Reducing Exposure to Air Pollution from Public Transportation: A Partnership Between Translink, GIRO and UBC

Brian Gouge, Francis Ries & **Hadi Dowlatabadi**
The University of British Columbia, Vancouver

Charles Fleurent, Julie Suprenant & **Pierre Trudeau**
GIRO Inc. Montreal

David Gourley & Dave Leicester
Translink (South Coast British Columbia Transportation Authority)

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Let’s get people out of cars...

Photograph by: Ian Smith, Vancouver Sun files

...same storyline as before

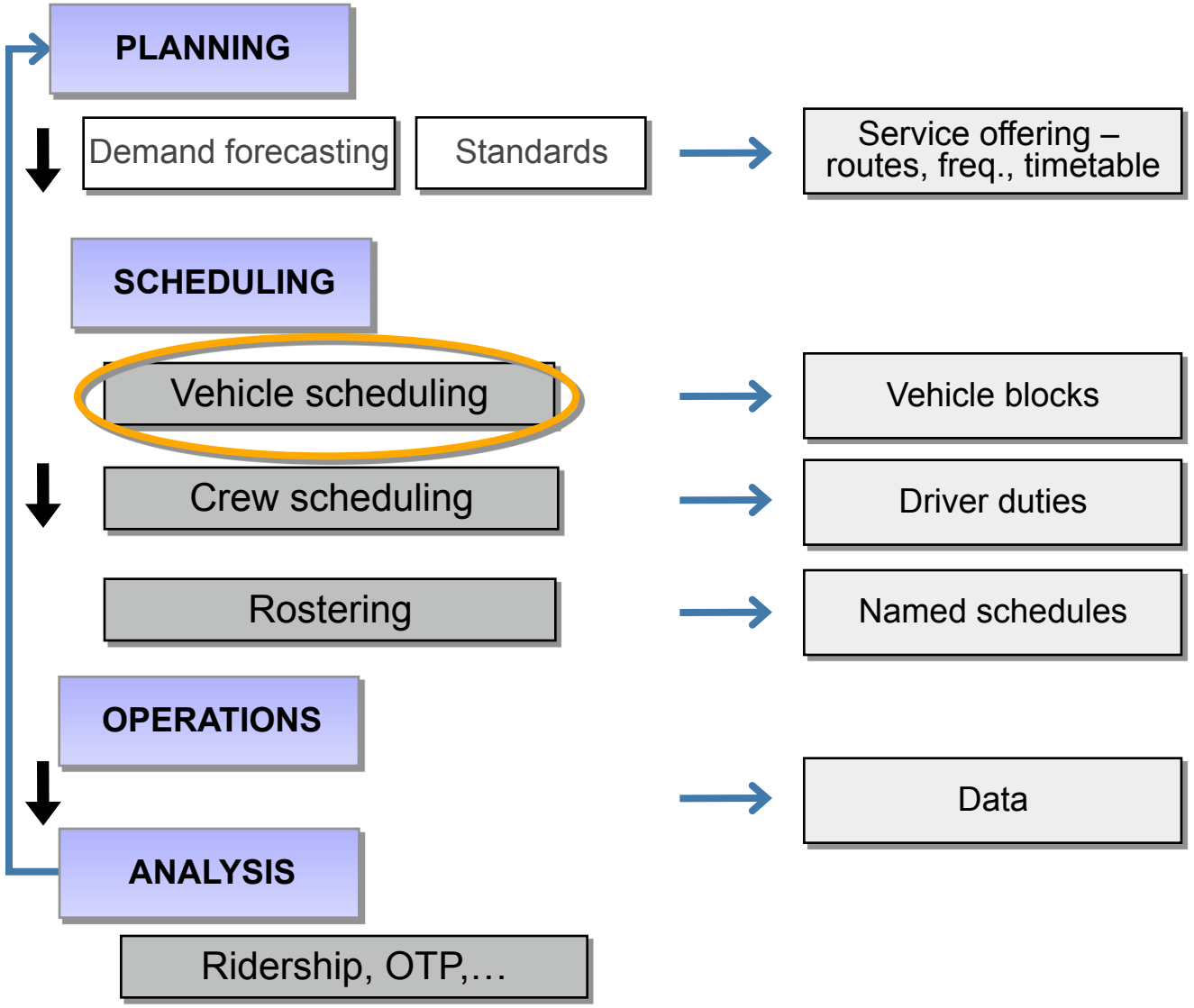
- Public transit and active transportation promoted as GHG mitigation option, but...
- Earlier we studied the impacts of United Kingdom GHG policy targeting private automobiles
  - 400 kt/yr of GHG reductions
    + ~90/yr early deaths due to poorer AQ
    + ~30% increase in 2-car collision fatalities.

    [E. Mazzi, H. Dowlatabadi, *Environ. Sci. Technol.* 41, 387 (2007) …]
- Getting people out of their cars will save GHGs, but is it a recipe for a healthier public?

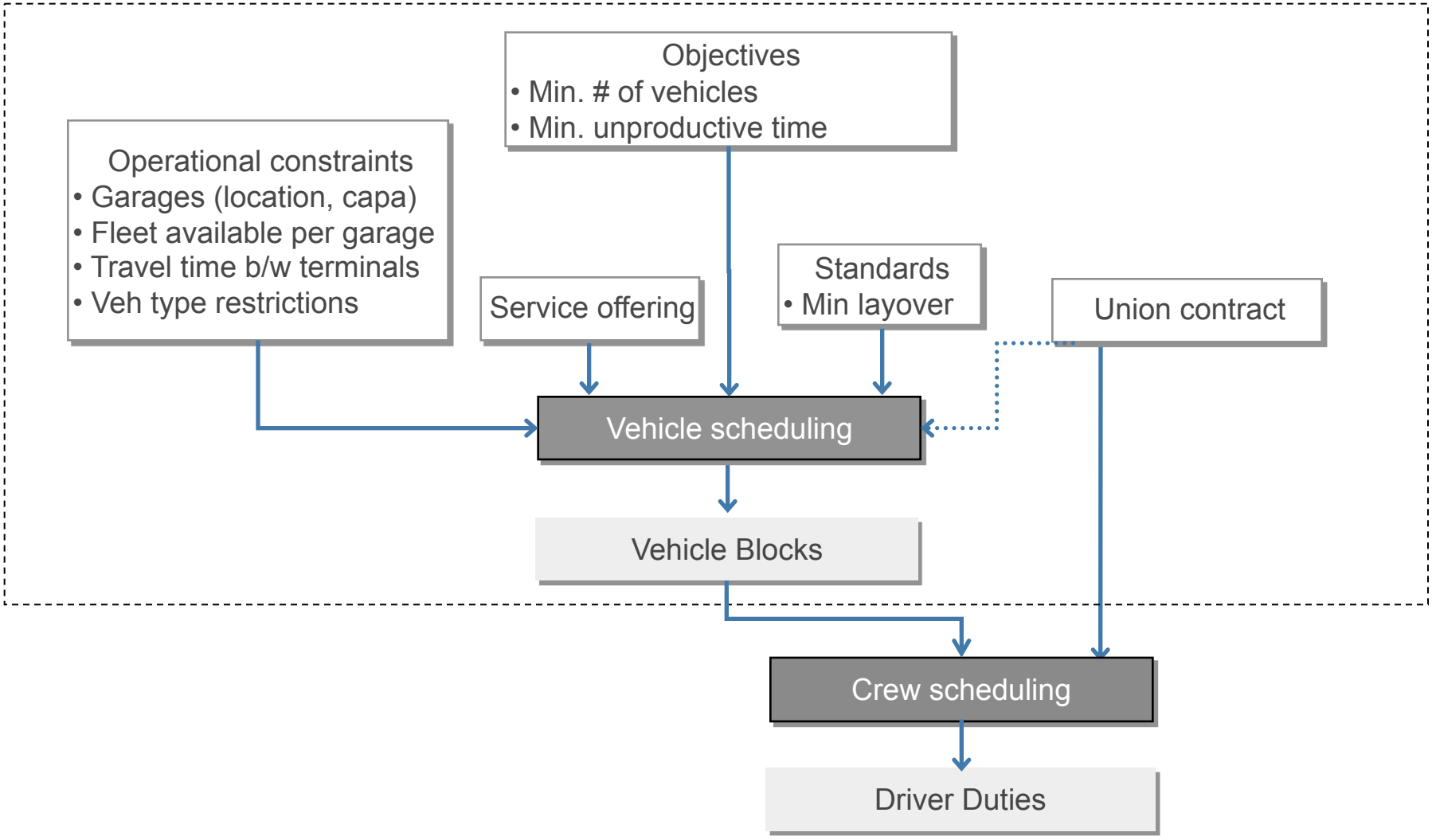
Public transportation scheduling

Source: http://www.flickr.com/photos/bctransit/3273243381/

Public transportation business process

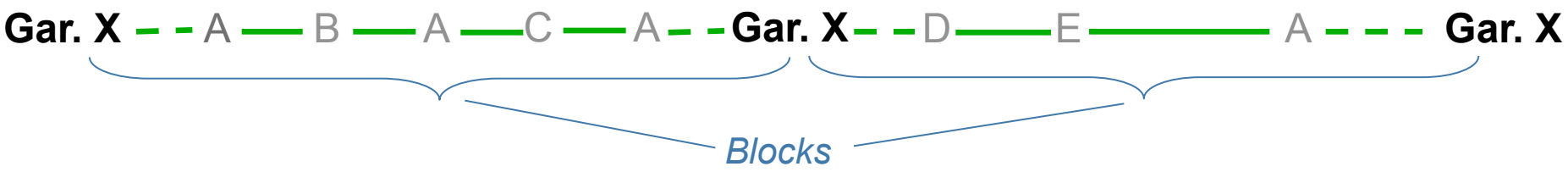


Scheduling sub-process – without exposure

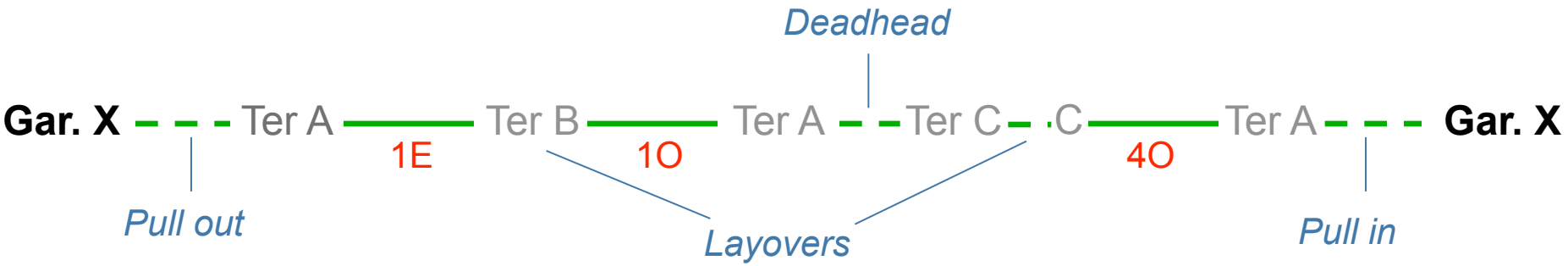


Unproductive time

- Vehicle task - a sequence of Blocks performed by the same vehicle

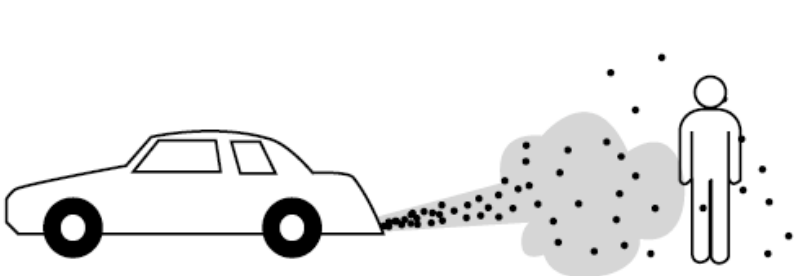


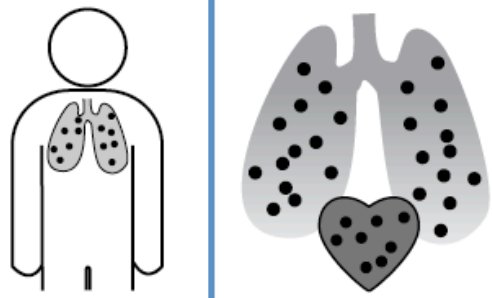
- Block – a sequence of Trips performed by the same vehicle, from the time it leaves a garage to the time it returns to the garage
  - Layover – off-service time between Trips to make up for delays
  - Deadhead – off-service time when a vehicle travels b/w terminals
  - **Unproductive time** – pull out/in, layovers, deadheads

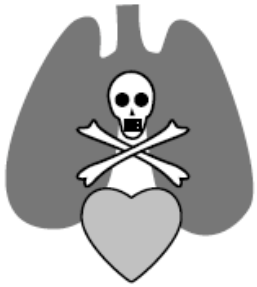


Exposure to public transportation emissions

Air pollution impact pathway







Emissions	Concentration	Exposure	Intake	Dose	Health Effects
Mass emitted	Mass per volume air	Average concentration over time	Total mass inhaled	Total mass deposited in body	Health outcomes based on dose
kg emitted	$\mu g/m^3$	$\mu g/m^3$	g inhaled	g deposited	Quality adjusted life years lost

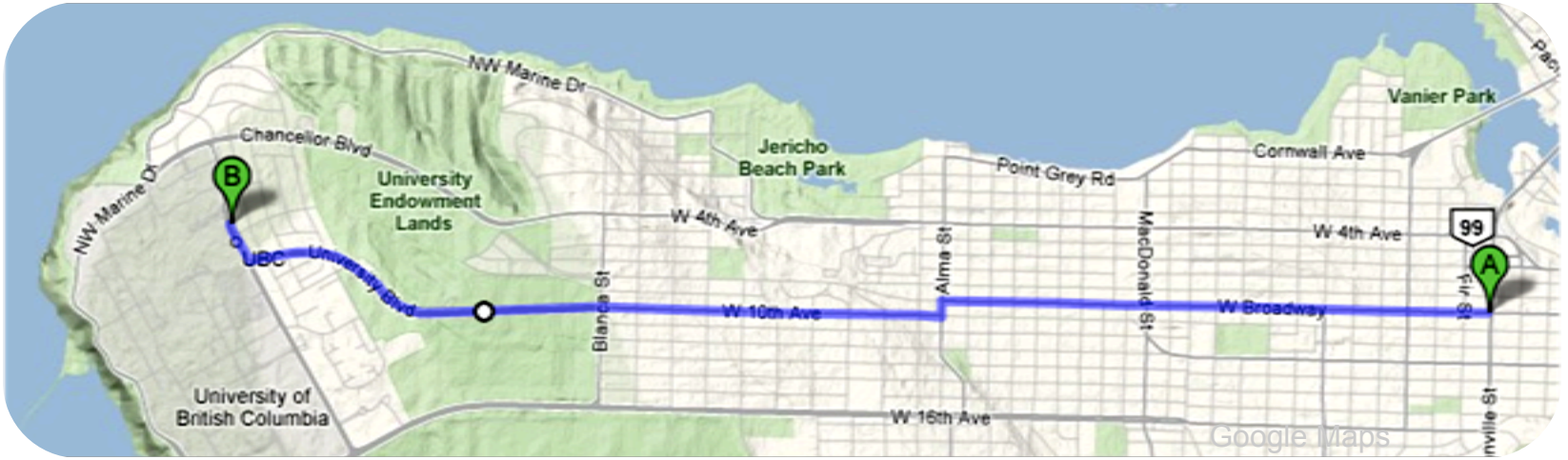
When & Where Emissions Are

When & Where People Are

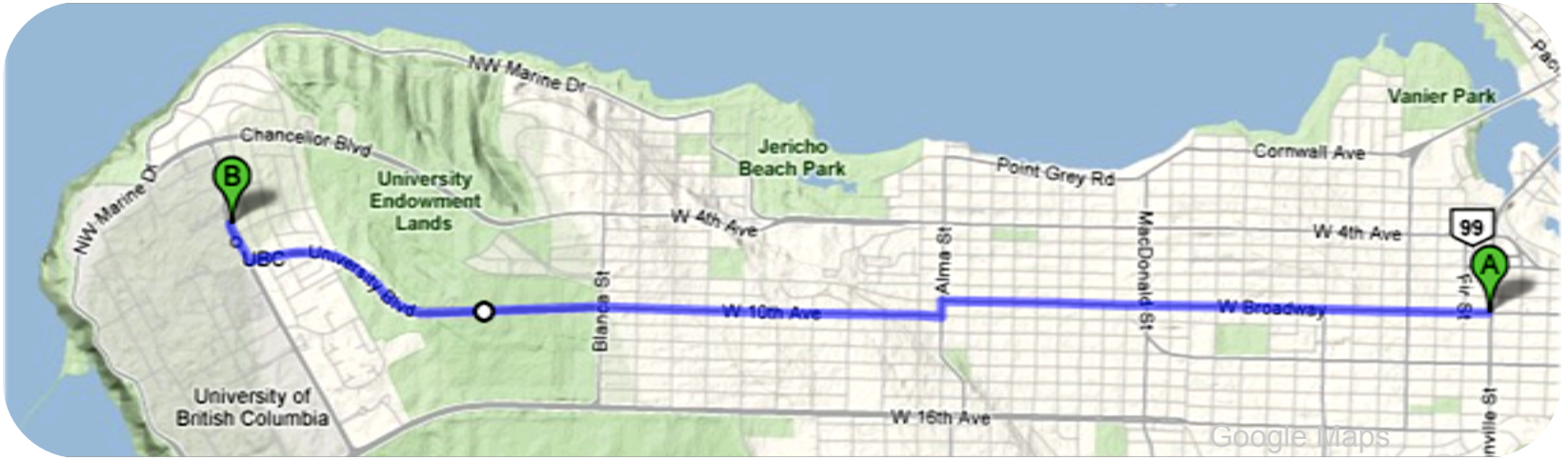
What People Are Doing

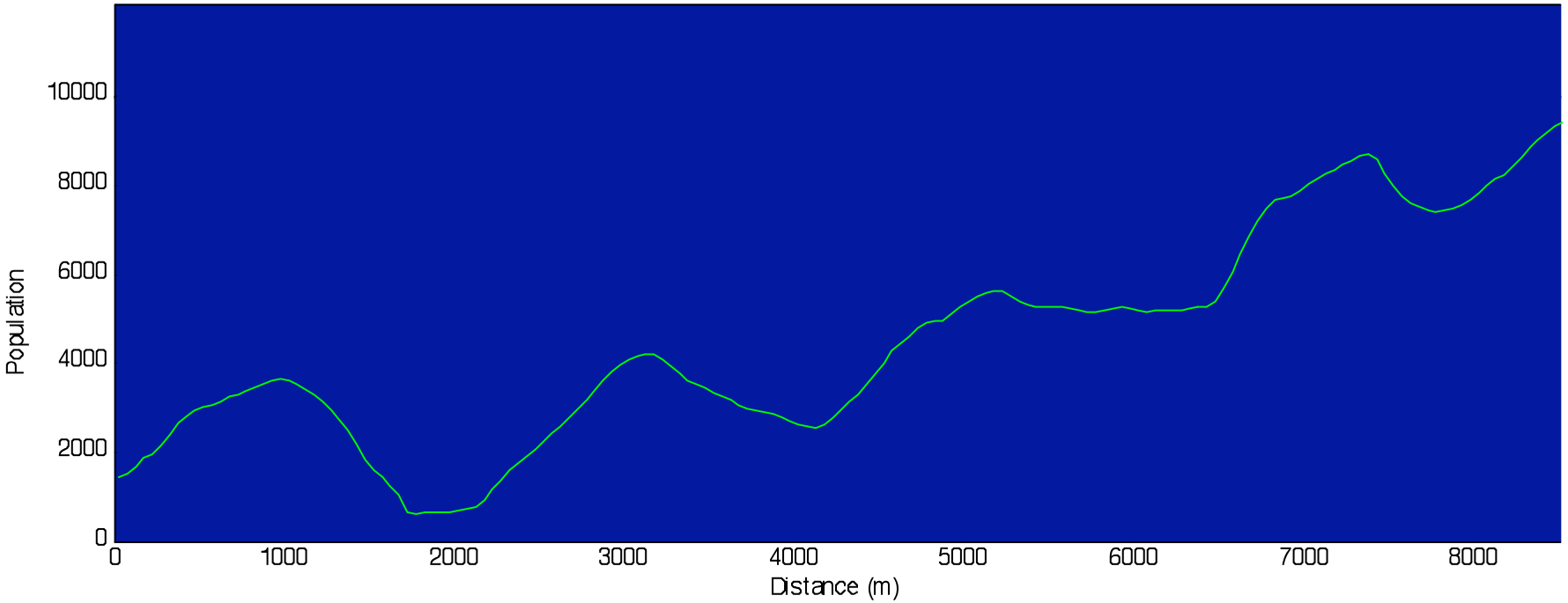
[Marshall & Nazaroff (2006) after Smith (1993)]

99 B-Line: our case study

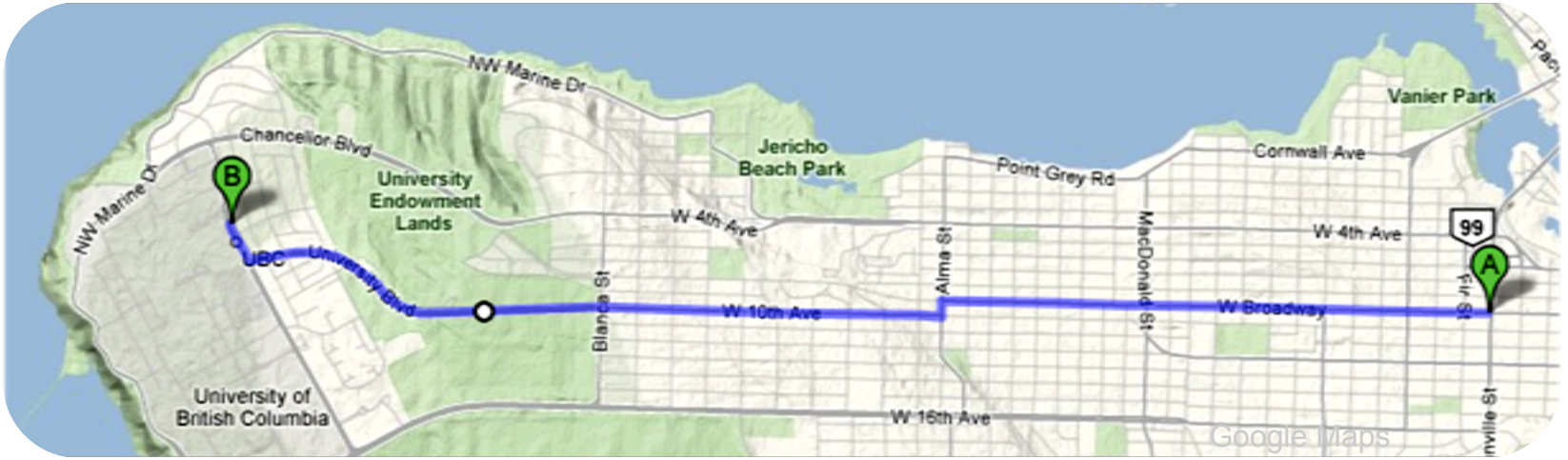


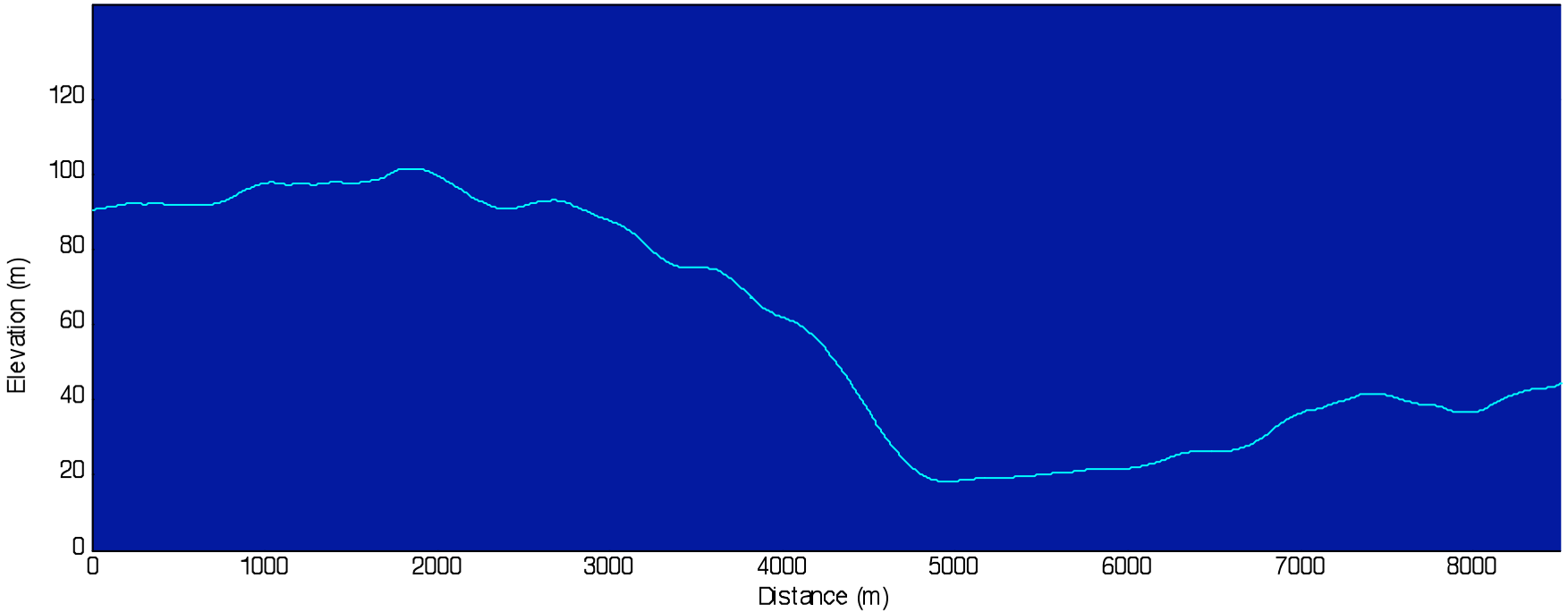
99 B-Line: Population profile



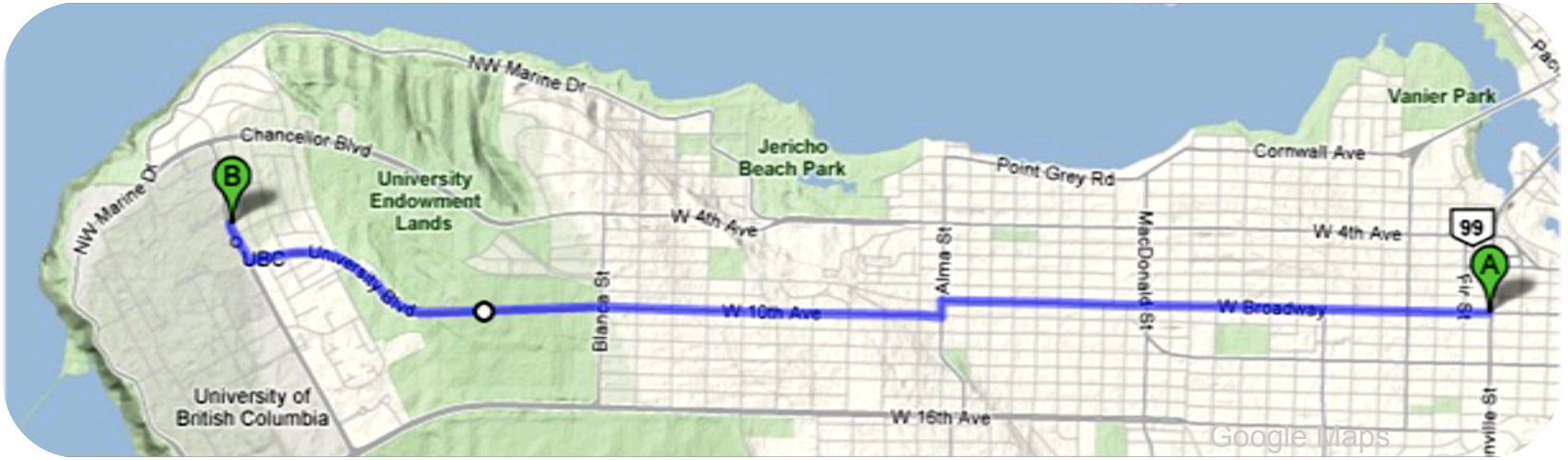


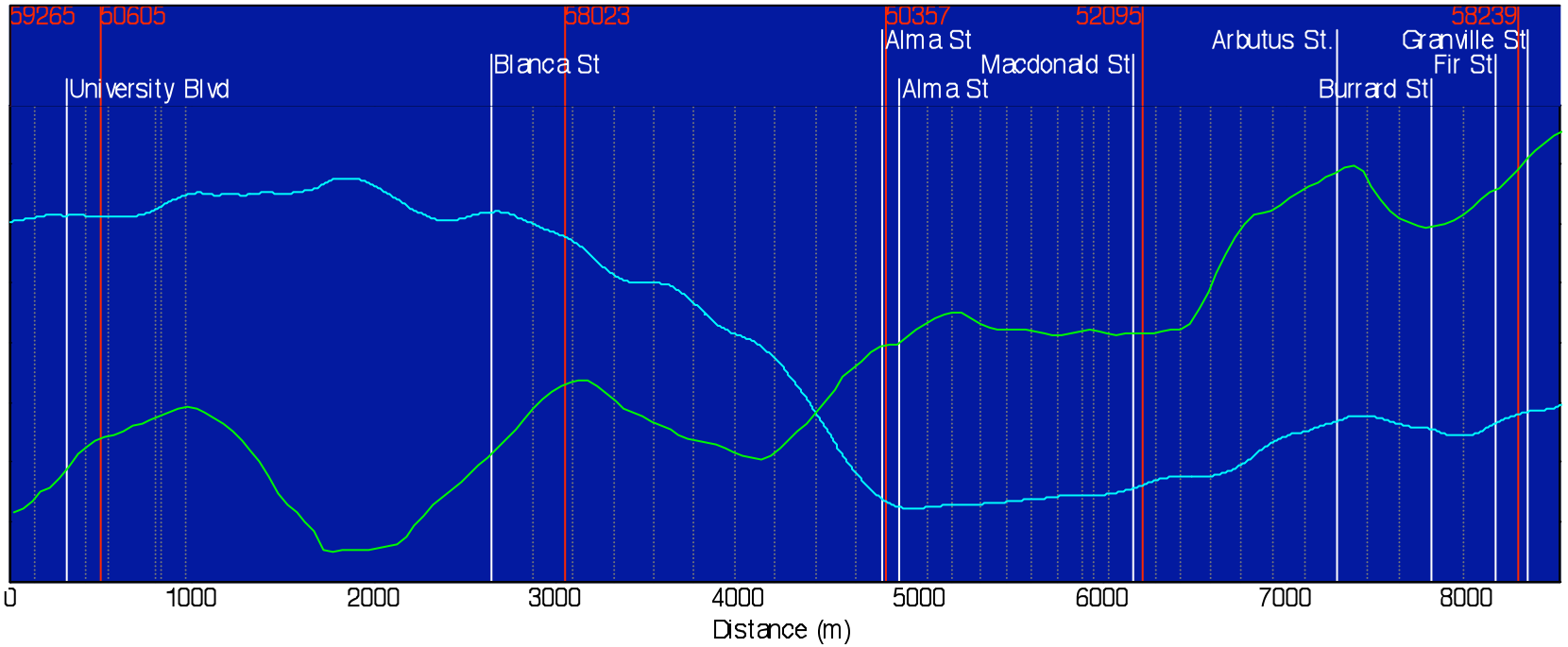
99 B-Line: Elevation profile



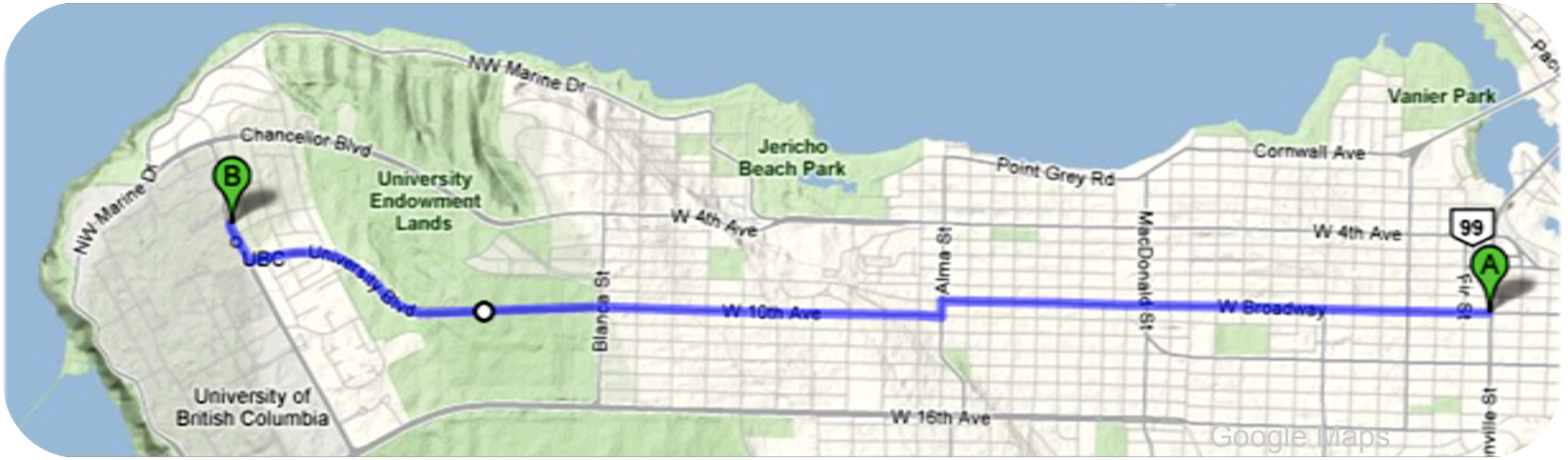


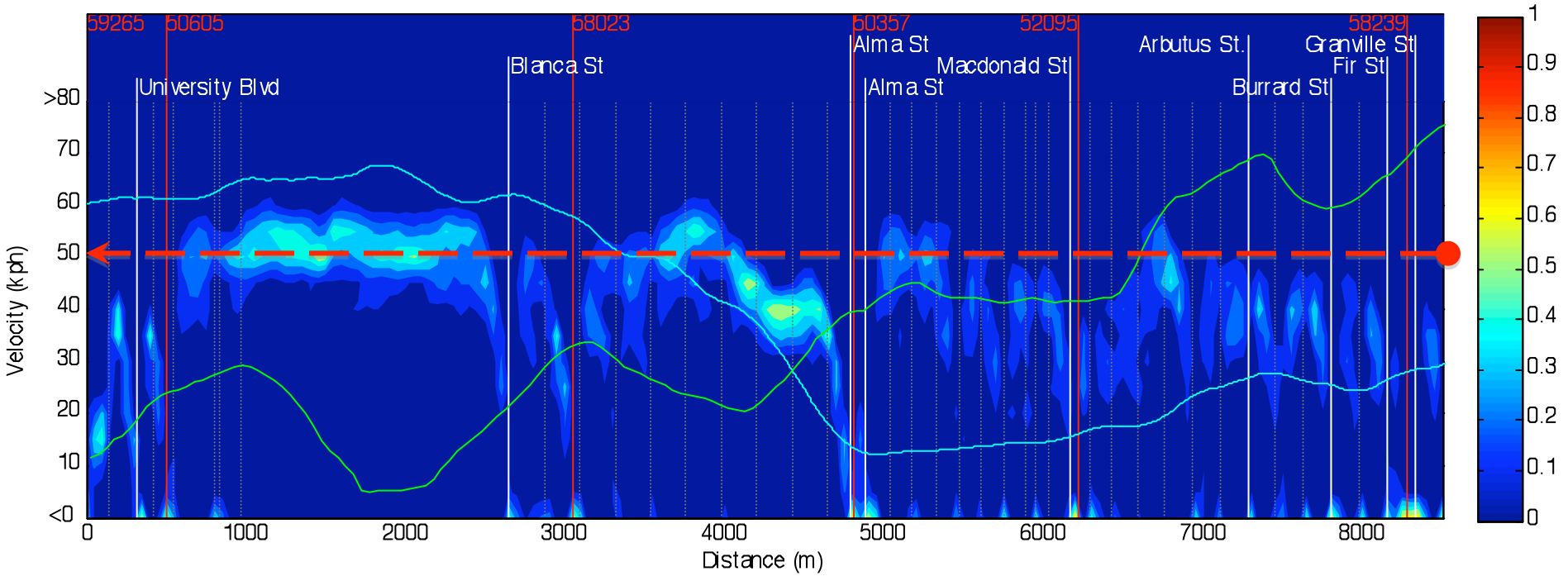
99 B-Line: Stops & intersections



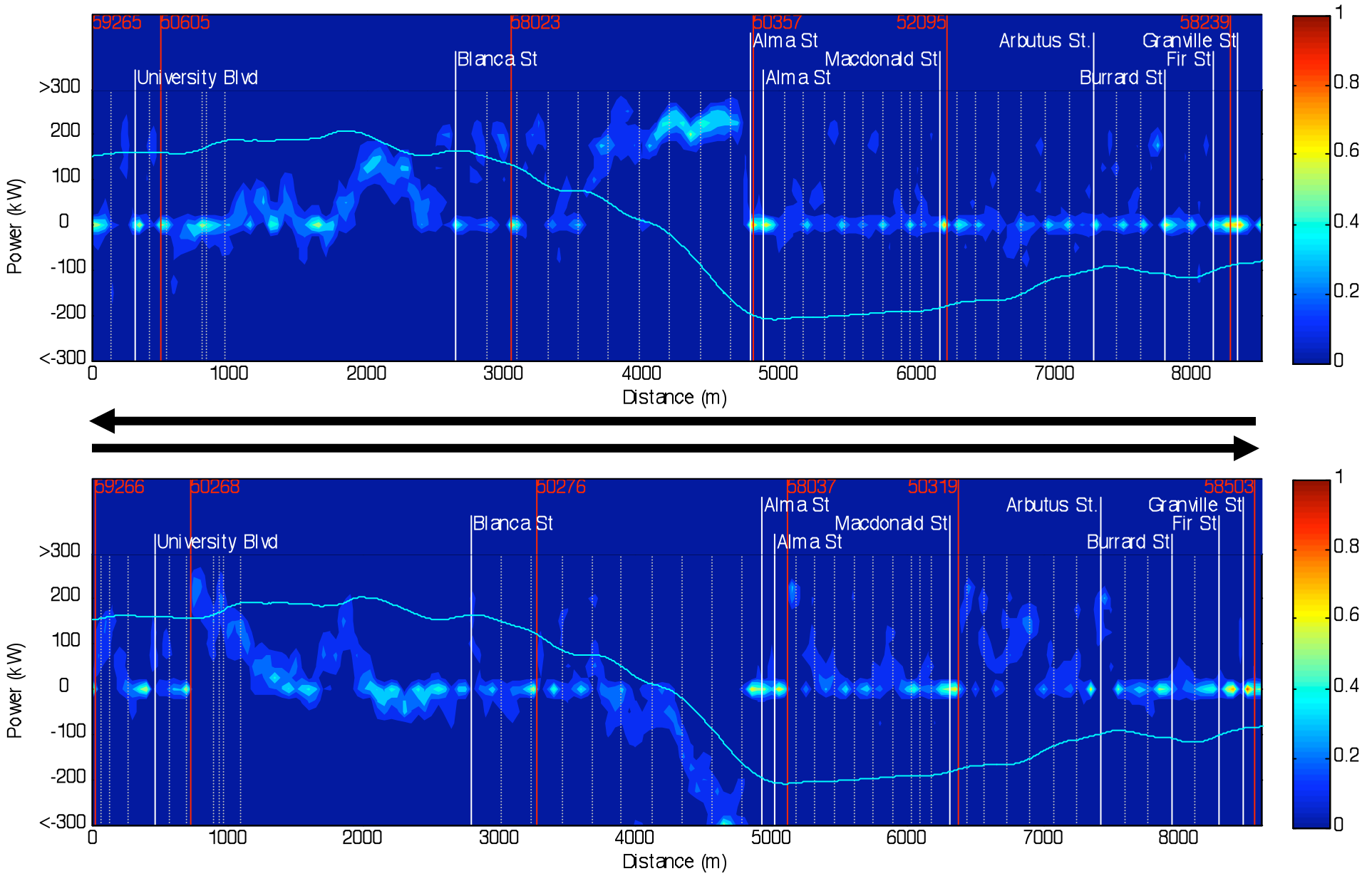


99 B-Line: Westbound velocity profile

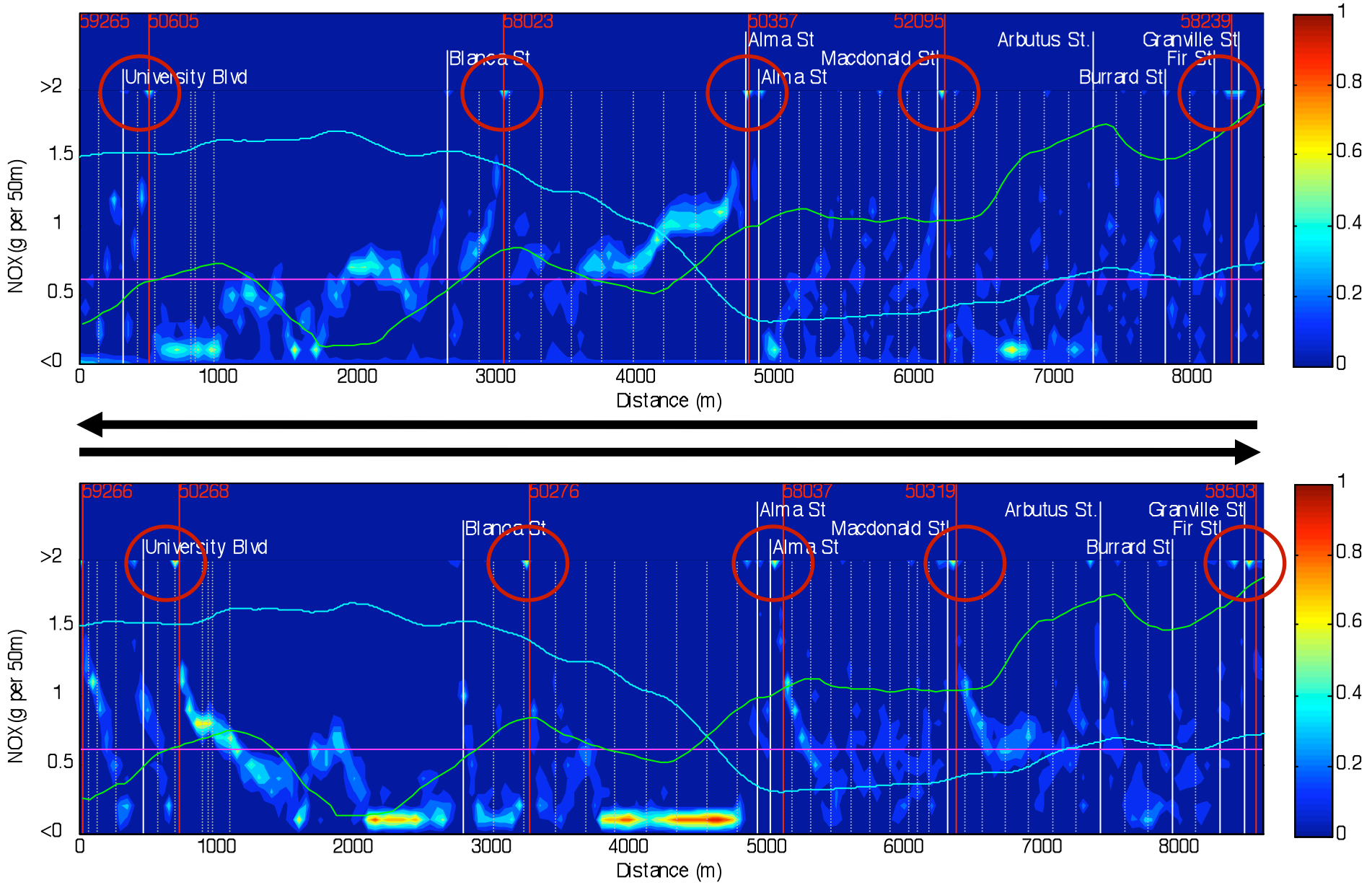




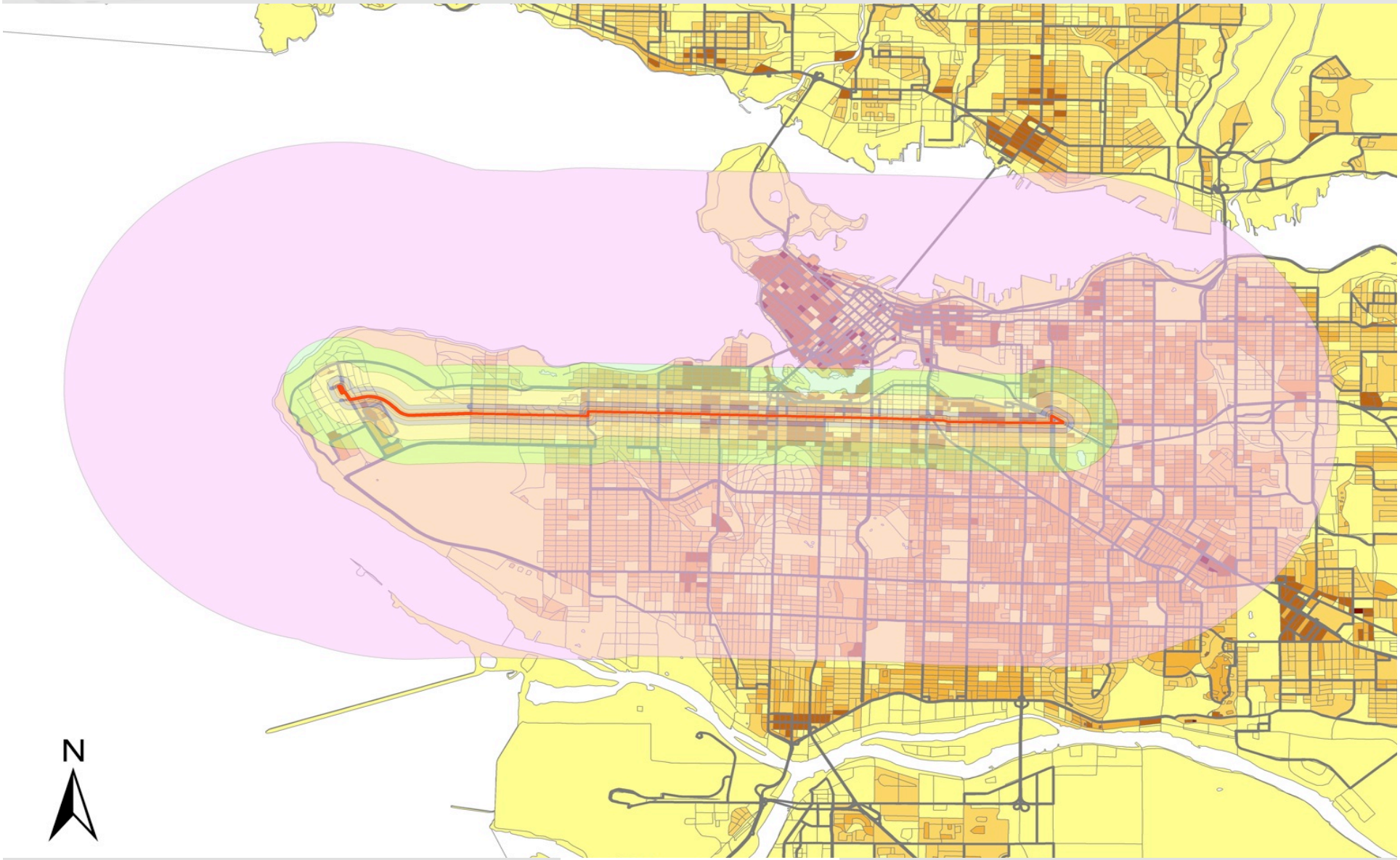
99 B-Line: Power profiles



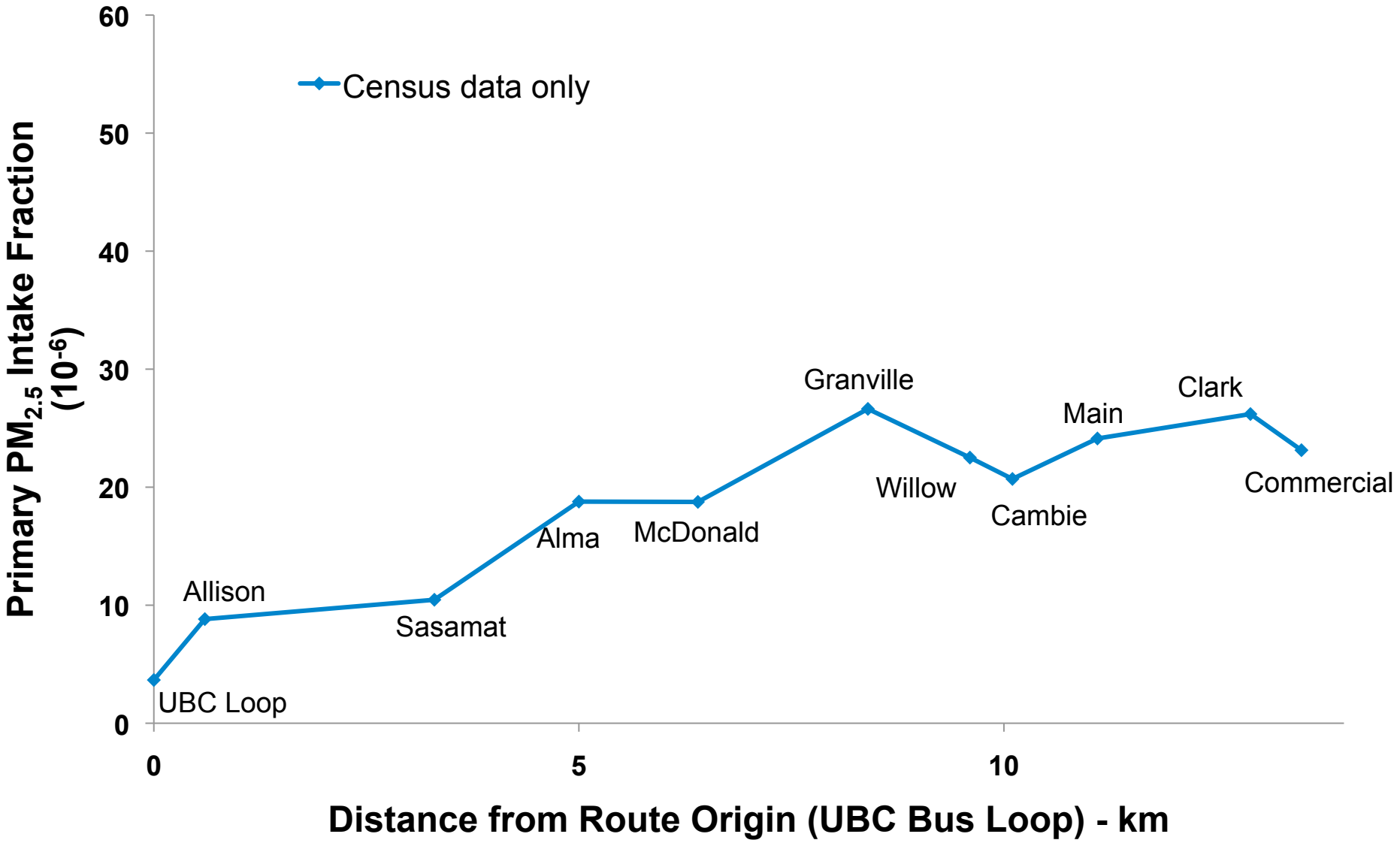
99 B-Line: Nitrogen oxides (NO_x) profiles



99 B-Line: Dispersion buffers



99 B-Line: Intake fraction



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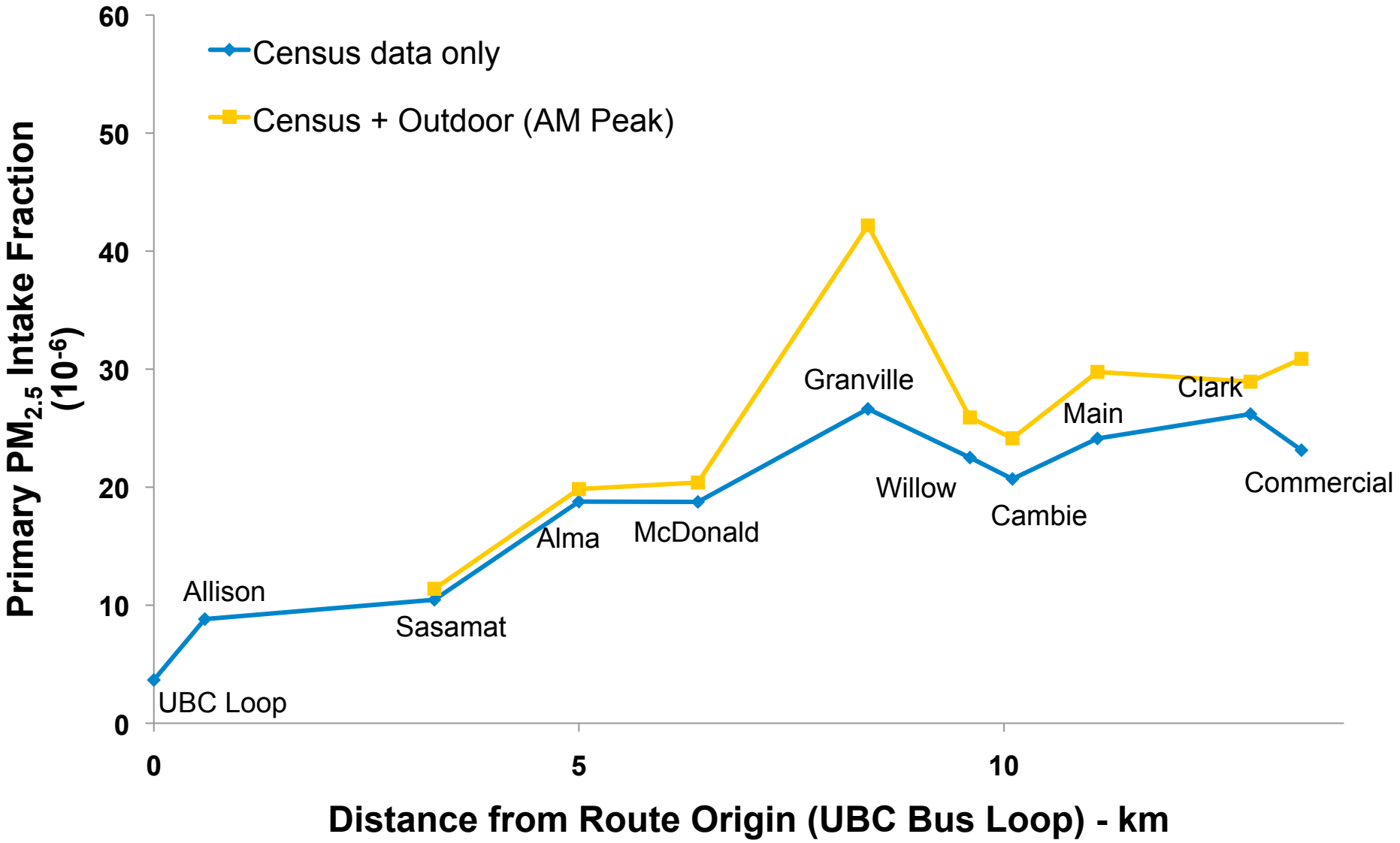

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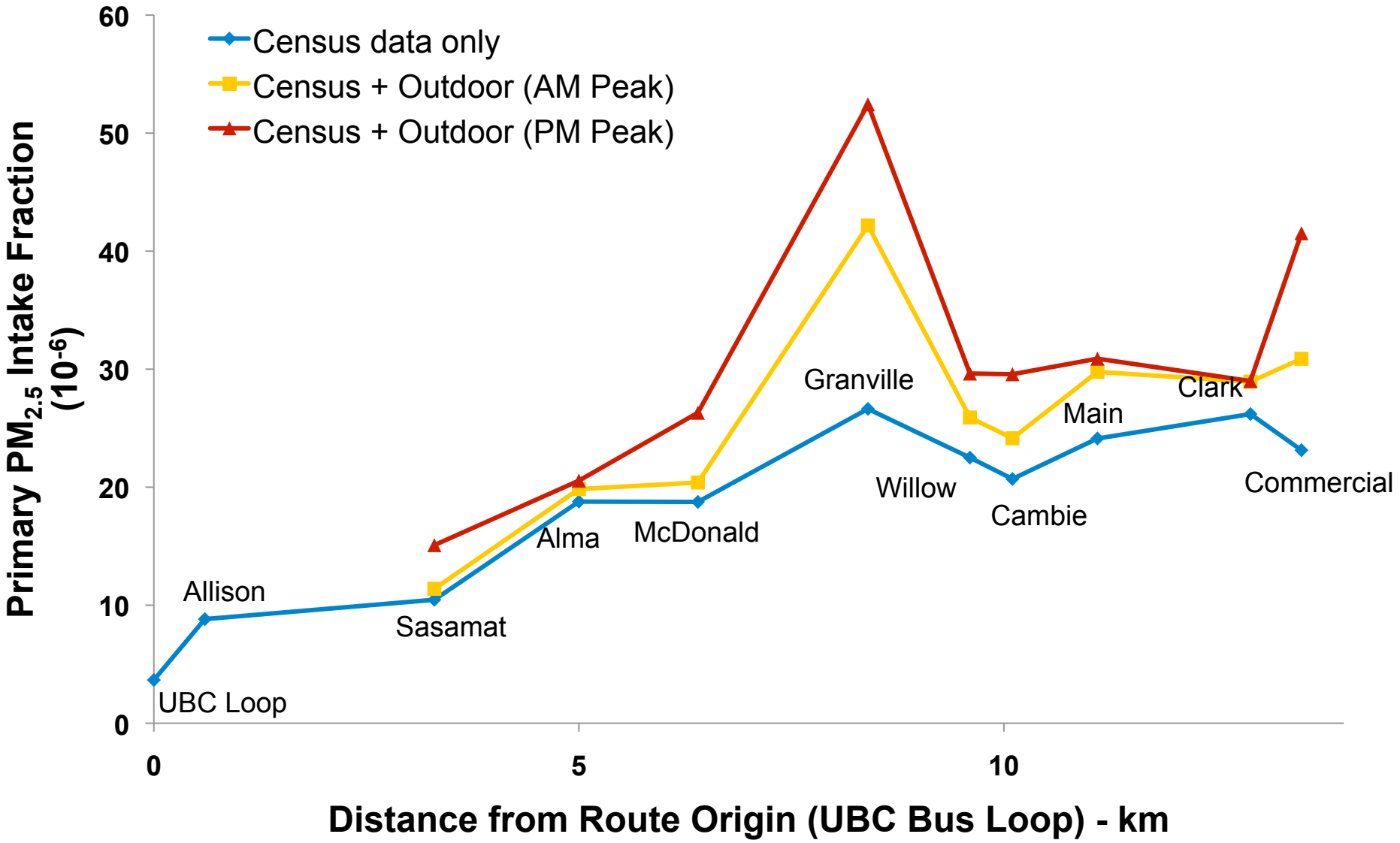
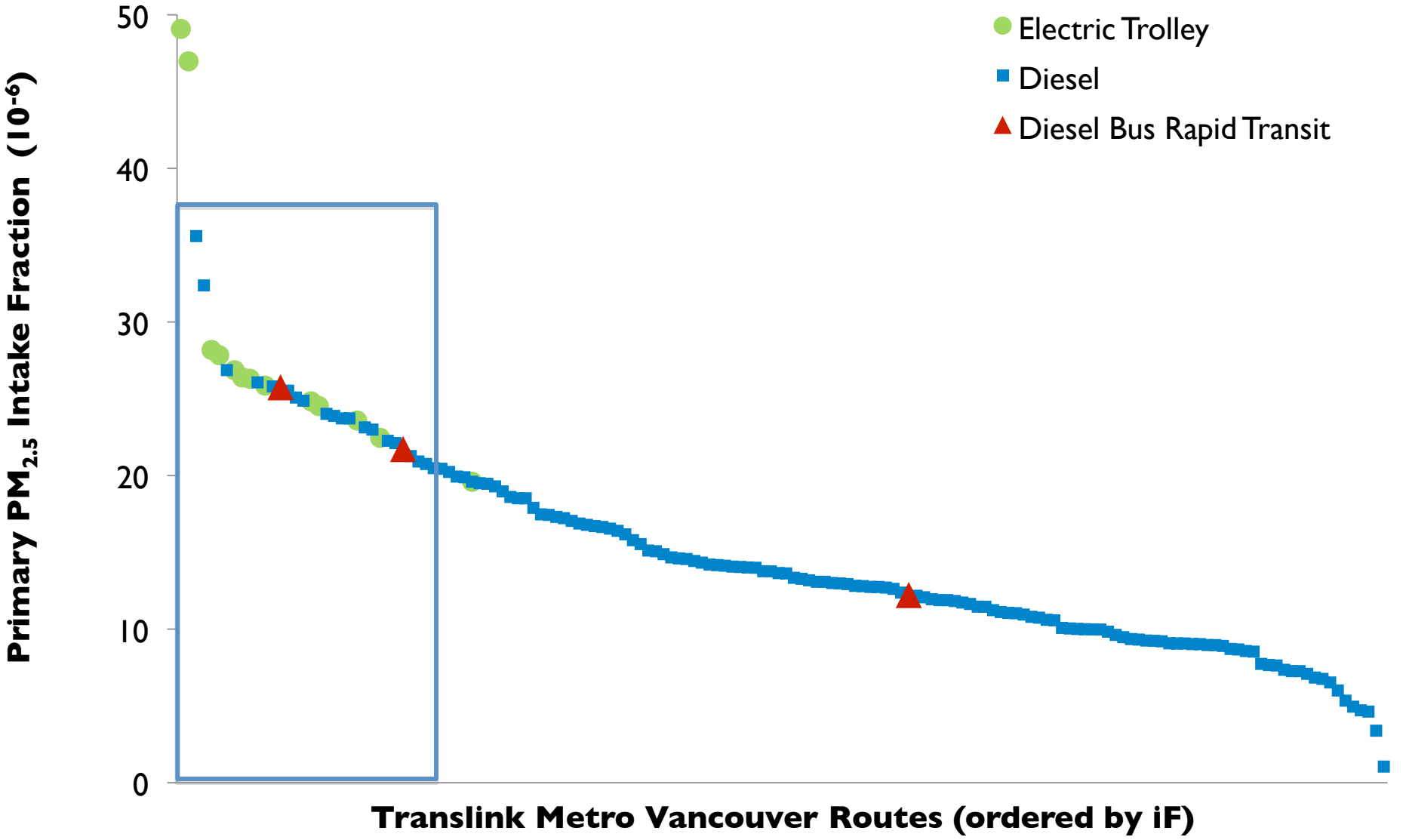
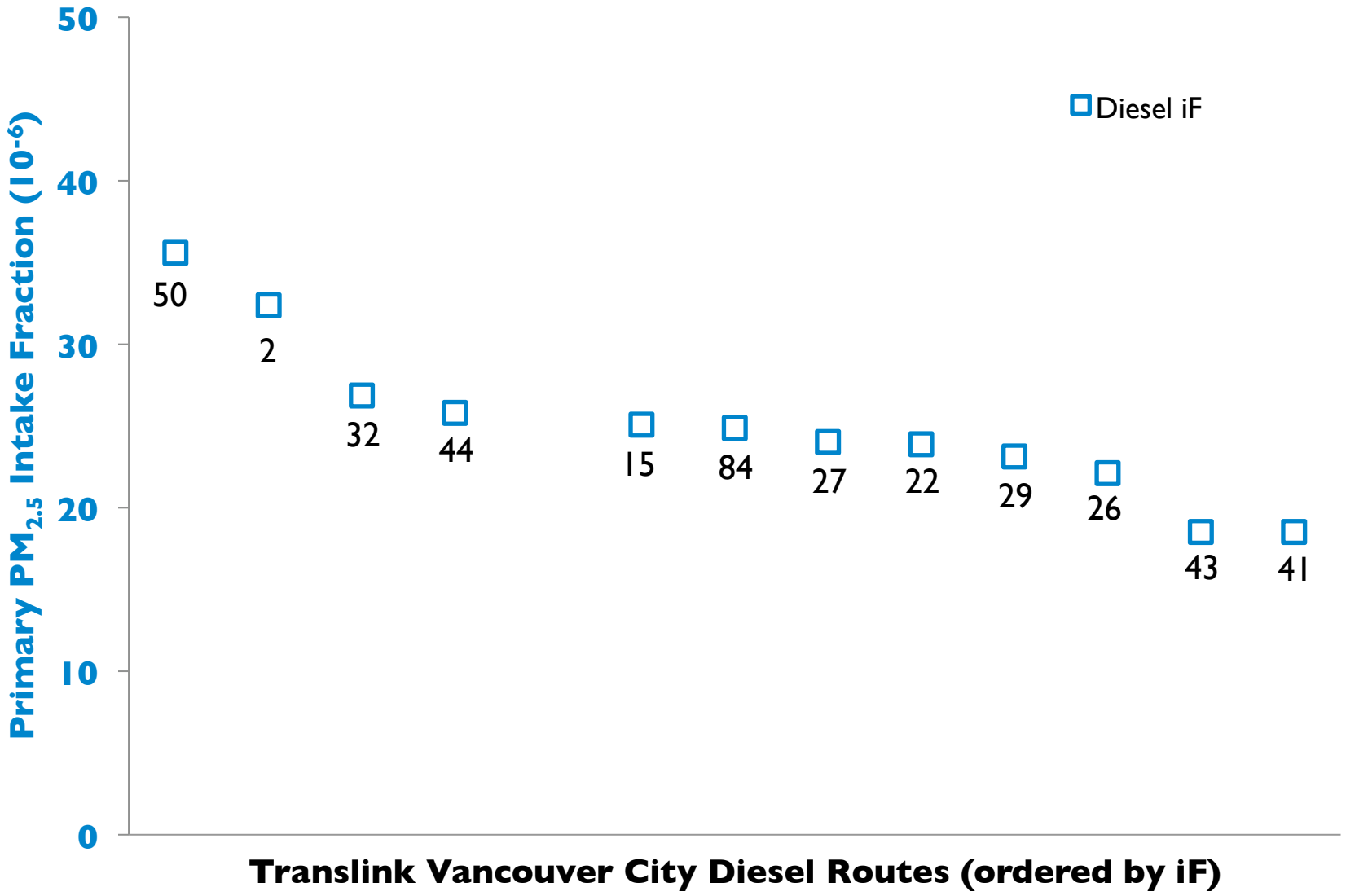


Intake fraction by bus route



Frequency matters, or why BRT is special



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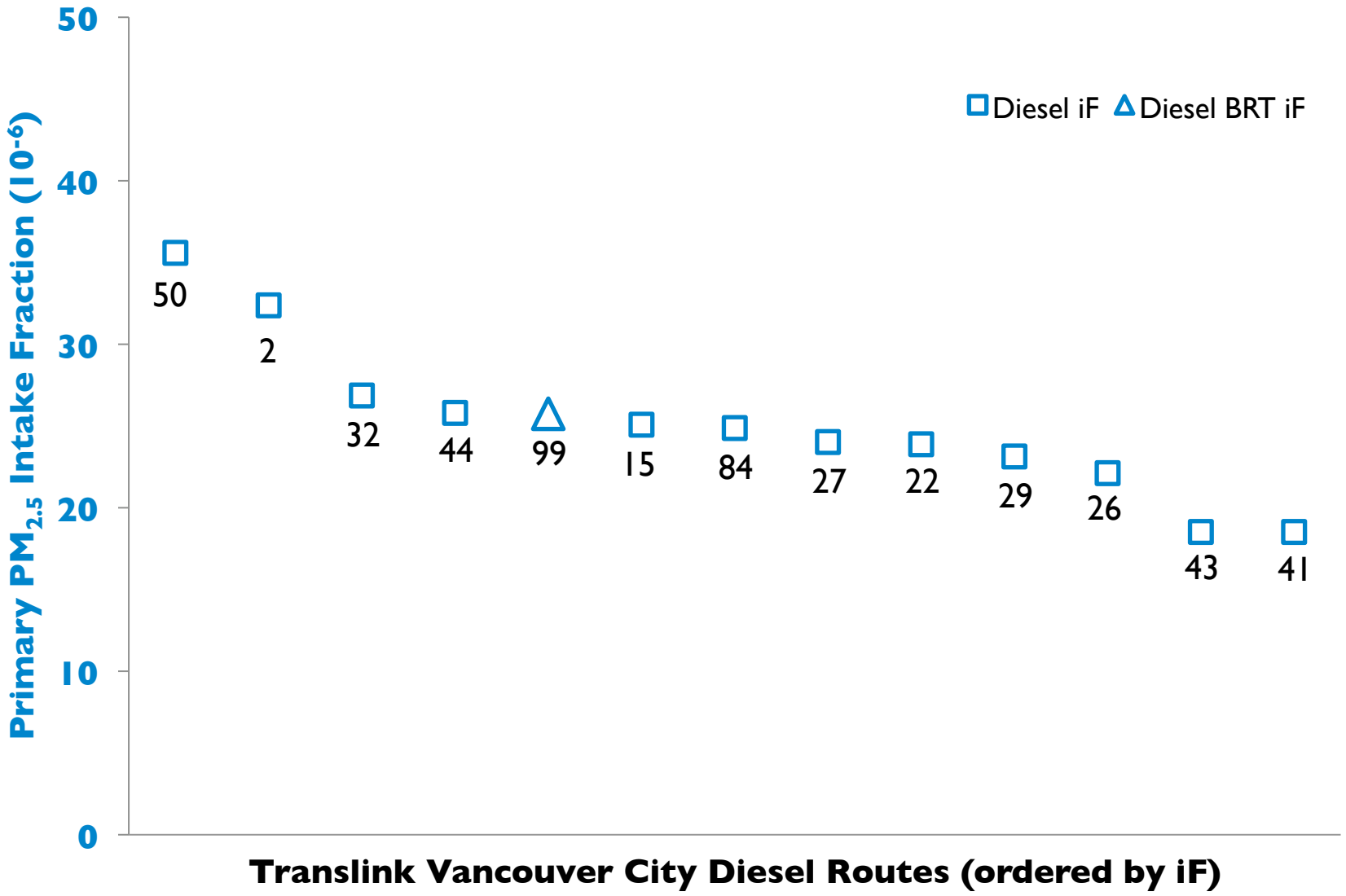

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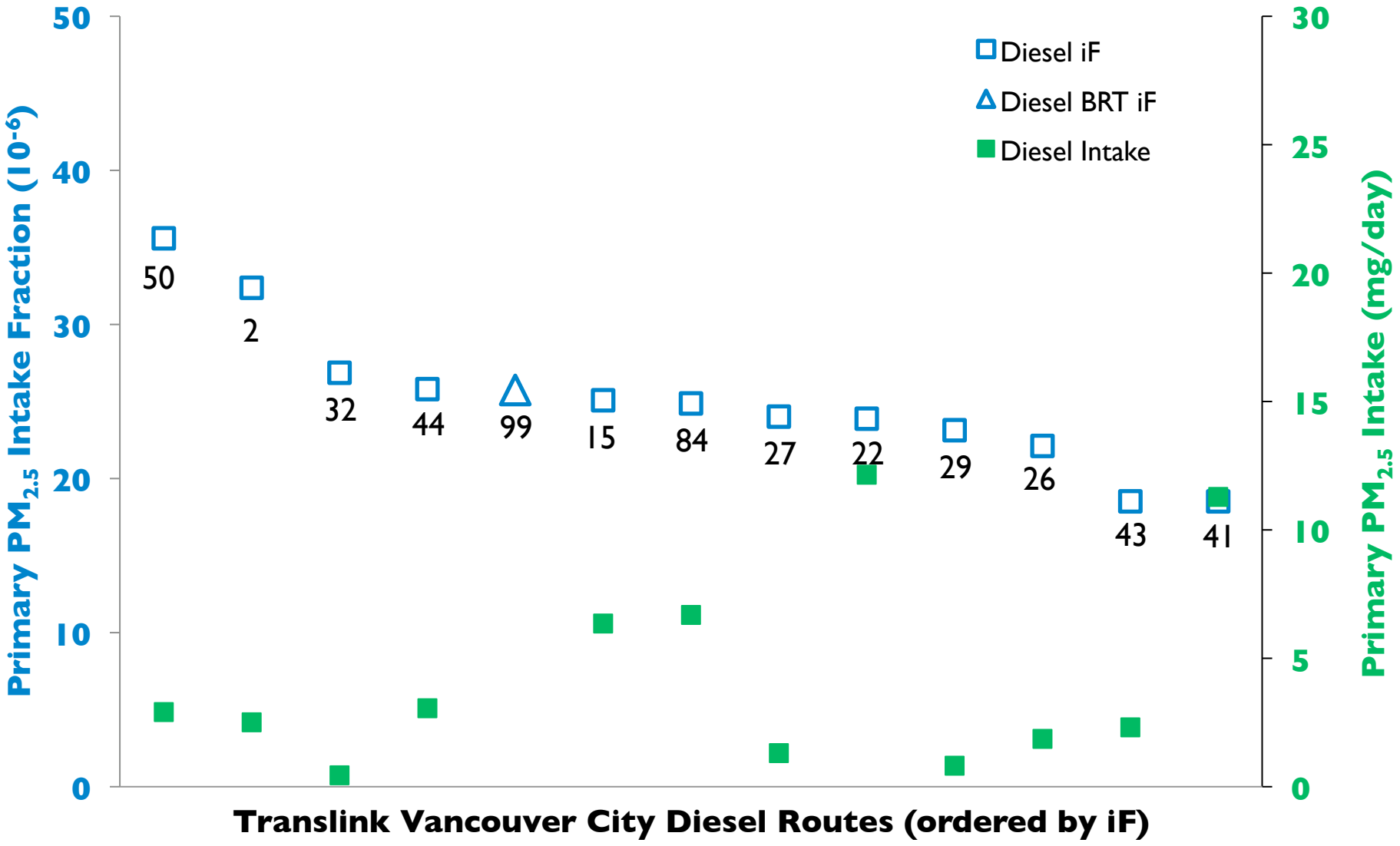

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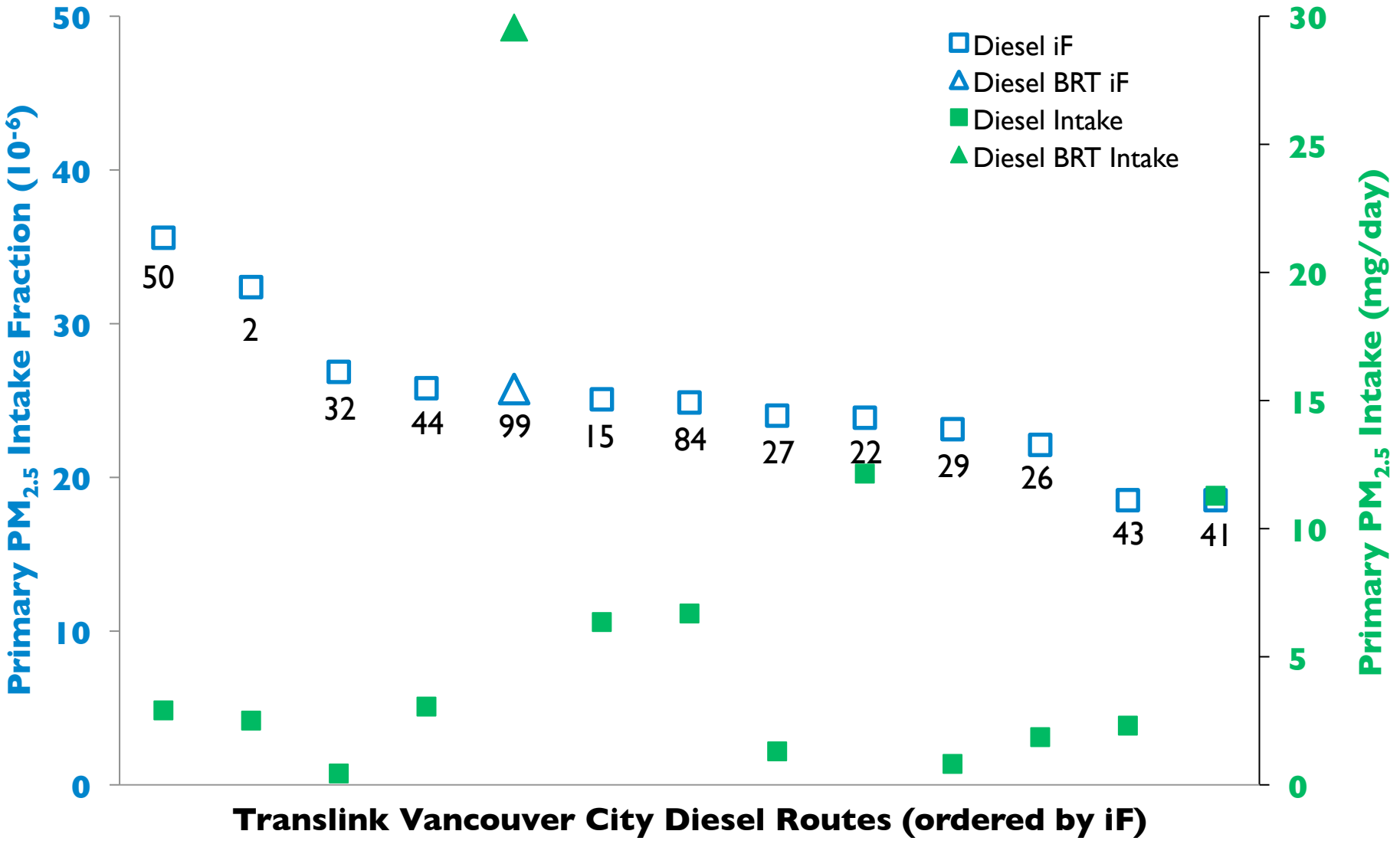


Putting it all together

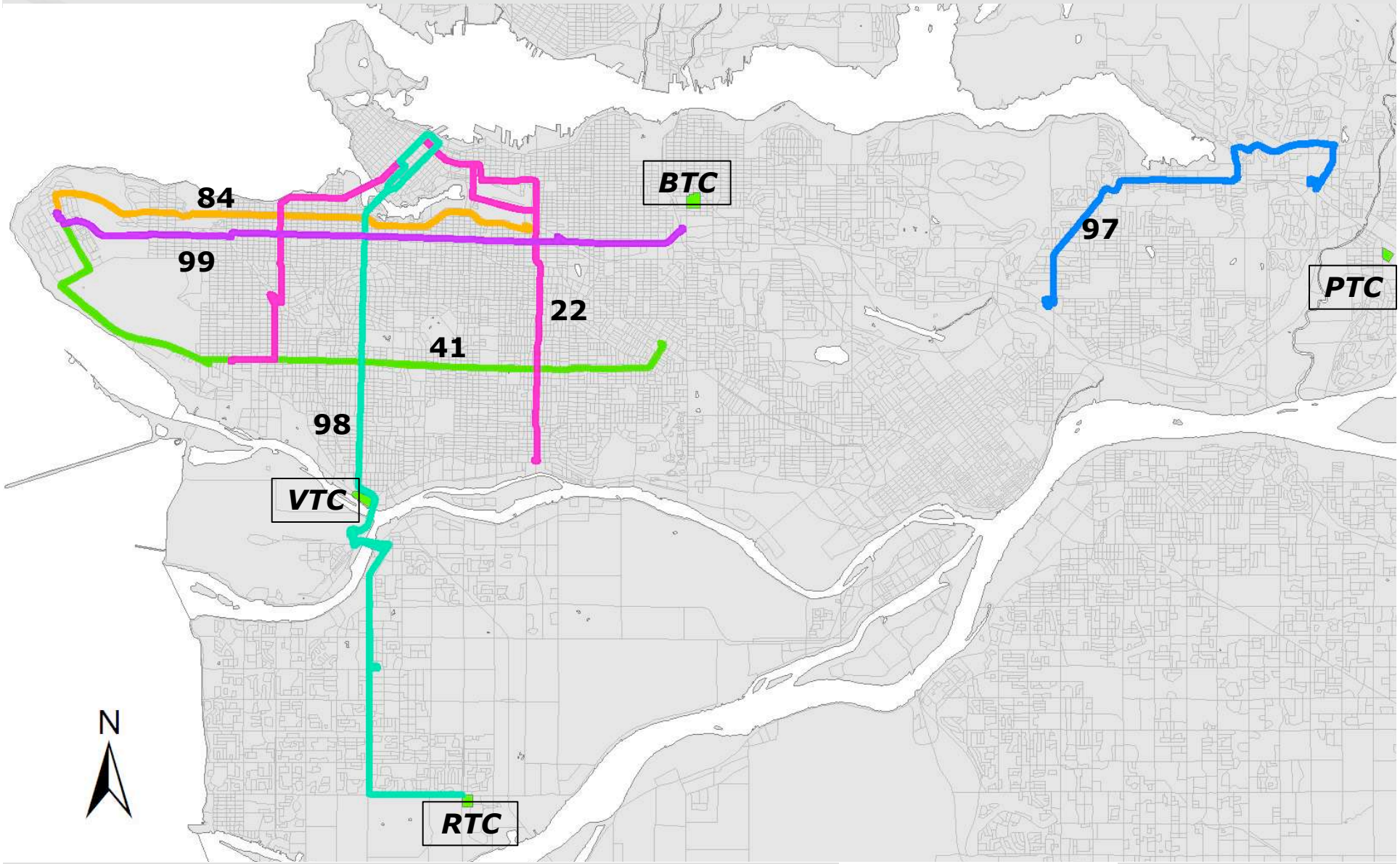
Source: http://kevino.net/images/kevino.net/fullsize/l-99-ubc-at-granville-and-broadway.jpg

Scheduling sub-process – with exposure

Objectives
- Min. # of vehicles
- Min. unproductive time (pull in/out, layovers, deadheads)

- Objective function to minimize
  - K_1*(# of vehicles) + K_2*(unproductive time)
  - Schedulers can vary weights to produce different compromises (Pareto solutions)

Scheduling scenario map



Scheduling scenario

- Subset of TransLink network over one weekday
  - No. of routes: 6; no. of route variants: 25
  - Total # of trips: 1746
  - Total trip time: 1269h40
  - 4 garages: BTC, PTC, RTC, VTC
- Route-vehicle type restrictions
  - Routes 22, 41, 84 must be operated by 40 ft vehicles
  - Routes 97, 98, 99 must be operated by 60 ft vehicles
- Route-garage restrictions
  - Each route must be operated from a specific garage
- Fixed fleet mix per garage

Scheduling scenario results

	Run 1 – Random	Run 2 – Fuel Only	Run 3 – Fuel & Health
# of vehicles	126	126	126
Unproductive time	216h 25 (17.0%)	216h 25 (17.0%)	218h 22 (17.2%)
Health cost	32 998	18 926 (-43%)	15 991 (-52%)

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Garage – Veh. type			
Burnaby – 60 Adv	4 veh / 12.7 hrs/ day		8 / 17.8
Burnaby – 60 Base	24 / 11.4		20 / 9.1

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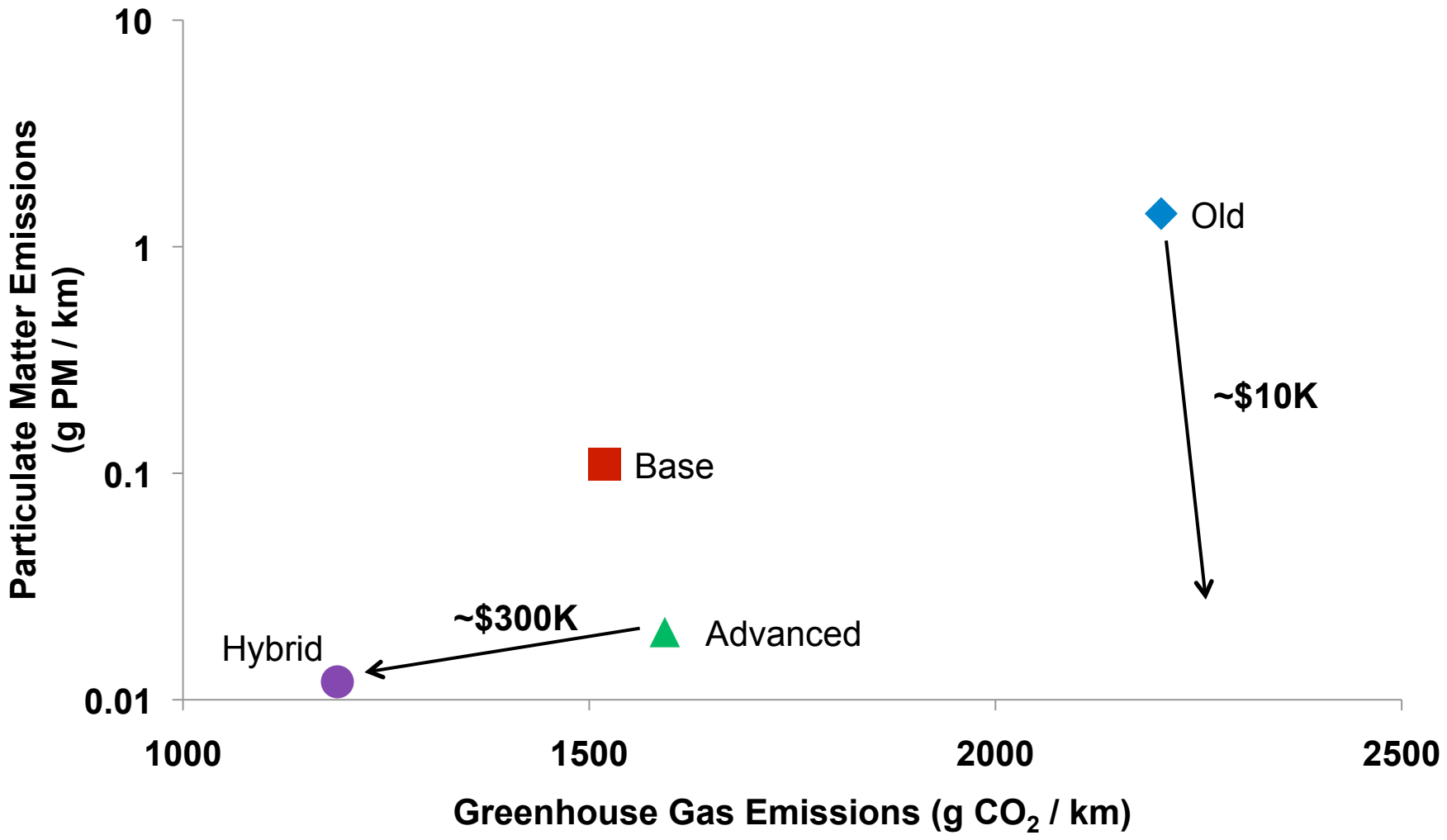
Burnaby – 60 Base	24 / 11.4		20 / 9.1
Vancouver - 40 Hyb	1 / 6.4		2 / 18.1
Vancouver – 40 Adv	18 / 11.5		18 / 15.8
Vancouver – 40 Base	29 / 10.1		30 / 11.4
Vancouver - 40 Old	15 / 12.5		13 / 2.4

What's going on here: GHGs vs CACs



In conclusion, “It’s the exposure, stupid”

Source: http://picasaweb.google.com/chris.dustin/808#5236704901832350242

Outcomes and conclusions

- Consideration of exposure can be integrated into existing bus scheduling frameworks
  - In our scenario, we halved exposure to criteria air pollutants at minimal additional cost
- Bus investments and operations are often far from optimal to minimize exposure.
  - Focus on simplest (least cost) available technologies to effect improvements in exposure
- If we're asking people to step out of their cars, we should focus on cleaning up key proximate sources of pollution.

Acknowledgements

- **Research partners**

UBC

GIRO

TRANS LINK

- **Funders**

AUTO21

NSERC CRSNG

The Bridge PROGRAM

CDMC

RESOURCES FOR THE FUTURE

Source: http://farm2.static.flickr.com/1147/652939906_ 155c8ea004.jpg

Questions?