Transport Infrastructure and Air Pollution Exposure for Urban Commuters

Transport Knowledge Hub

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THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

MEDICAL AND HEALTH SCIENCES

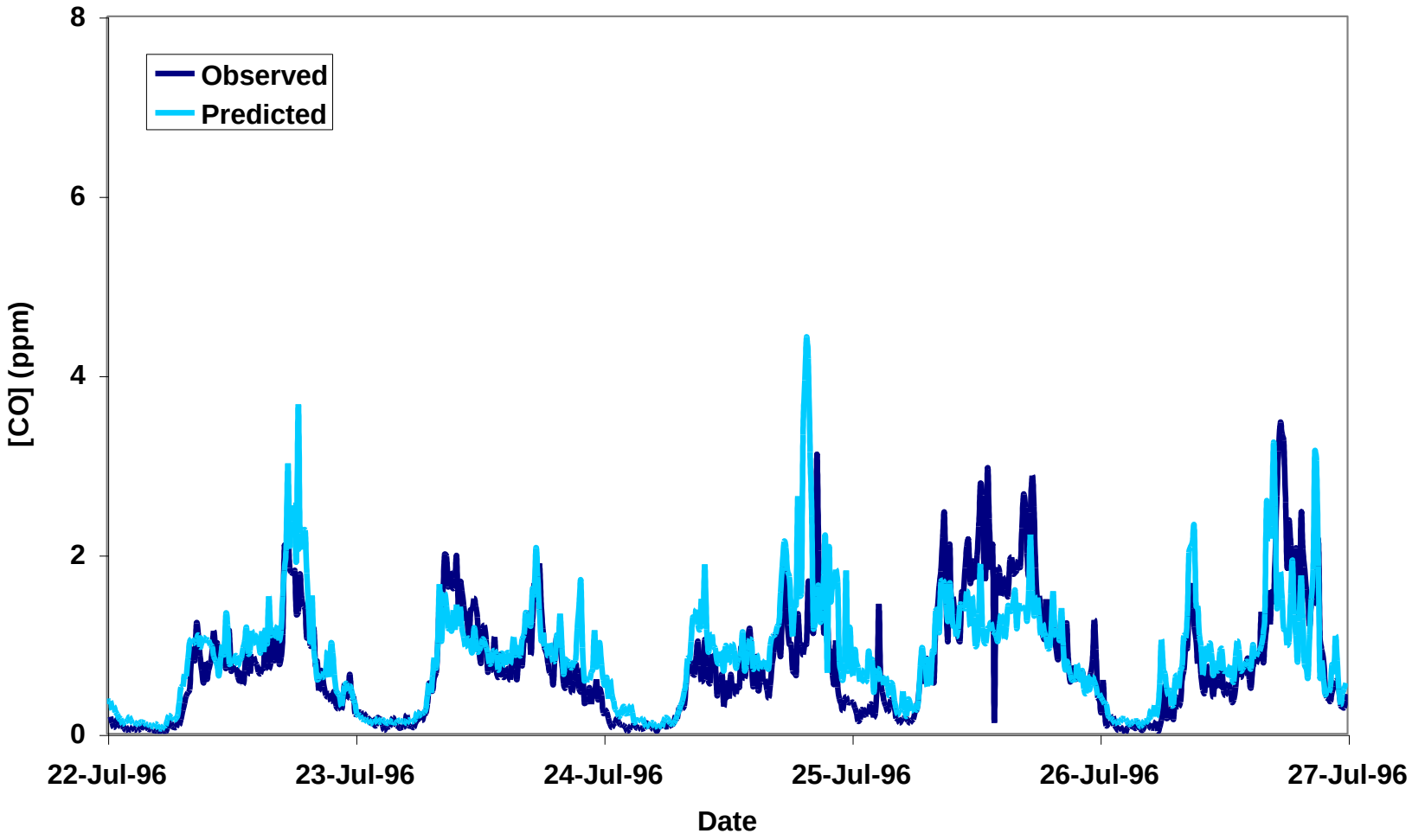
https://www.bikeradar.com/advice/buyers-guides/whats-the-best-bike-for-commuting/

Outline

- Results of recent research projects investigating the implications for urban planning and route optimisation associated with air pollution exposure, including the walking journey to school and travel to work via active modes.

- Some cost-effective strategies for minimising exposure will be presented as well as the air pollution exposure implications of large-sale infrastructure developments

How well can we model roadside air pollution?



DIRKS, K.N., JOHNS, M.D., HAY, J.E., STURMAN, A.P. (2002) 'A semi-empirical model for predicting missing carbon monoxide concentrations'. *Atmospheric Environment* 36(39-40), 5953-5959. DOI:10.1016/S1352-2310(02)006767-7

How well can we model the uptake of air pollution?

The Coburn, Forster and Kane (1965) model is known as the "best all round model for the prediction of COHb levels from CO concentrations" (WHO, 1999).

$$V_B \frac{d[COHb]}{dt} = V_{co} - \frac{[COHb]}{[O_2Hb]} \frac{P_CO_2}{MB} + \frac{P_ICO}{B}$$

$$B = \frac{1}{D_LCO} + \frac{P_L}{V_A}$$

Rate of change of COHb

Endogenous production

Removal of COHb

Uptake due to exposure to CO

M is the Haldane ratio

P_L is the pressure of dry gases in the lungs (713 mmHg)

V_B is the blood volume (5500 mL)

D_LCO is the pulmonary diffusing capacity for CO (30 mL/min mmHg)

P_ICO is the partial pressure of CO in inhaled air (mmHg)

V_{CO} is the endogenous production of CO (0.007 mLCO/min)

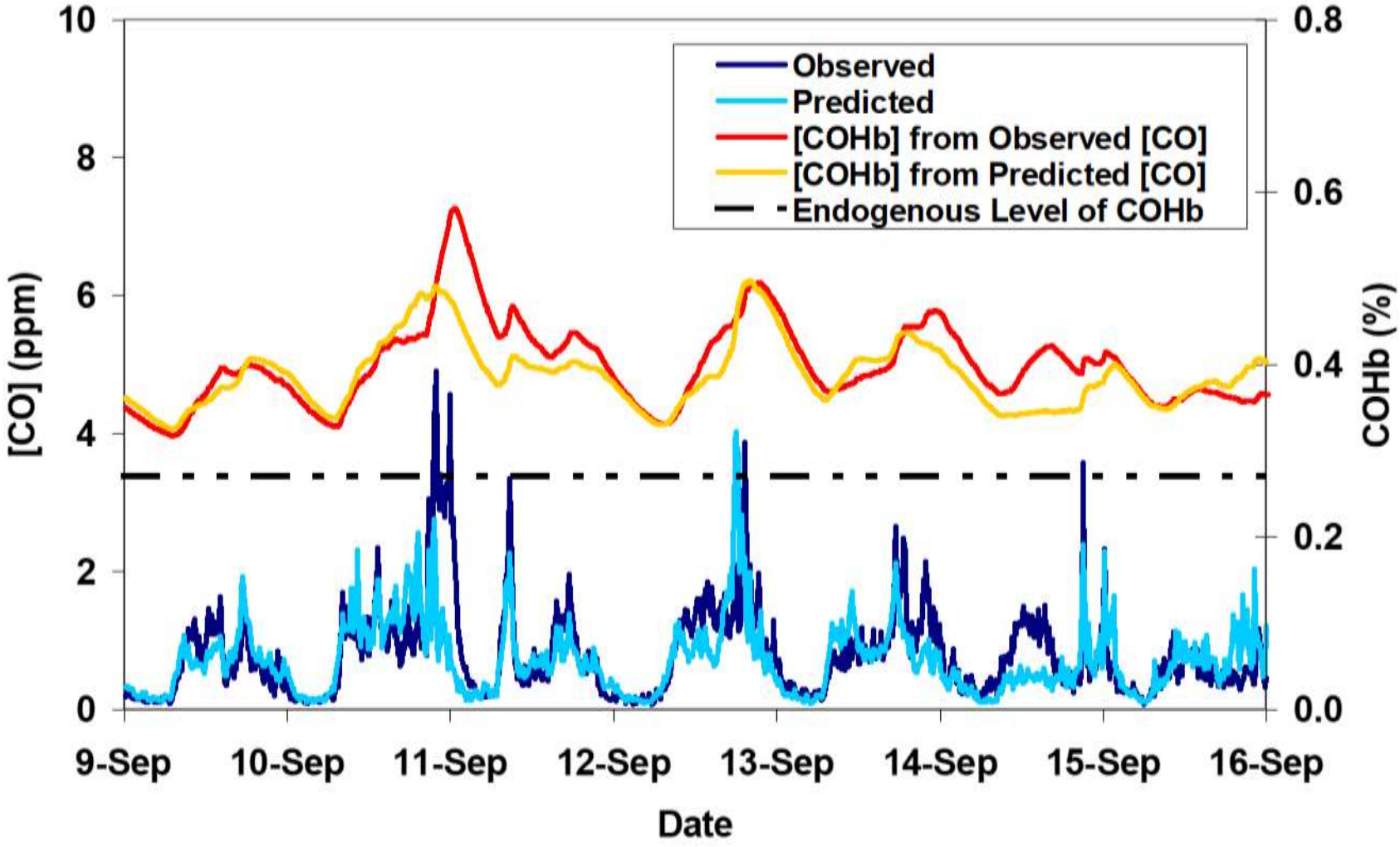
[COHb] is the volume of CO per volume of blood (mLCO/mL blood)

P_cO_2 is the average partial pressure of O_2 in the lung capillaries (100 mmHg)

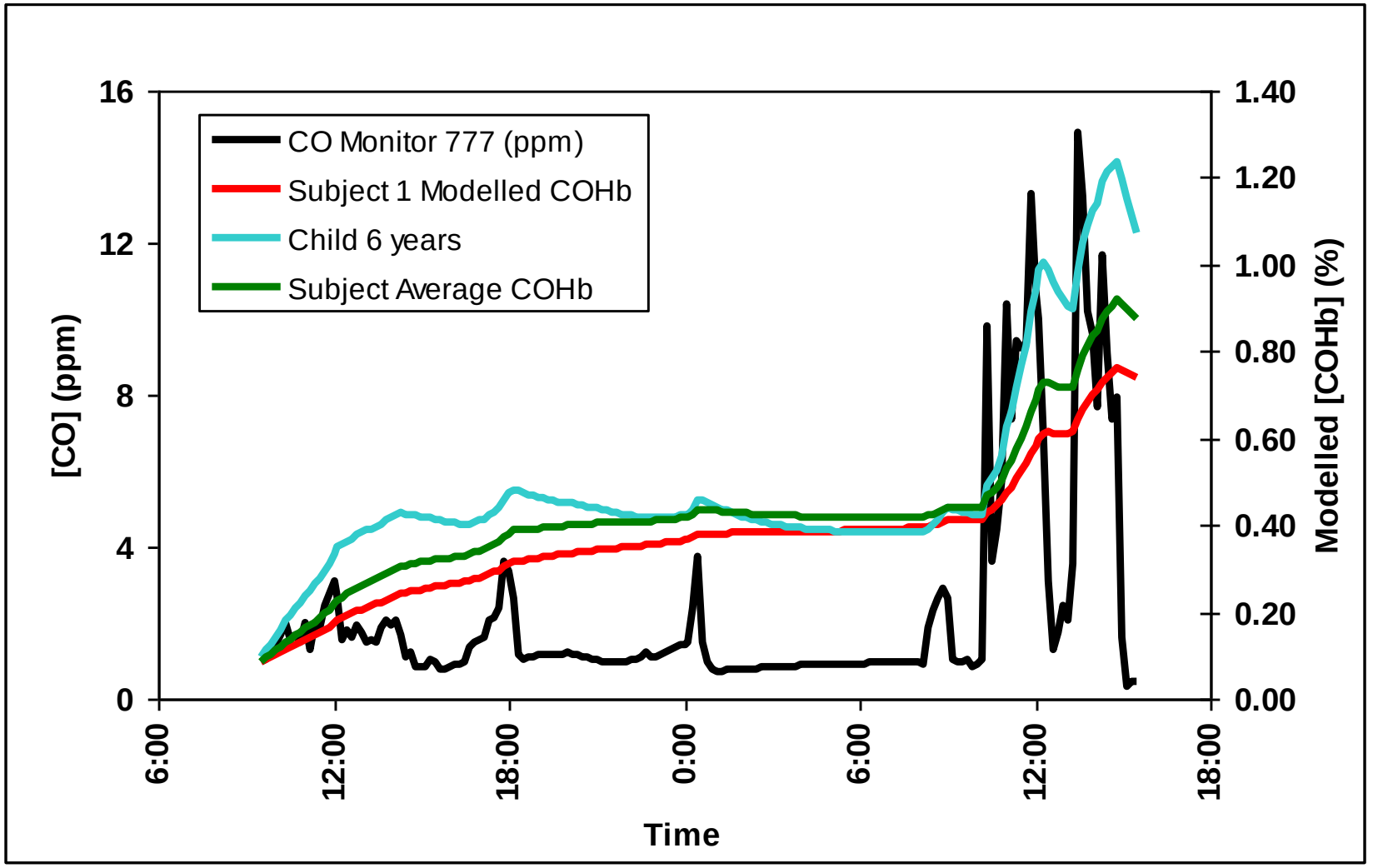
$[O_2Hb]$ is the maximum volume of O_2 per mL of blood (0.2 mL O_2/mL blood)

V_A is the alveolar ventilation rate (sleeping 300 mL/min, light work 500 mL/min)

COHb Modelling



COHb Modelling

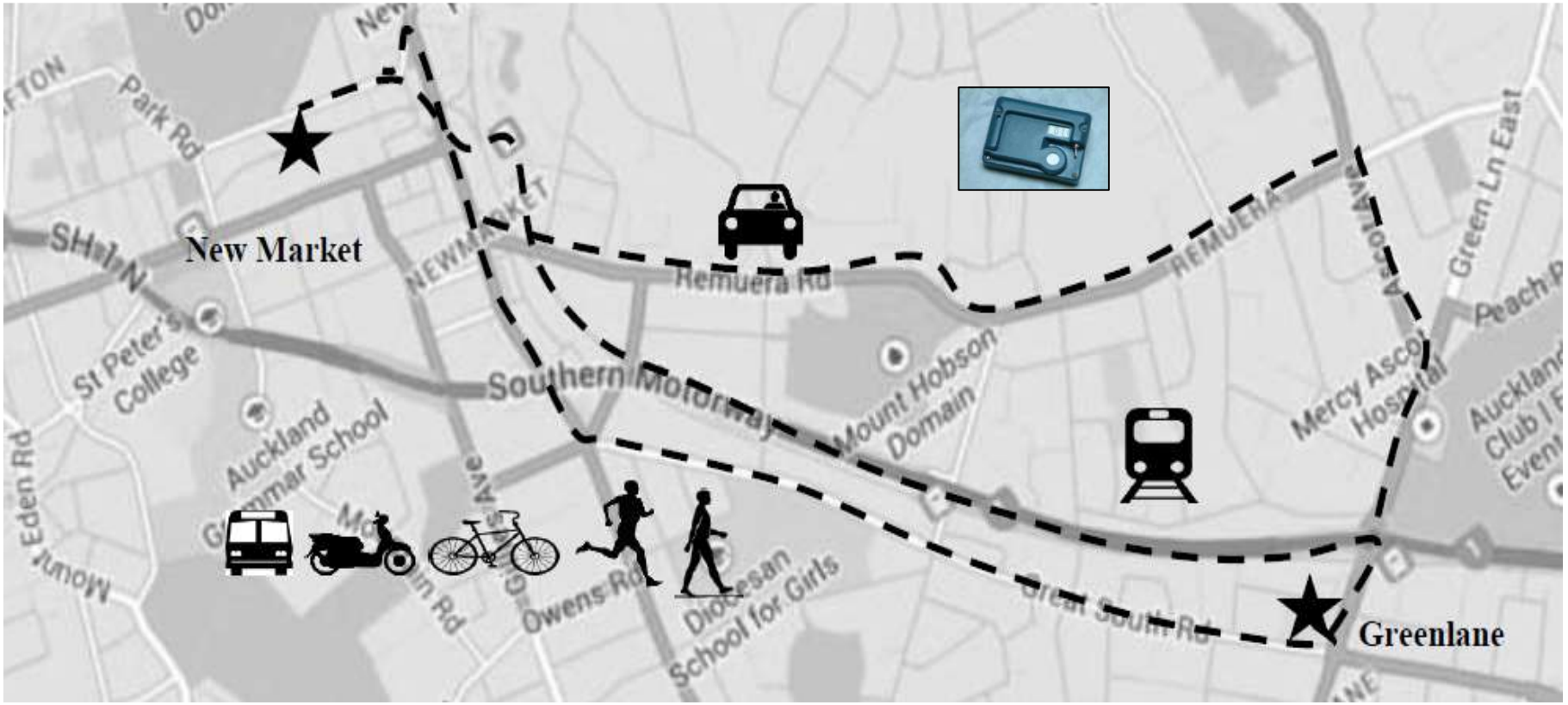


DIRKS et al (2009) 'Blood carboxyhemoglobin levels as a biomarker for urban air pollution'
International Conference on Southern Hemisphere Meteorology and Oceanography, Melbourne, February 2009


GPS
P-Trak Ultrafine
Particle Counter
CO Langan
Noise dosimeter

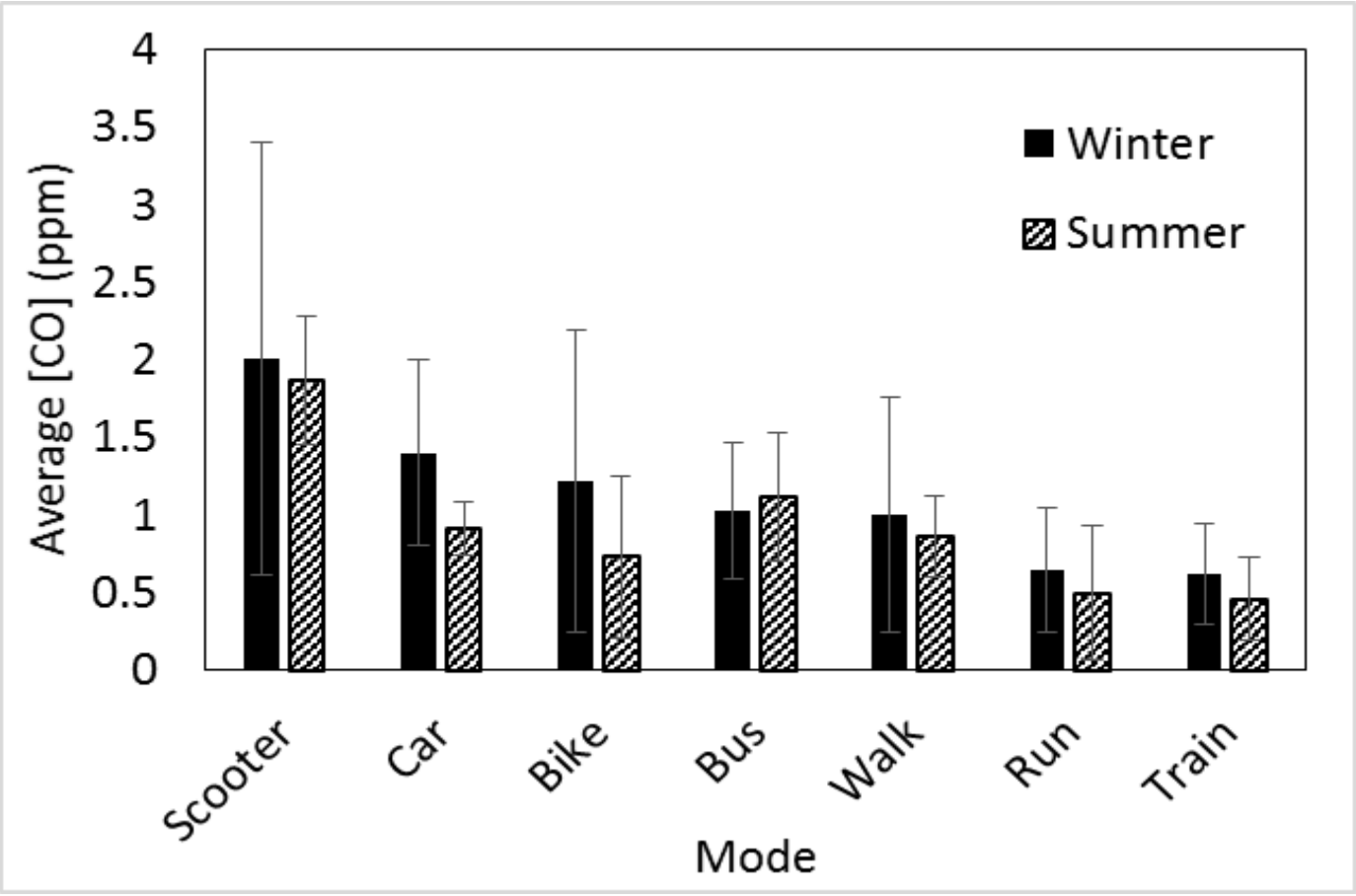
Mode Choice

Seven Modes Study
A 5-km journey along a popular commuting route –
7 modes, summer and winter data collection, carbon monoxide
(*Illustrative…*)



PEYROUX, C., BUSSEN, L., COSTELLO, S.B., DIRKS, K. N. (2015) Exposure to traffic pollution while commuting – Does mode matter*? Weather & Climate,* 35, 2-12.

When looking at average air pollution exposure….



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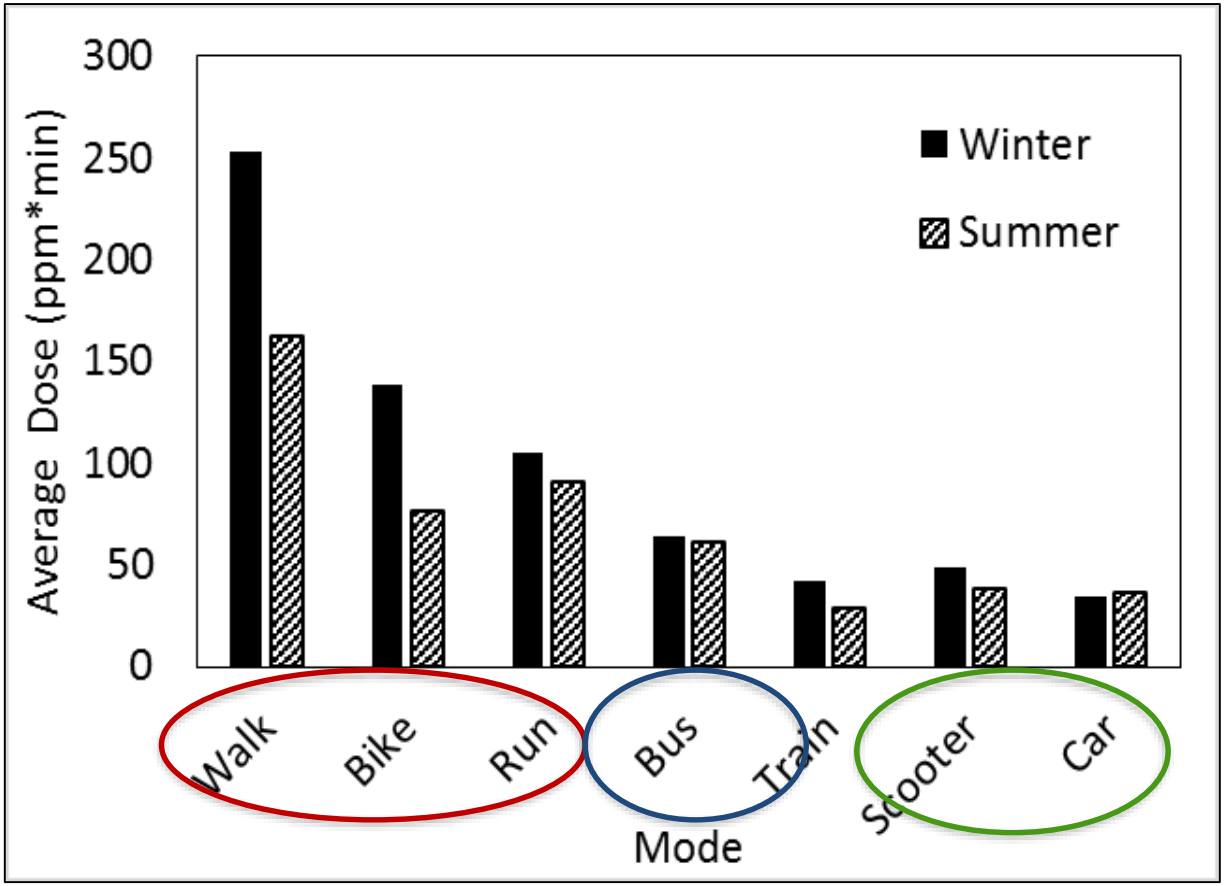
When taking into account breathing rate and travel time….



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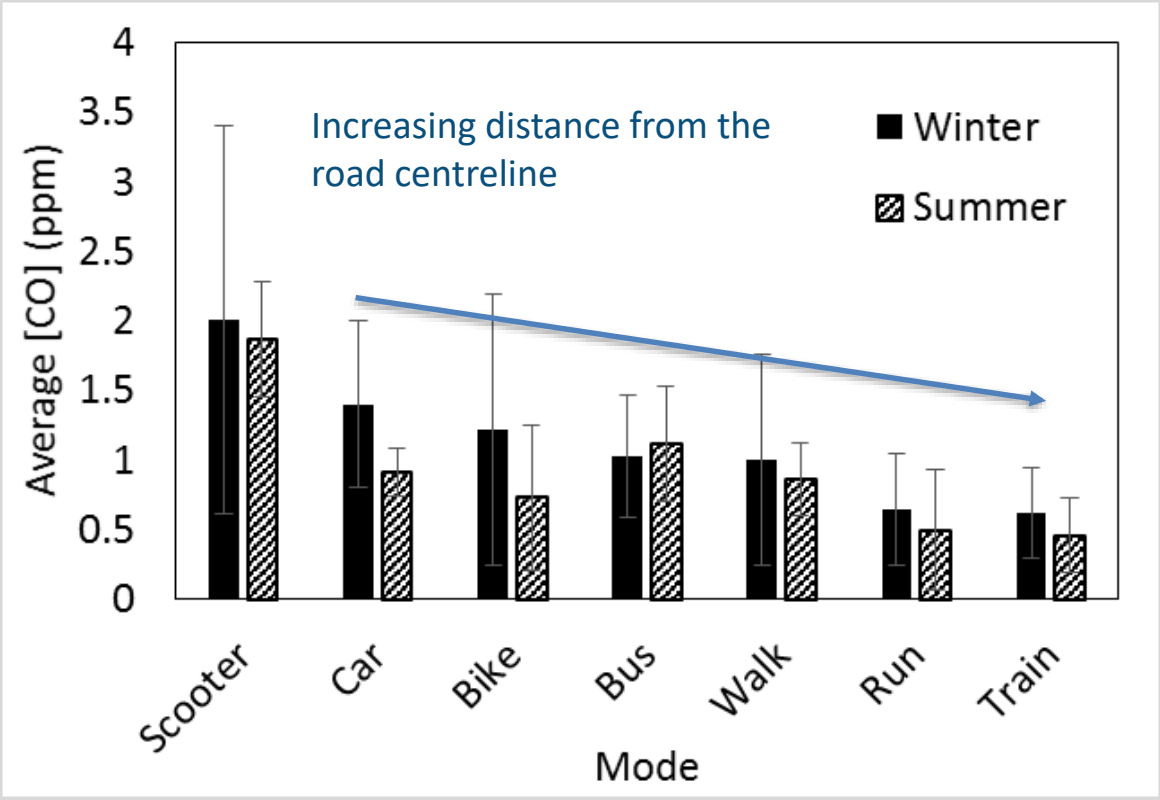
Route Choice

When looking at average air pollution exposure….



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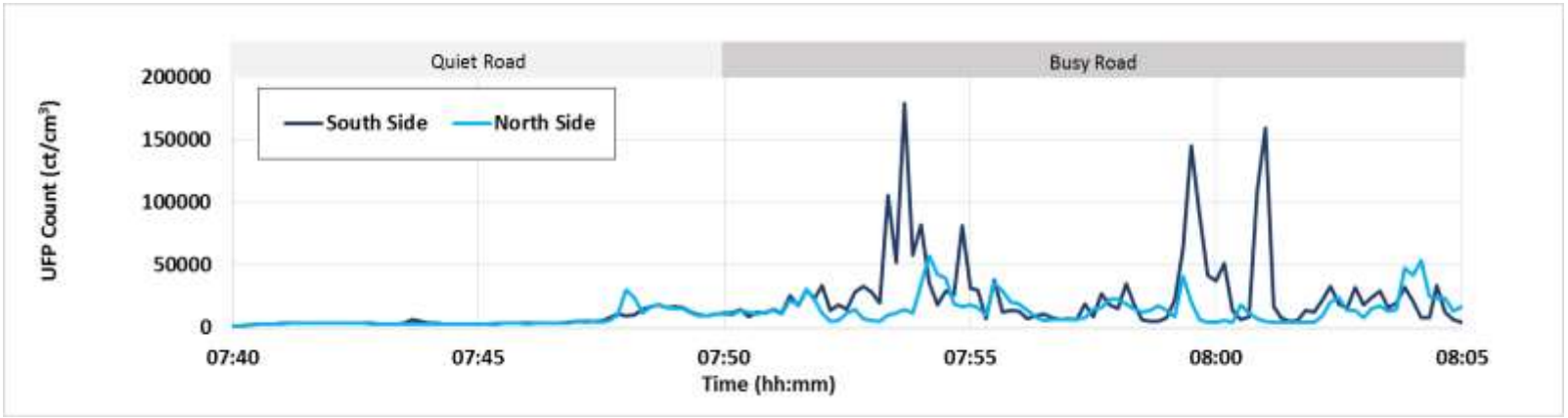
Air Pollution Exposure in Walking School Bus Routes: A New Zealand Case Study



DIRKS, K.N., SALMOND, J.A., TALBOT, N. Air pollution exposure in walking school bus routes: a New Zealand case study. IJERPH, 15(2802) DOI:10.3390/ijerph15122802.

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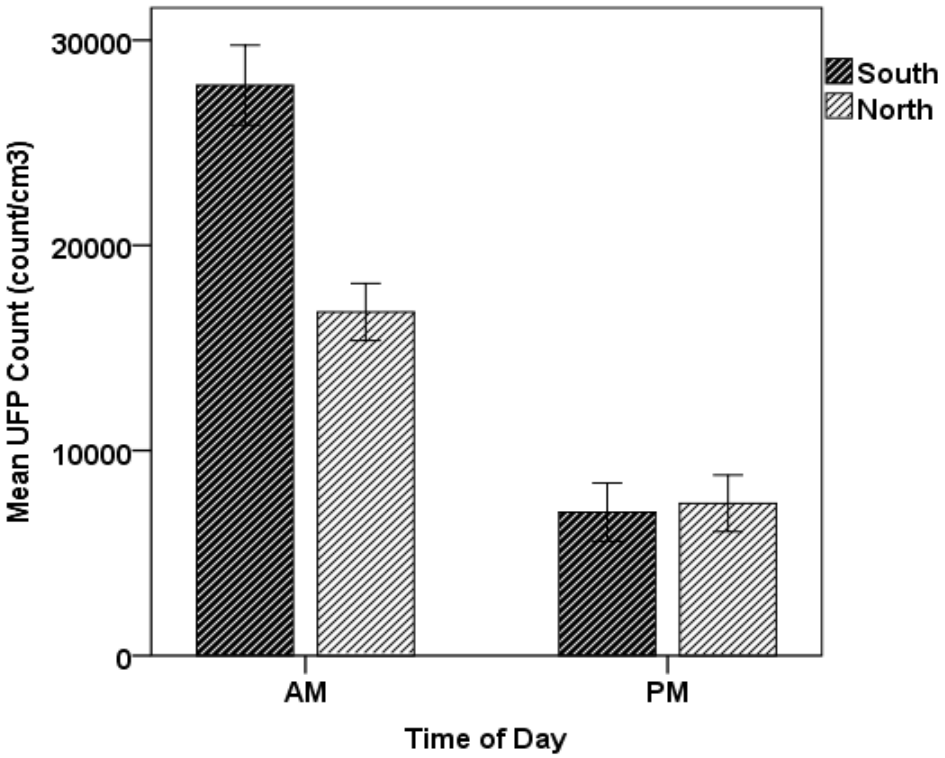

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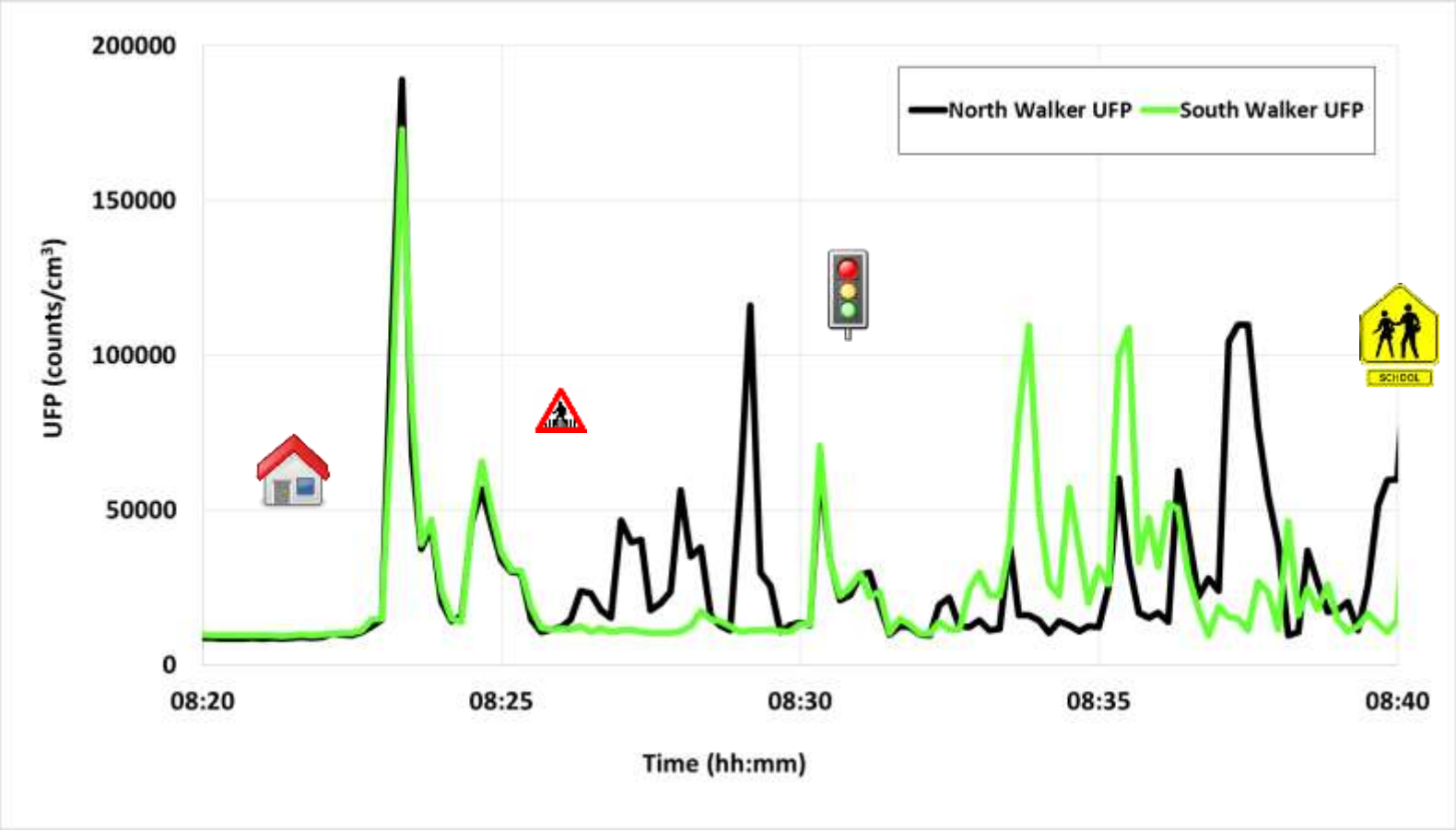
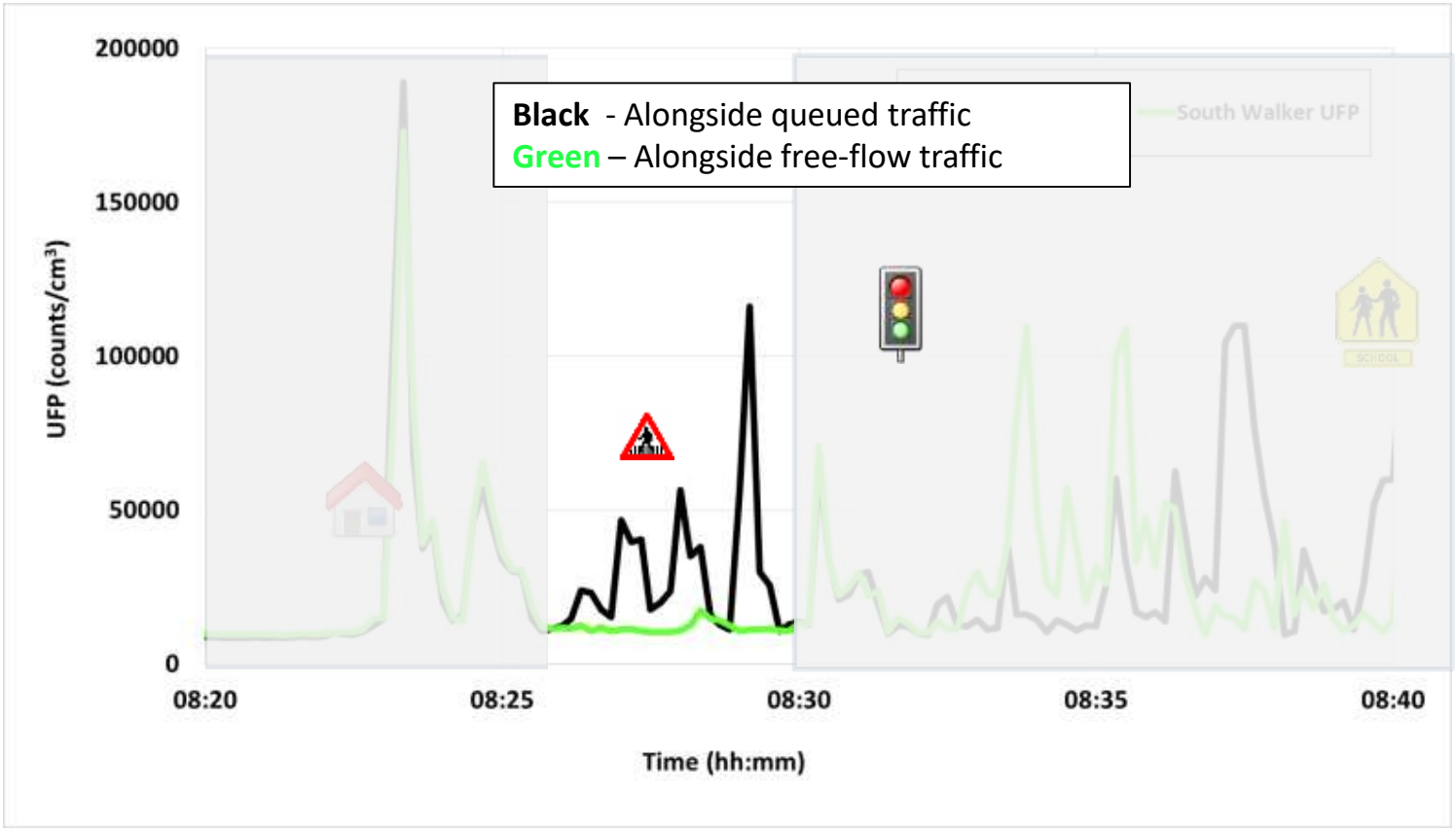
Air Pollution Exposure in Walking School Bus Routes: Bradford, UK



Dirks, K. N., Wang, J.Y.T., Khan, A., **Rushton**, C. (2016) Air pollution exposure in relation to the commute to school: a Bradford UK Case Study. IJERPH, 13, 1064. DOI:10.3390/ijerph13111064.

Air Pollution Exposure in Walking School Bus Routes: Bradford, UK



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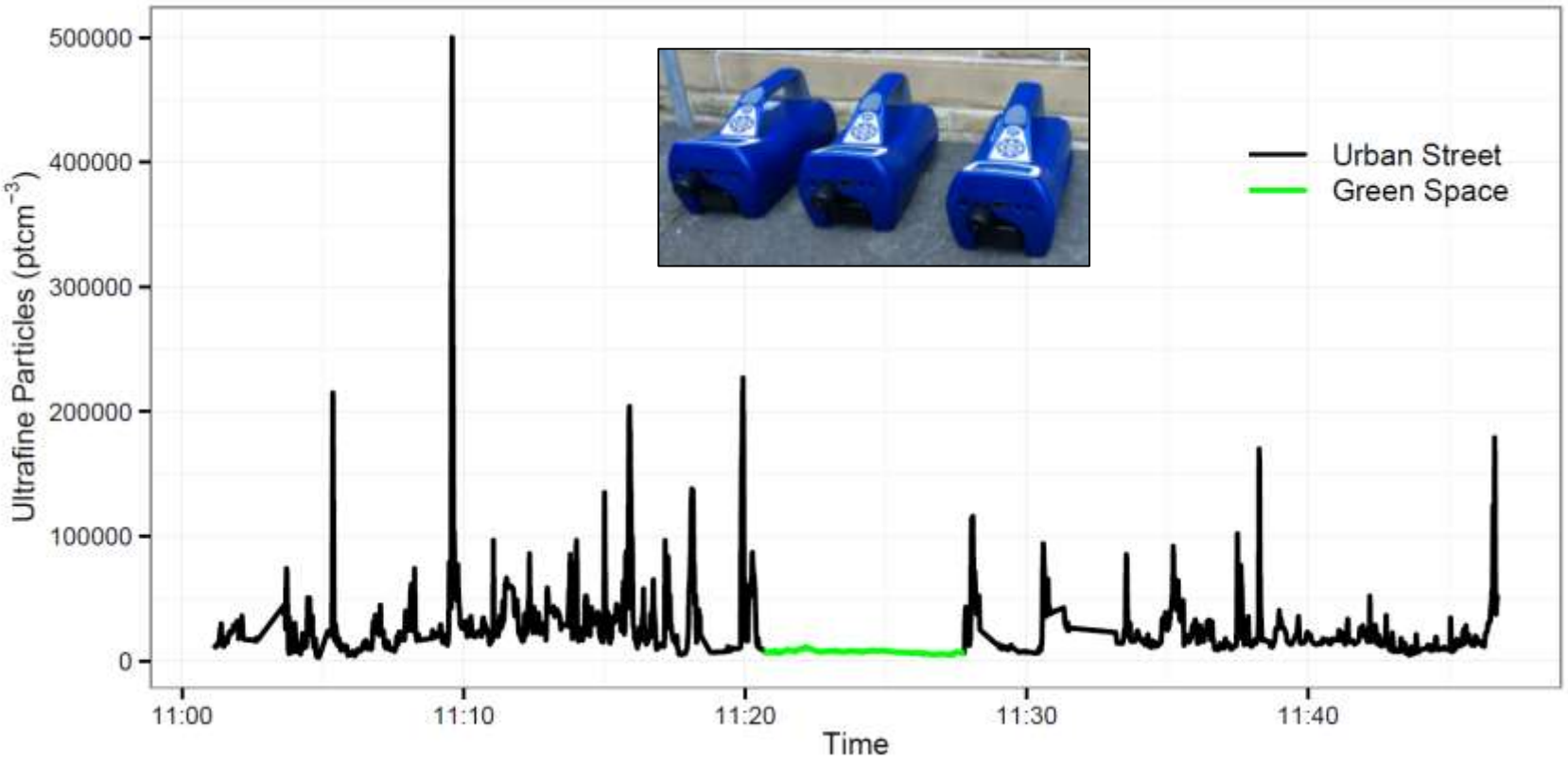
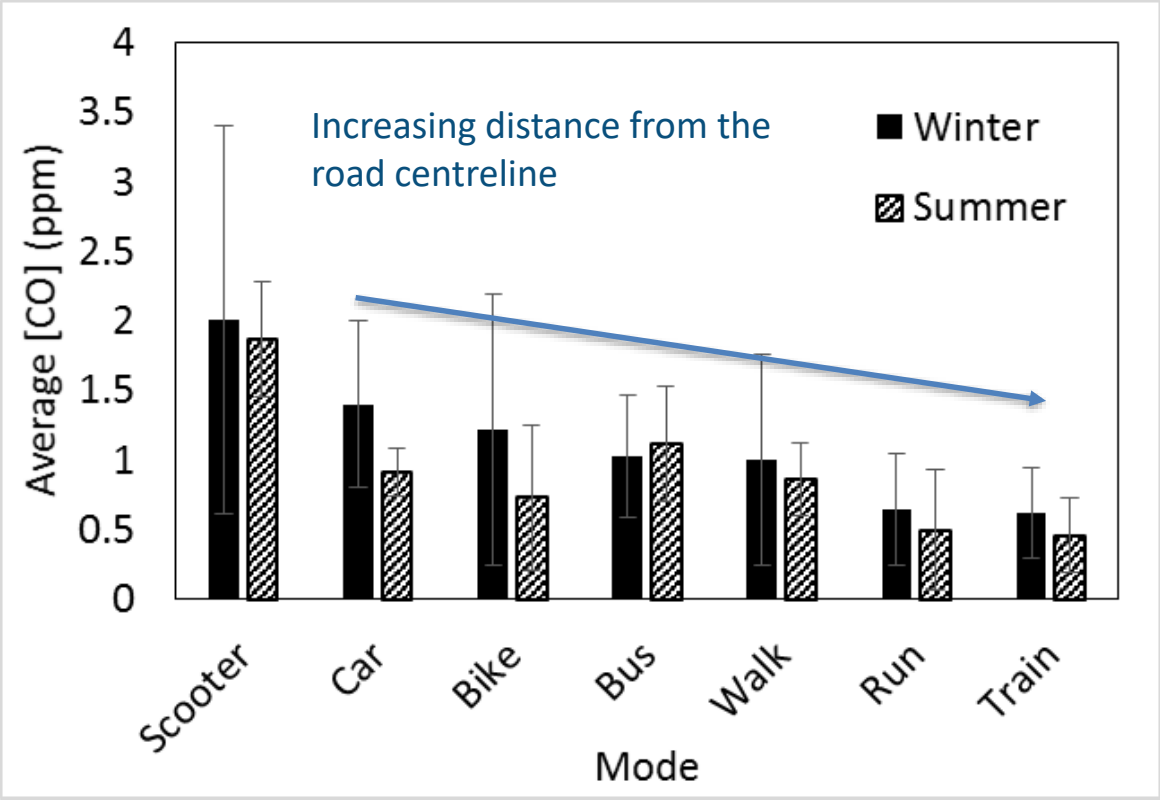
Air pollution exposure while walking through a park



Lin , H. 2013 Exposure of school children to traffic-related ultrafine particles during travel to school and school hours. Masters Thesis, University of Auckland, Faculty of Science,

The Role of Urban Design and Transport Infrastructure

When looking at average air pollution exposure….



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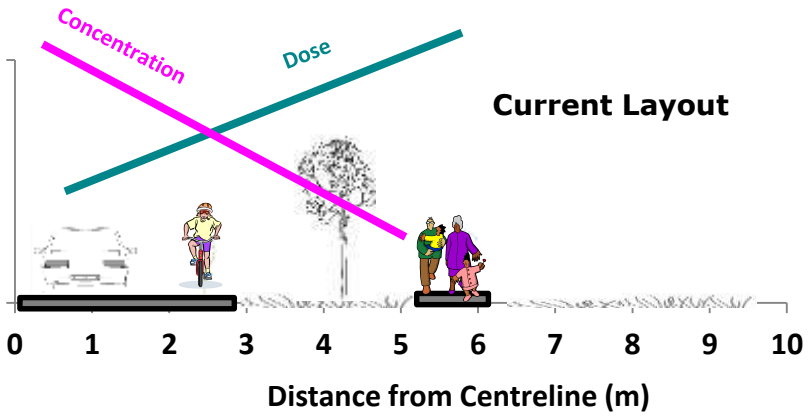
Meola Road Layout Design for Equal Air Pollution Dose



2014. GRANGE, S.K., DIRKS, K.N., COSTELLO, S.B., SALMOND, J. Cycleways and footpaths: what separation is needed for equivalent air pollution dose between modes? *Transportation Research Part D: Transport and Environment.* 32, 111-119. DOI:10.1016/j.trd.2014.07.014.

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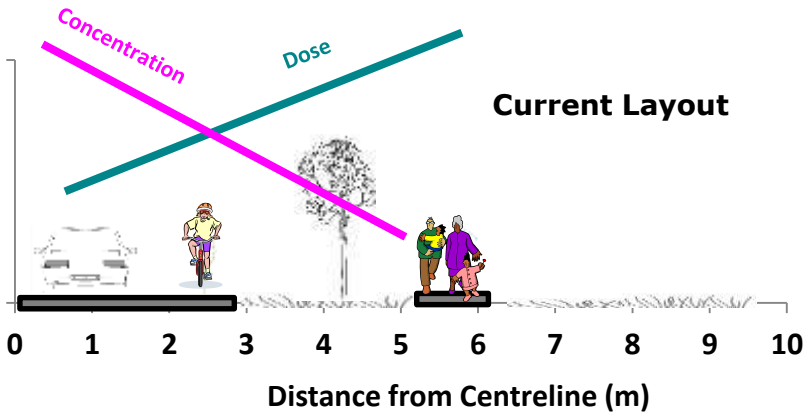

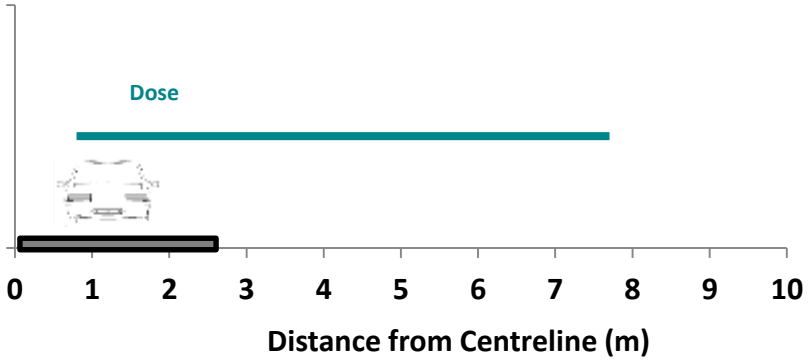

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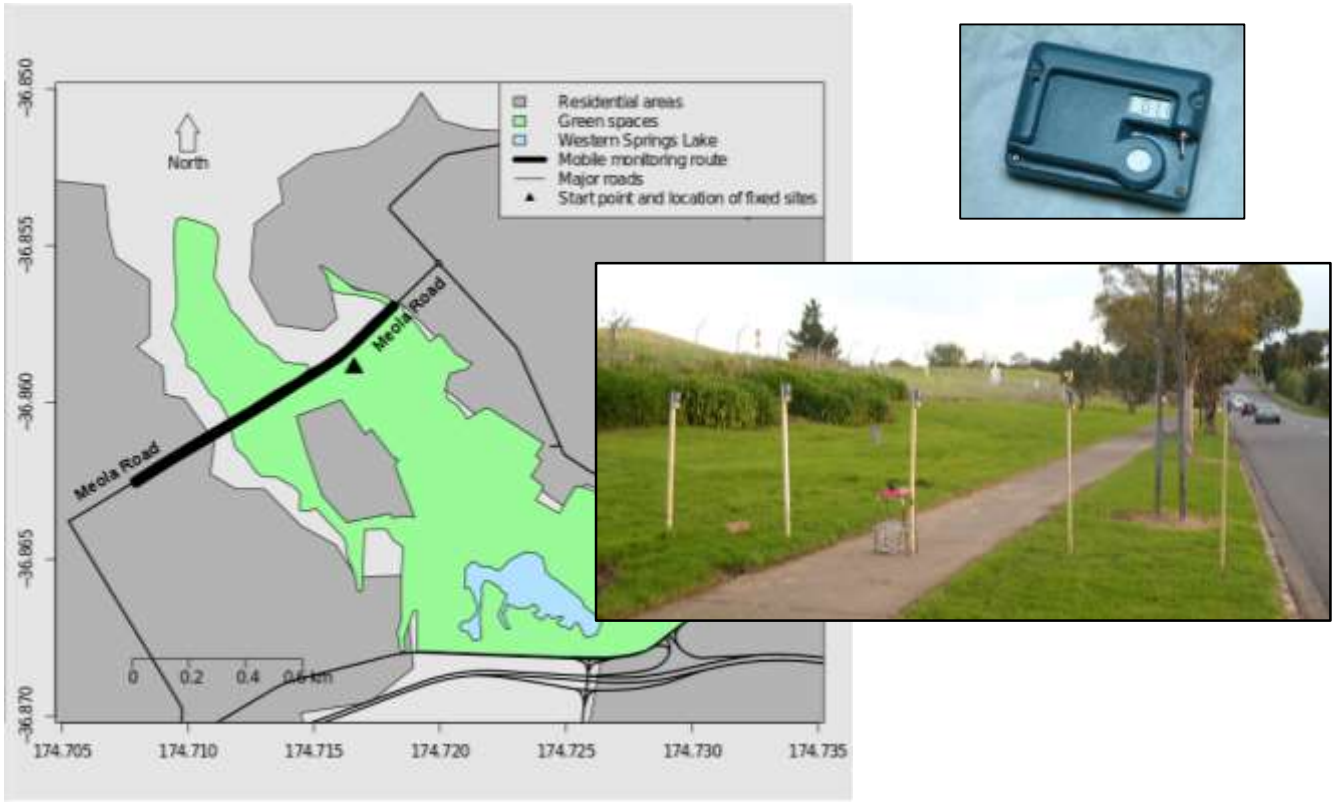
Meola Road, Pt Chevalier Study



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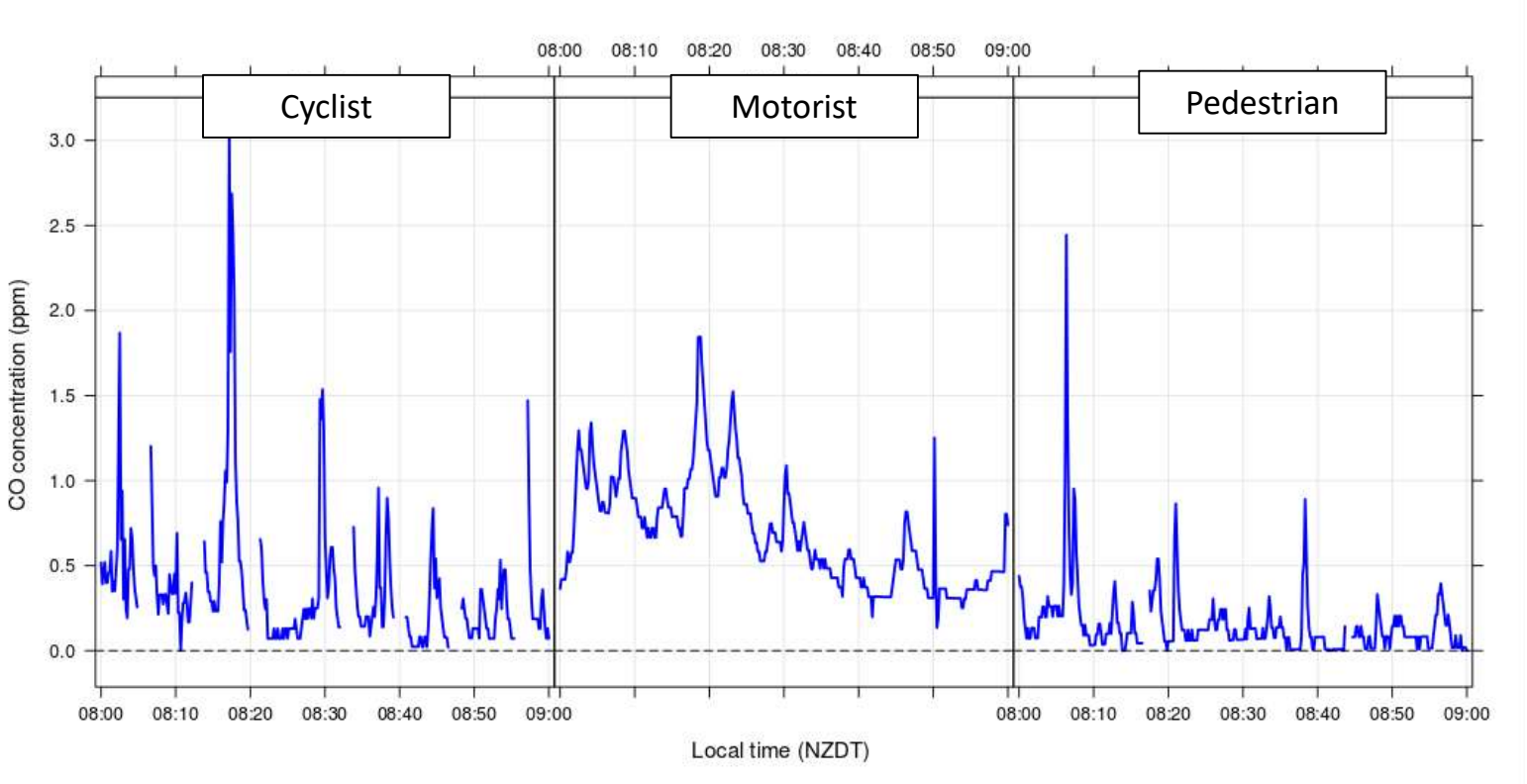
Time Series of Concentrations for Three Modes of Commuting



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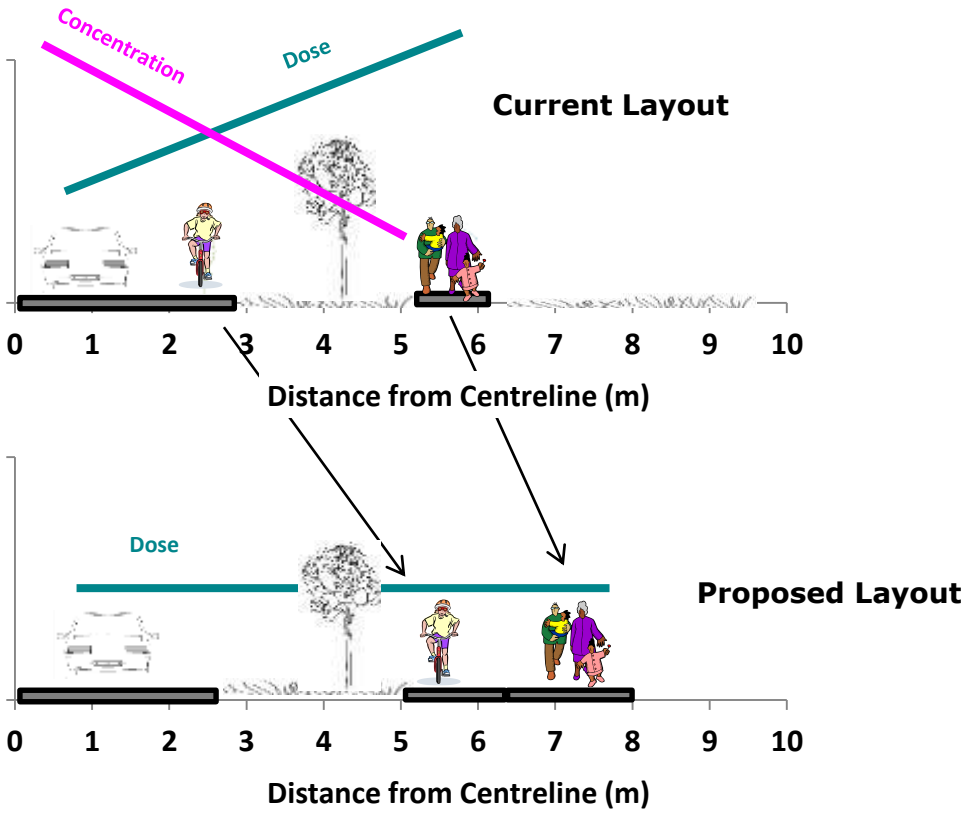

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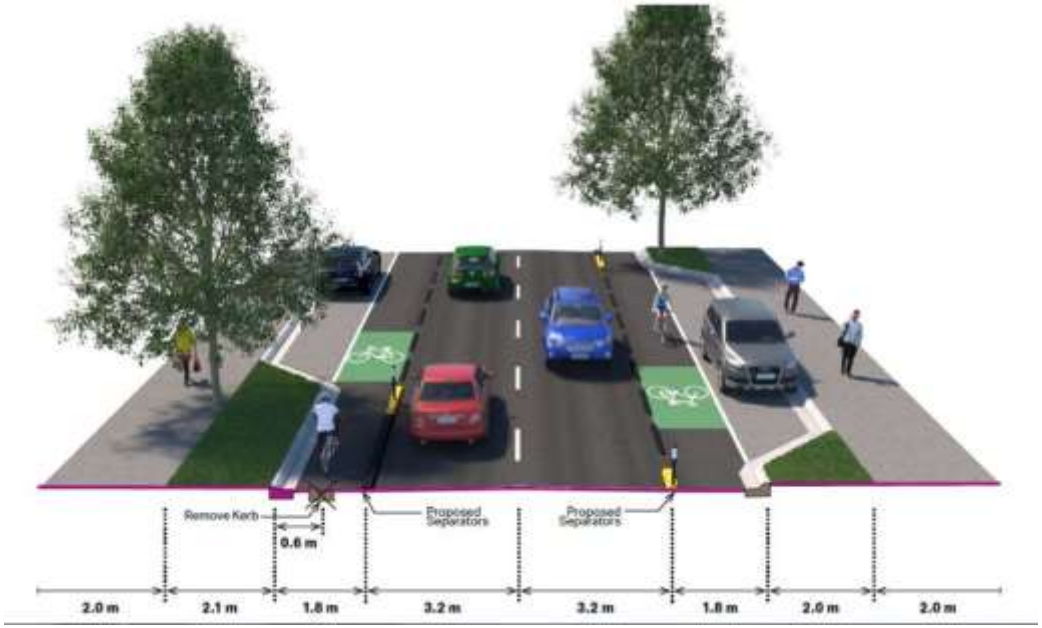
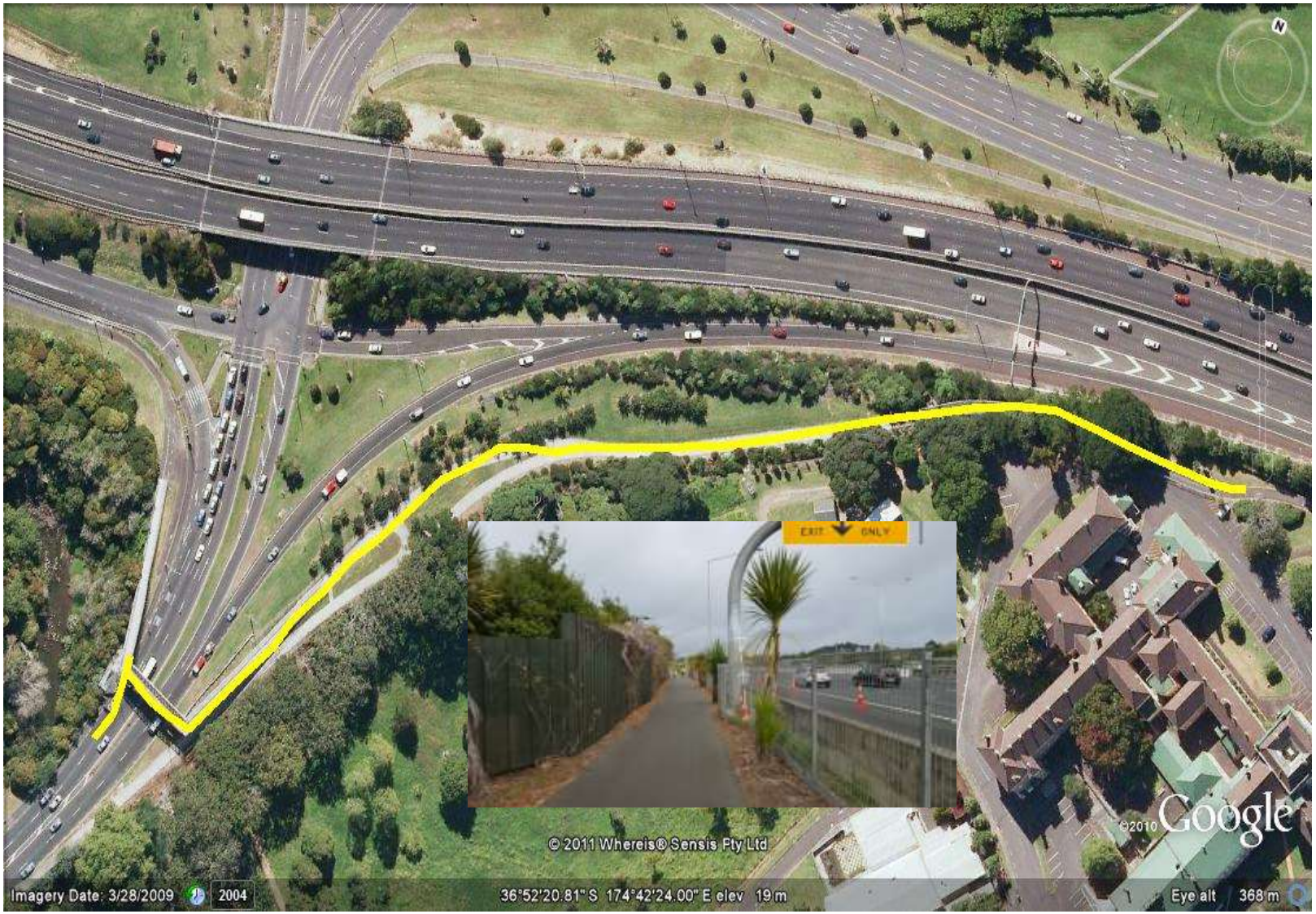
Meola Road, Pt. Chevalier (proposed)



https://at.govt.nz/projects-roadworks/pt-chevalier-to-westmere/#map

Innsbruck, Austria

Northwestern Motorway



Dedicated Lanes for Cyclists

https://www.bikeauckland.org.nz/i-see-your-auckland-protected-lane-and-raise-you-a-copenhagen-one/

Dedicated Cycleway/Footbath – Grafton Gully

Northern Busway

T2/T3/Bus Lanes

City Rail Link

https://www.cityraillink.co.nz/crl-presentations/

Queen Street-Walkability

https://commons.wikimedia.org/wiki/File:Queen_Street,_Auckland.jpg

Strategies for Minimising Traffic-Related Air Pollution for Active Mode Commuters

- Increase separation from road traffic
- Avoid walking/cycling routes alongside queued traffic
- Avoid waiting time at traffic lights

Impacts of Travel Choice