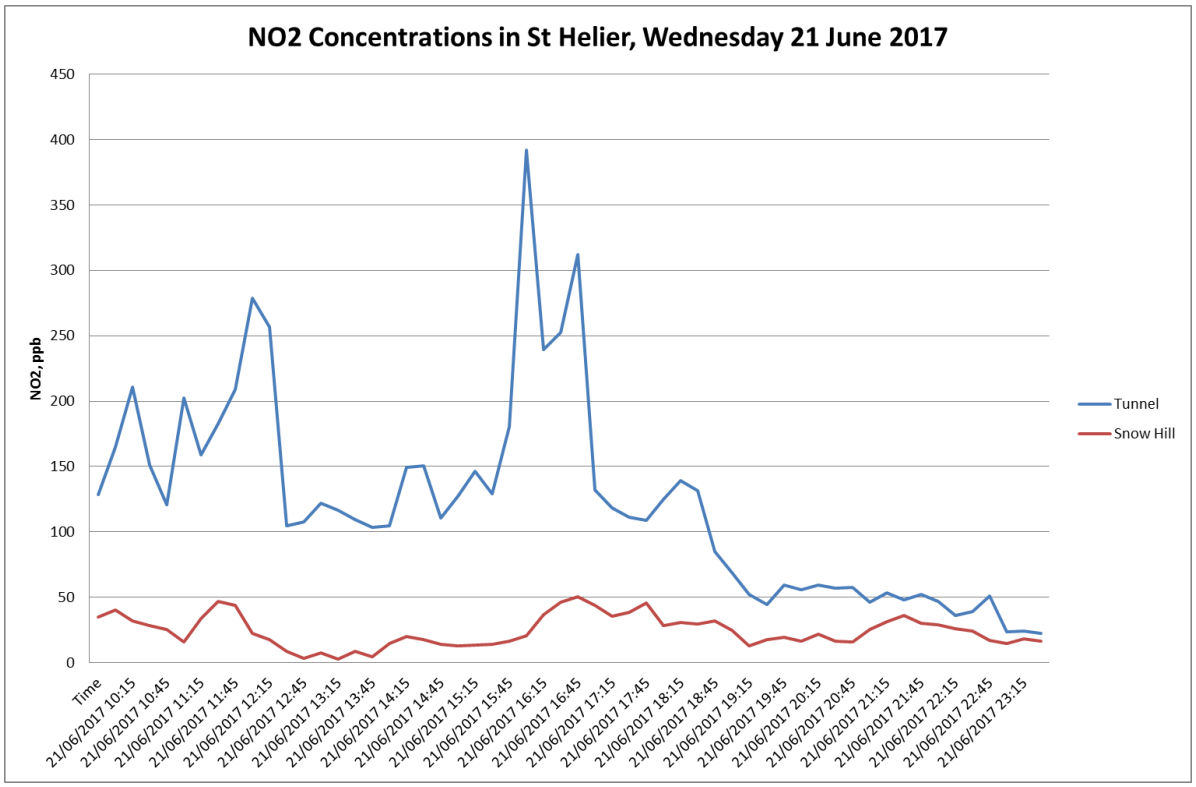
The data from the two locations are summarised in the table below:

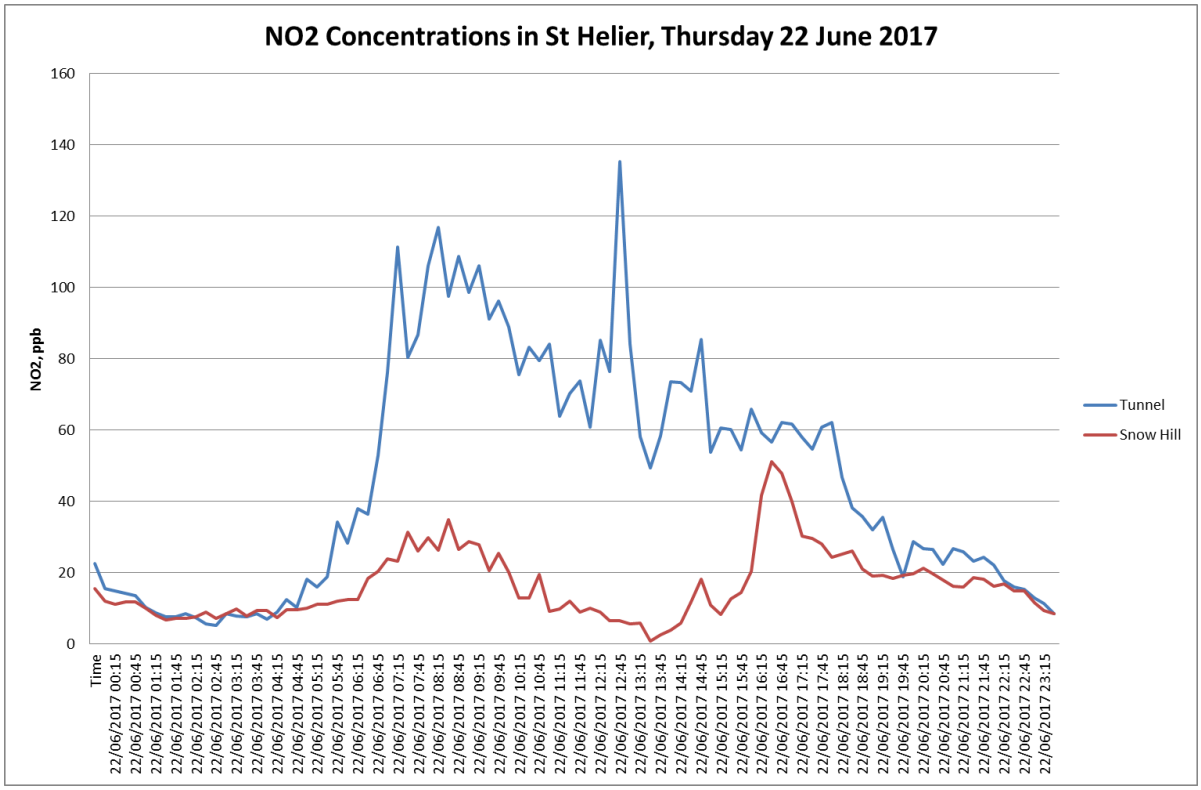
	Tunnel, ppb	Snow Hill, ppb
Survey average	59.8	16.6
Maximum 5 minute average	481.3	72.0
Wednesday average 10:00 – 19:00	161.5	25.4
Thursday average 08:00 – 19:00	74.0	19.3
Friday average 08:00 – 19:00	80.0	18.6
Saturday average 08:00 – 16:45	70.1	13.4

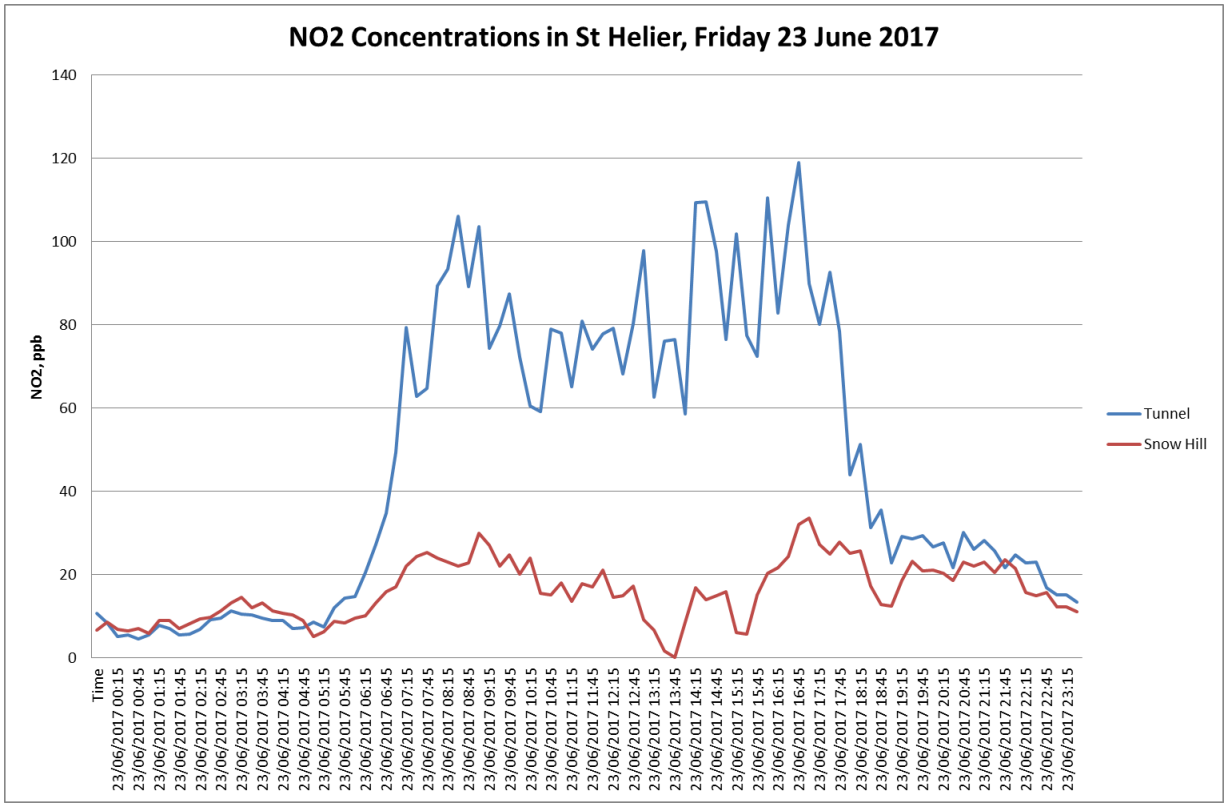
The survey timeseries data is presented below:



Daily timeseries data from the two locations, aggregated into 15 minute averages for ease of viewing, are presented below:






NO2 Concentrations in St Helier, Friday 23 June 2017
NO2, ppb
140
120
100
80
60
40
20
0
Time
23/06/2017 00:15
23/06/2017 00:45
23/06/2017 01:15
23/06/2017 01:45
23/06/2017 02:15
23/06/2017 02:45
23/06/2017 03:15
23/06/2017 03:45
23/06/2017 04:15
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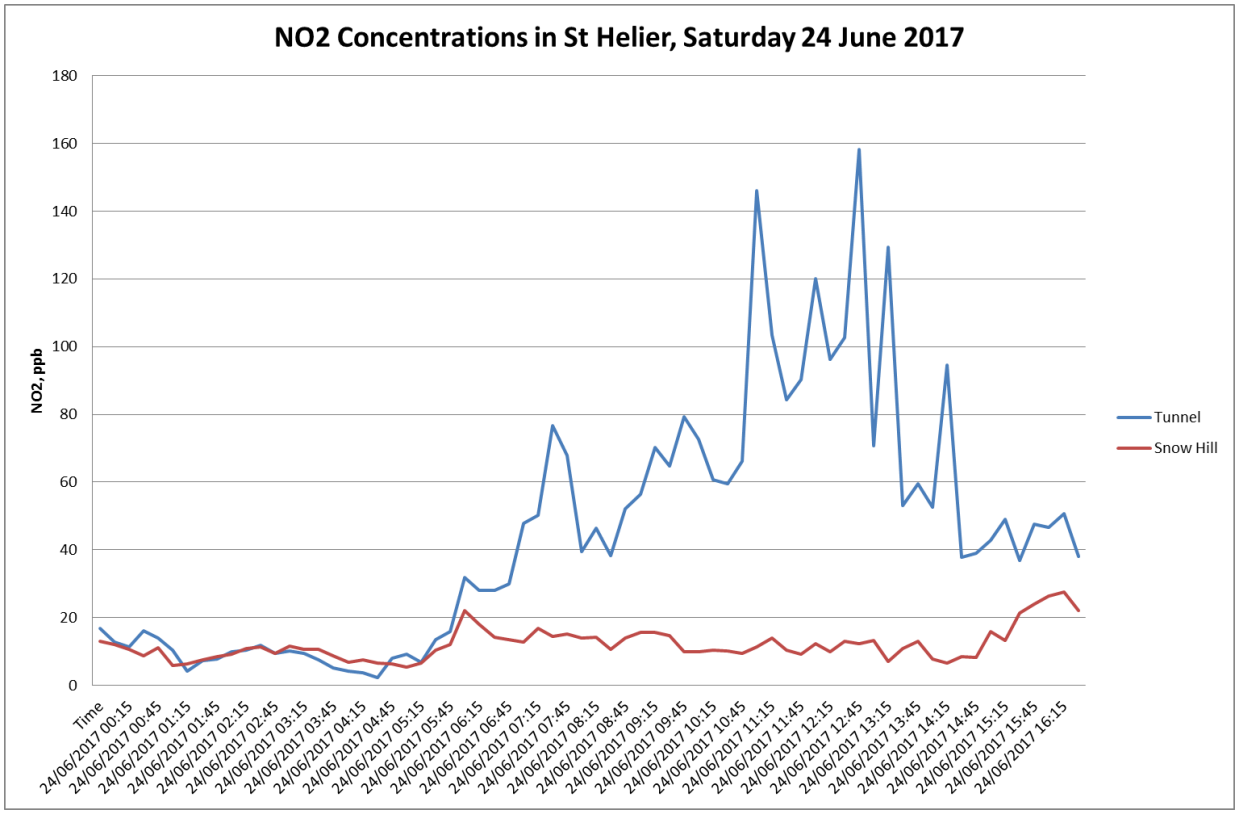
23/06/2017 21:15
23/06/2017 21:45
23/06/2017 22:15
23/06/2017 22:45
23/06/2017 23:15
Tunnel
Snow Hill


NO2 Concentrations in St Helier, Saturday 24 June 2017
NO2, ppb
180
160
140
120
100
80
60
40
20
0
Time
24/06/2017 00:15
24/06/2017 00:45
24/06/2017 01:15
24/06/2017 01:45
24/06/2017 02:15
24/06/2017 02:45
24/06/2017 03:15
24/06/2017 03:45
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24/06/2017 13:45
24/06/2017 14:15
24/06/2017 14:45
24/06/2017 15:15
24/06/2017 15:45
24/06/2017 16:15
Tunnel
Snow Hill

The following observations can be made from these datasets:

- Elevated concentrations of NO_2 in the tunnel clearly correlate with traffic density. In contrast, concentrations of NO_2 at Snow Hill show only small increases during the day
- Average NO_2 concentrations in the Tunnel are 4 times higher than at Snow Hill
- The maximum 5 minute average NO_2 concentration in the tunnel is nearly 7 times higher than the equivalent measurement at Snow Hill
- During peak vehicle activity (08:00 to 19:00), average NO_2 concentrations in the tunnel are between 4 and 6 times higher than at Snow Hill
- During the week, NO_2 concentrations in the tunnel are elevated between the hours of 06:00 and 19:00.
- On Saturday, elevated NO_2 concentrations in the tunnel were delayed somewhat compared to weekdays, likely coinciding with reduced early morning vehicle activity at the weekend.
- Overnight NO_2 concentrations at the two locations showed good agreement with each other, confirming vehicle movements are the predominant exposure source in the tunnel.
- On Wednesday 21 June, measured concentrations of NO_2 in the tunnel were consistently higher than the 1-hour WHO/EC threshold value. This observation was repeated to lesser extents on the remaining days of the survey.
- Average NO_2 concentrations in the tunnel are significantly higher than the 21ppb (40µg/m3) WHO/EC annual mean threshold value. While it is not appropriate to compare this short survey with uncalibrated sensors against an annual mean, it is still likely that this threshold will be exceeded. As noted earlier, the tunnel does not meet EC siting requirements as a suitable measurement location.
- The 1-hour threshold value was not exceeded at Snow Hill. The survey average at Snow hill was also lower than the annual mean threshold value.

In conclusion, this short survey of air quality in St Helier has shown that elevated concentrations of NO_2 and Particulate Matter are likely to be experienced in the tunnel throughout a normal working day. These elevated concentrations coincide with vehicle movements in the tunnel; when vehicle movements drop to zero overnight, concentrations return to background levels.

Pedestrian exposure in the tunnel is likely to last in the order of 3 minutes, for a fit person. Depending on congestion, travelling through the tunnel by bicycle or vehicle is likely to take around 1 minute.

Measurements at Snow Hill were significantly lower than in the tunnel. A fit person could walk from the tunnel entrance to Liberation Square in 8 minutes and be exposed to 75% lower NO_2 concentrations of those in the tunnel.

A brief study of the differences in travel modes through the tunnel revealed that driving through the tunnel with windows closed and ventilation off was likely to be the best approach to minimising exposure. This is still likely to be higher than choosing an alternative route.

The survey gives valuable insight into the role that traffic plays in exposure of the general population, it does not provide any detail about the emissions performance of individual vehicles. The very latest measurement technologies are able to provide information in real time about individual vehicle emissions, and compare these against stated manufacturer performance. Further details of these measurement surveys can be provided separately.

I hope that this information is useful. If you need any further details, or have any questions about the study, please do not hesitate to get in touch.

Best wishes,

Brian Stacey,

Knowledge Leader, Air Quality Measurements