



# Comparison of VEPM (model) and RSD (on-road) vehicle emission factors



**VERSES**

## Vehicle Emissions Prediction Model (VEPM) Version 5.0 Development and User Information Report

Prepared for:  
NZ Transport Agency and  
Auckland Council

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## Project Objectives

- To verify that the VEPM is providing **useful and realistic estimates** of light duty vehicle emissions and
- To **increase stakeholder confidence** in the emission data produced by VEPM.





# Two Phase Project

## ■ Phase 1 – Data analysis

- Funded by Auckland Council
- Completed June 2013

### ■ Three Tasks

1. Calculate on-road emission factors for light duty vehicles from the RSD.
2. Assess the day-to-day and from site-to-site variation in RSD emission factors.
3. Compare the RSD and VEPM emission factors for light duty vehicles.

## ■ Phase 2 – Reporting

- Funded by NZTA
- 20 page report

December 9, 2013 ■ Draft completed. Finalised by Xmas



# VEPM INPUTS

Entry required in white cells. Entry optional in grey cells

Year

Run Number

Fleet Profile				
	Weight category	Fuel type	% of VKT	
			default values	optional user entry
			2006	
<b>Cars</b>	< 3.5 t	petrol	70.8%	
	< 3.5 t	diesel	8.1%	
	< 3.5 t	hybrid	0.1%	
<b>LCV</b>	< 3.5 t	petrol	4.2%	
	< 3.5 t	diesel	9.7%	
	< 3.5 t	hybrid	0.0%	
<b>HCV</b>	3.5 - 7.5 t	diesel	1.6%	
	7.5 - 12 t	diesel	0.8%	
	12 - 15 t	diesel	0.2%	
	15 - 20 t	diesel	0.3%	
	20 - 25 t	diesel	1.4%	
	25 - 30 t	diesel	1.2%	
	> 30 t	diesel	1.1%	
<b>Buses</b>	> 3.5 t	diesel	0.6%	

100%

Optional Inputs			
	default values	optional user entry	options
average trip length (km)	9.1		8 to 25
ambient temperature °C	13.1		-10 to 30
petrol fuel type - see worksheet	6		0 to 7
diesel fuel type - see worksheet	5		0 to 5
consider cold start?	yes		no
consider degradation?	yes		no
% of catalyst not working - old vehicles	15%		0-100%
% of catalyst not working - new vehicles	0%		0-100%
Heavy vehicles: gradient	0%		±2, 4, 6
Heavy vehicles: load	50%		0, 100%

Number of wheels			
Vehicle type	default values	optional user entry	
Car	4		
LCV	4		
HCV 3.5-7.5 t	6		
HCV 7.5-12 t	6		
HCV 12-15 t	8		
HCV 15-20 t	8		
HCV 20-25 t	8		
HCV 25-30 t	8		
HCV >30 t	8		
Buses >3.5 t	6		
Brake and tyre PM output	PM1		

Average Speeds		
<b>cars</b>	<b>35</b>	km/h
<b>LCV's</b>	<b>35</b>	km/h
<b>HCV's/buses</b>	<b>35</b>	km/h

Note: valid HCV speed range for selected load and gradient is 6 - 86 km/h



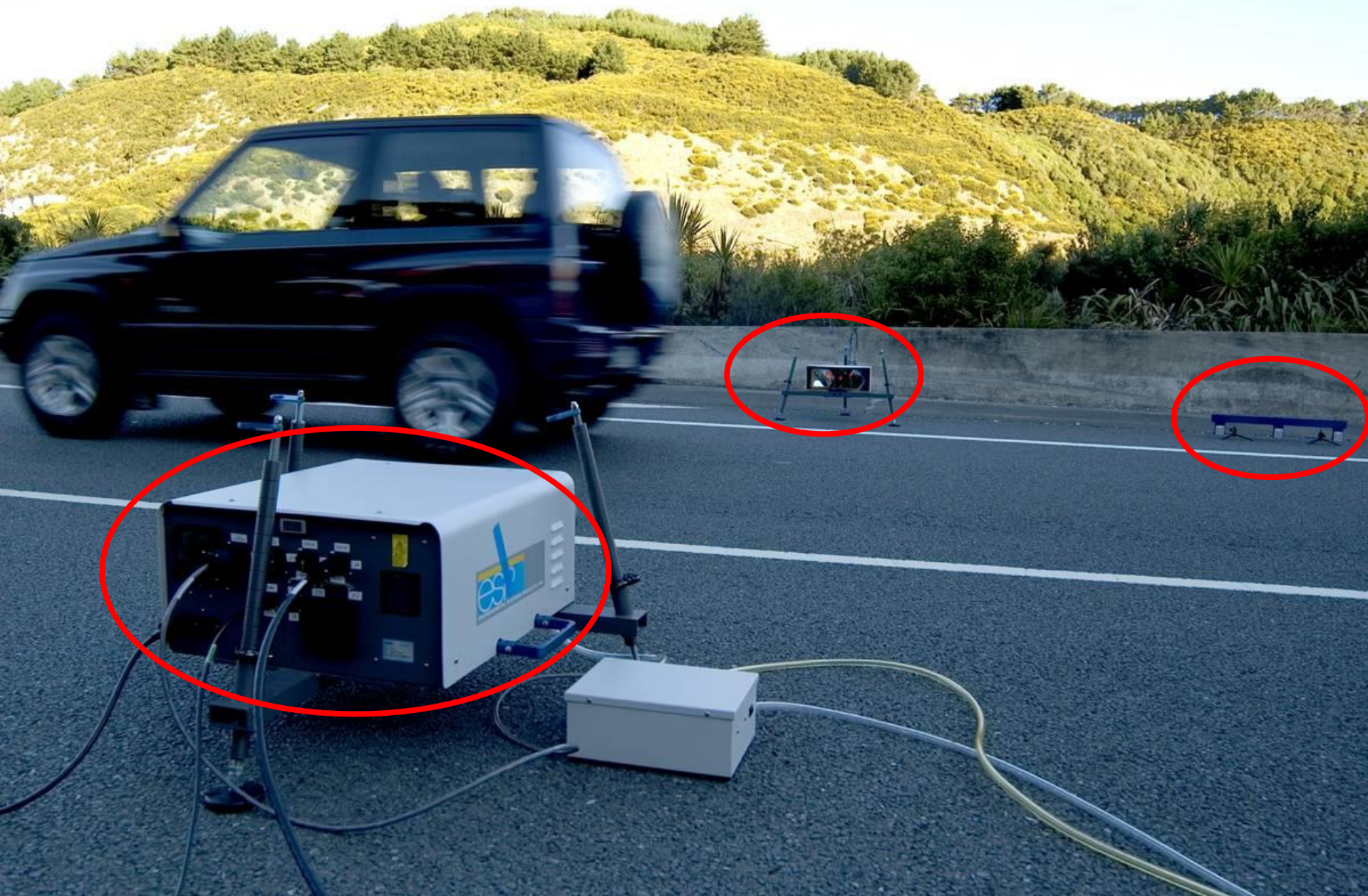
# VEPM OUTPUTS

Fleet average emissions factors		
CO	4.93	g/km
CO <sub>2</sub>	262.20	g/km
VOC	0.32	g/km
NO <sub>x</sub>	0.74	g/km
PM <sub>2.5</sub> exhaust	0.0440	g/km
PM1 B and T	0.0010	g/km
FC	11.14	l/100km

Petrol car		
CO	6.20	g/km
CO <sub>2</sub>	228.36	g/km
VOC	0.37	g/km
NO <sub>x</sub>	0.41	g/km
PM <sub>2.5</sub> exhaust	0.0051	g/km
PM1 B and T	0.0010	g/km
FC	10.29	l/100km

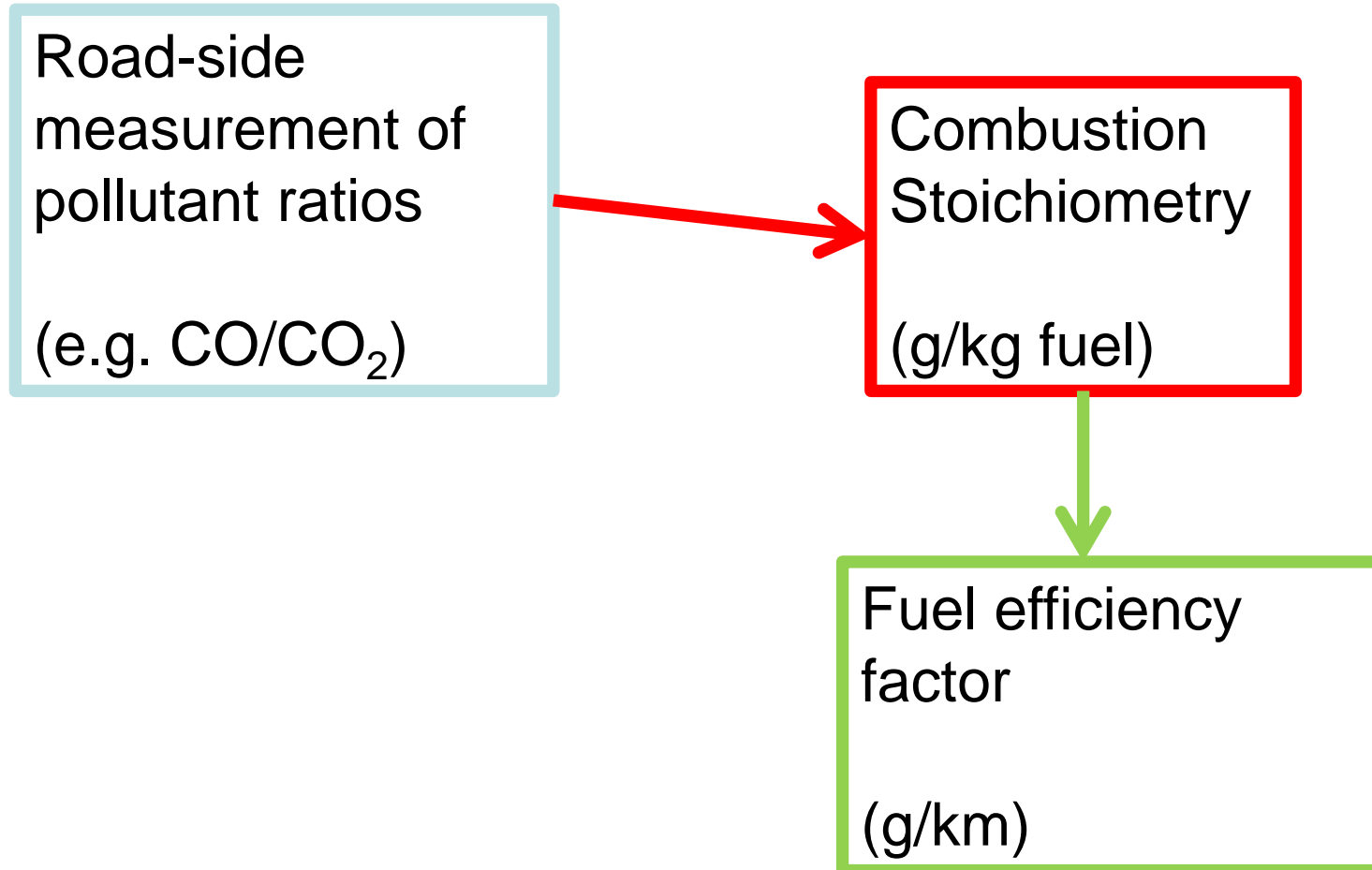
Diesel car		
CO	0.49	g/km
CO <sub>2</sub>	230.27	g/km
VOC	0.10	g/km
NO <sub>x</sub>	0.79	g/km
PM <sub>2.5</sub> exhaust	0.1909	g/km
PM1 B and T	0.0010	g/km
FC	8.76	l/100km





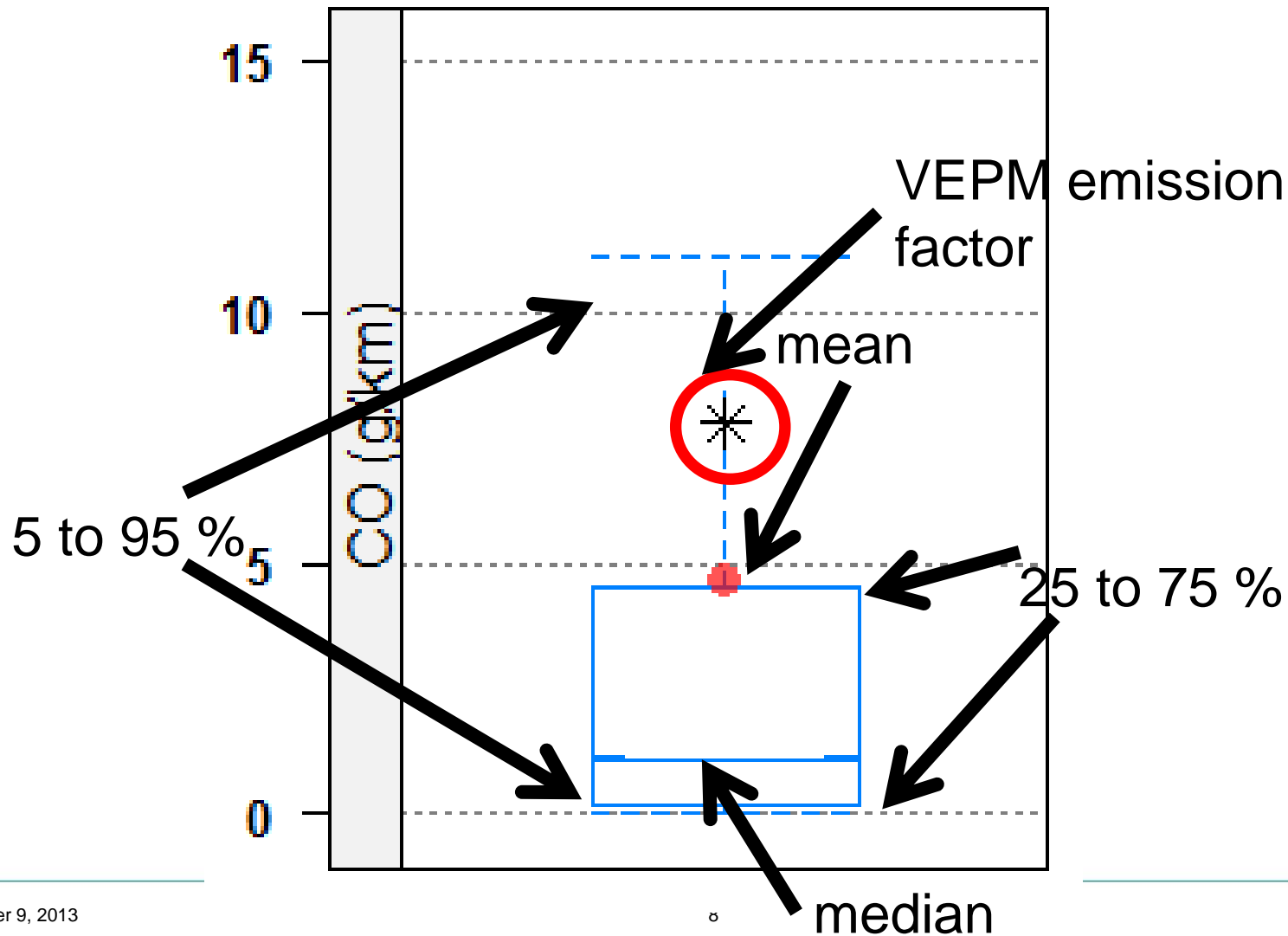


# RSD measurements to On-Road Emission Factors





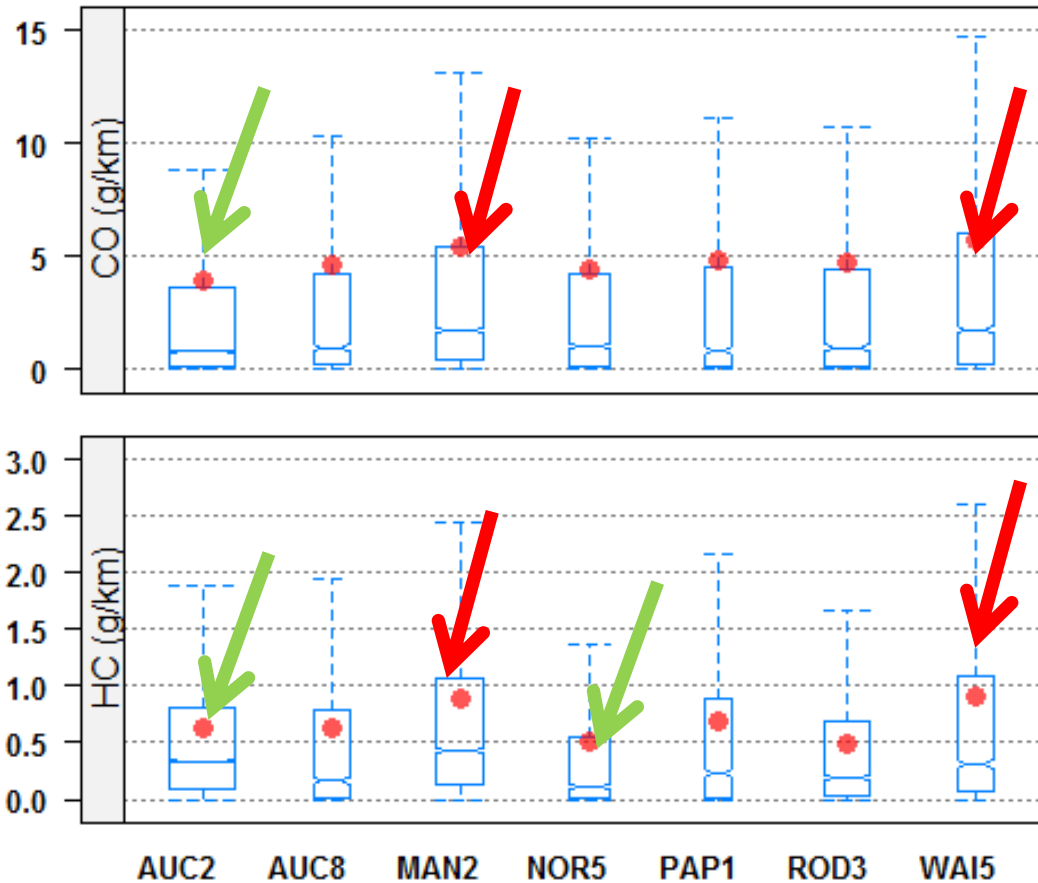
# Example results: RSD EMISSION FACTORS - petrol car







# Site to site variability of RSD emission factors.



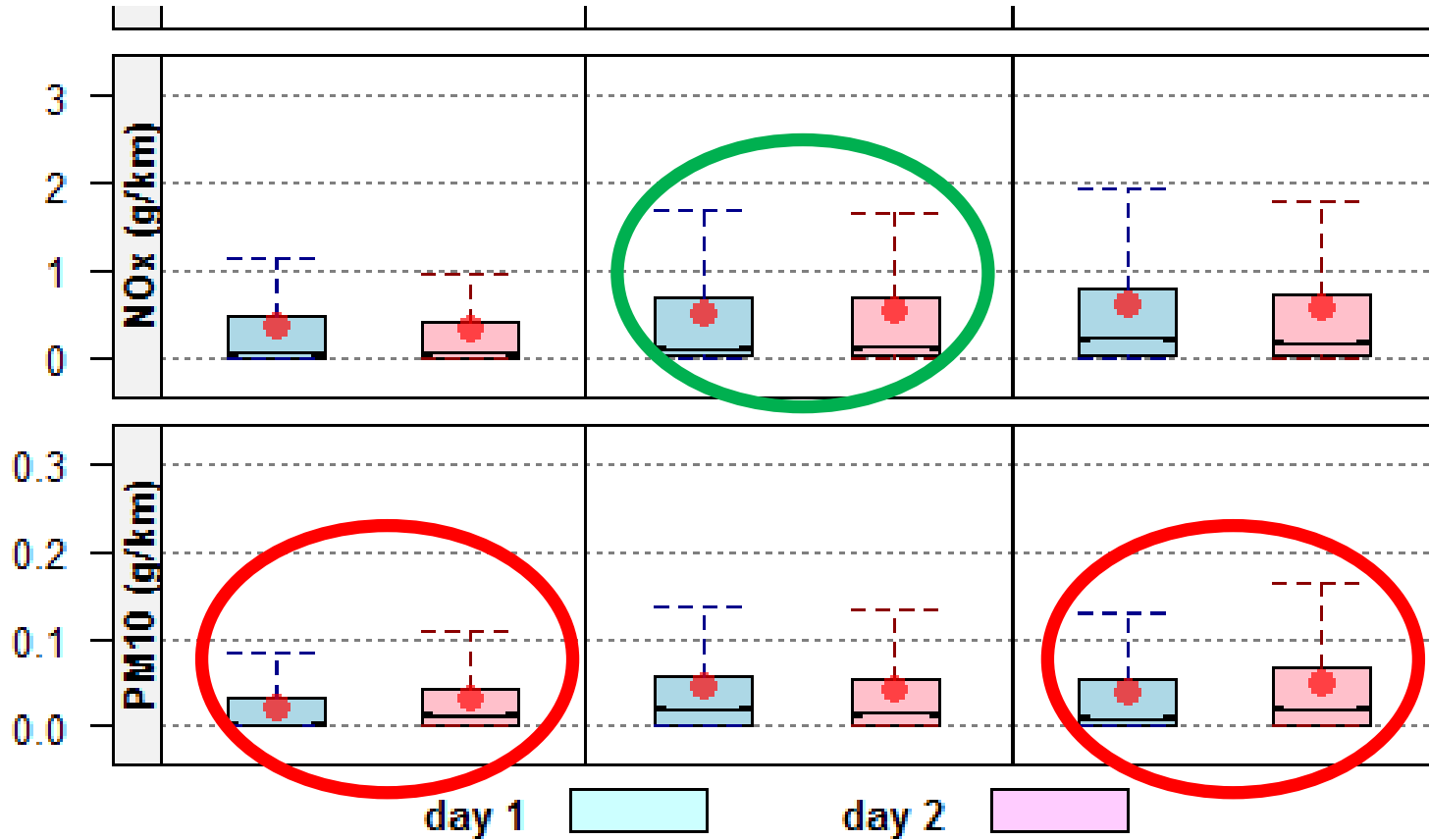


## Site to site variability of RSD emission factors

- **Considerable variation** of emission factors from site-to-site
- The **HC emission factors exhibit the highest** site-to-site variability.
- **Lagoon Drive** consistently had the **lowest emission** factors
- **Universal Drive** is always toward the **high end of the measurements** for all contaminants.
- The site-to-site variability of the emissions is most likely caused by:
  - the difference in vehicle fleet composition,
  - the age of the vehicles that are passing through the site



# Day to Day variability of RSD emission factors.





## Day to Day variability of RSD emission factors

- No significant day-to-day variation in the **CO emission factors** at any of the three sites.
- Significant day-to-day variation in the **HC emission factors** only at the Whangaparaoa Road site.
- Significant day-to-day variation in the **NOx emission factors** at the Lagoon Drive and Whangaparaoa Road sites.
- Significant day-to-day variation in the **PM<sub>10</sub> emission factors** at all three sites.
- The **reasons for the observed day-to-day** variability in emission factors **are not immediately clear.**



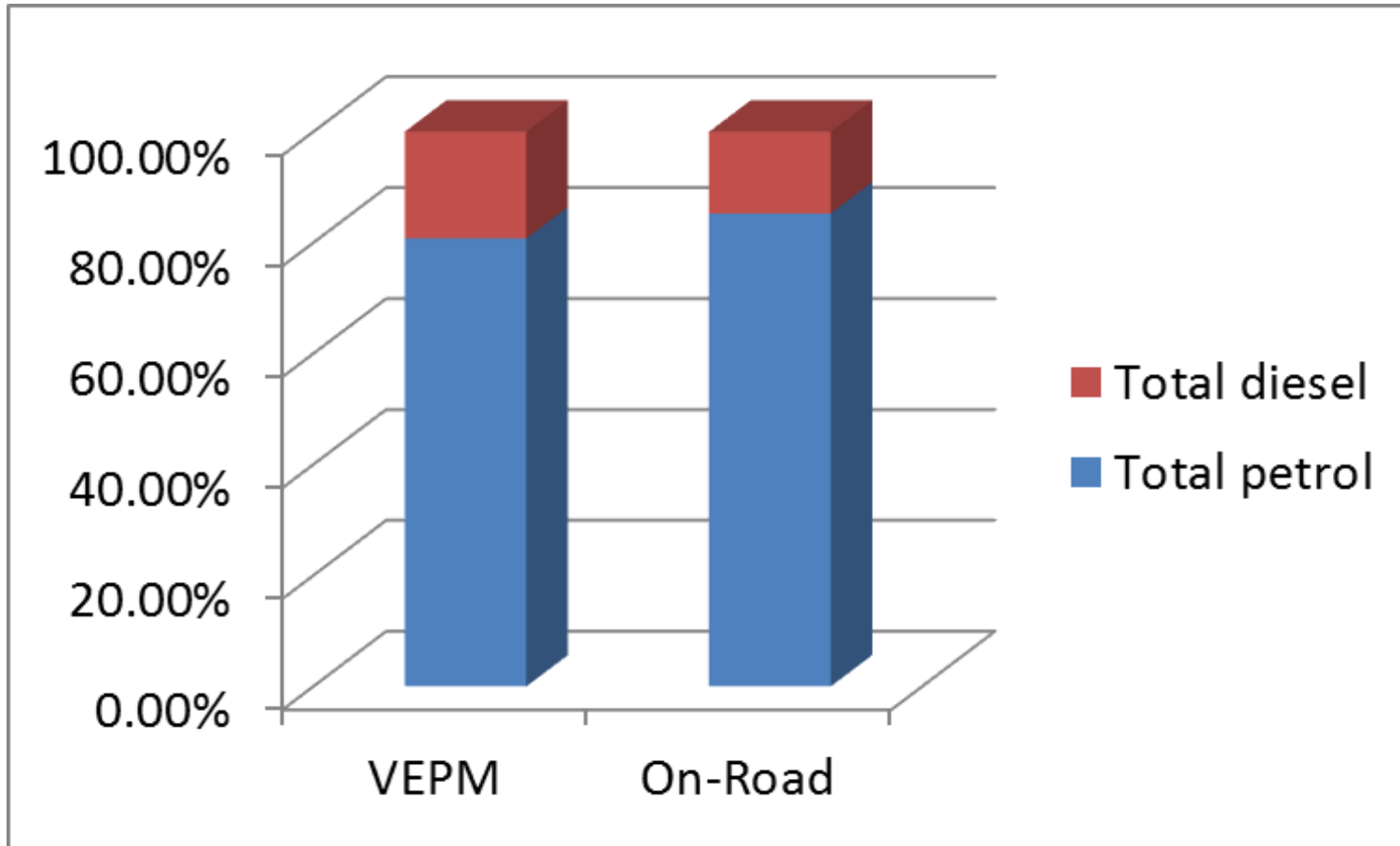
## VEPM vs On-road Emission Factors

- **VEPM (AC 2005 inventory)**
  - **Verses**
- **RSD emission factors (2006 monitoring programme)**
  - Petrol cars
  - Petrol light commercial vehicles
  - Hybrid and Electric vehicles (none in 2005 RSD)
  - Diesel car vehicles
  - Diesel light commercial vehicles



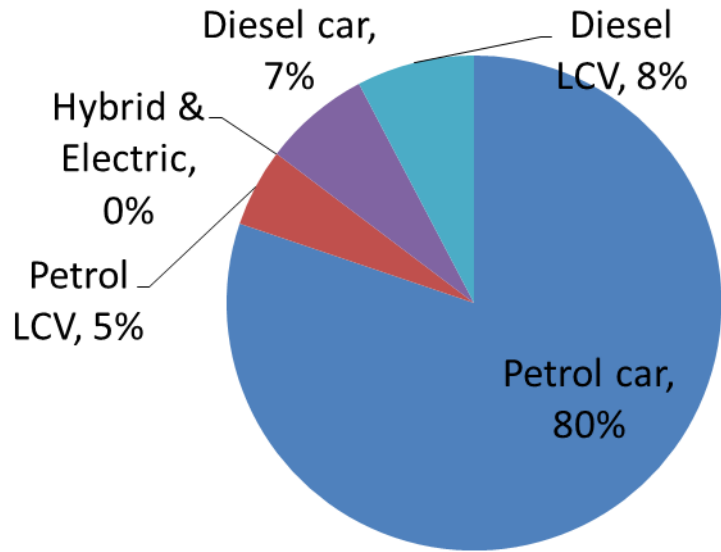


# VEPM vs On-road: Fuel type



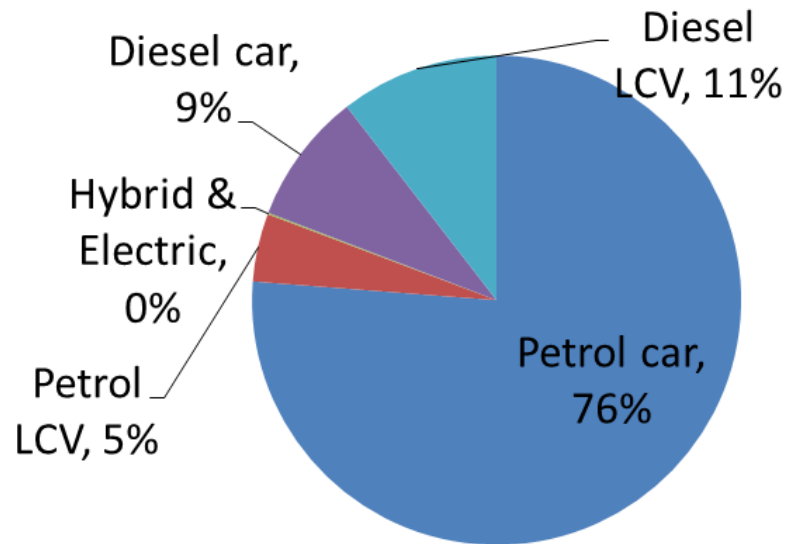


# VEPM vs On-road: Vehicle type



VEPM 2006

On-Road 2005





## CO – fleet average

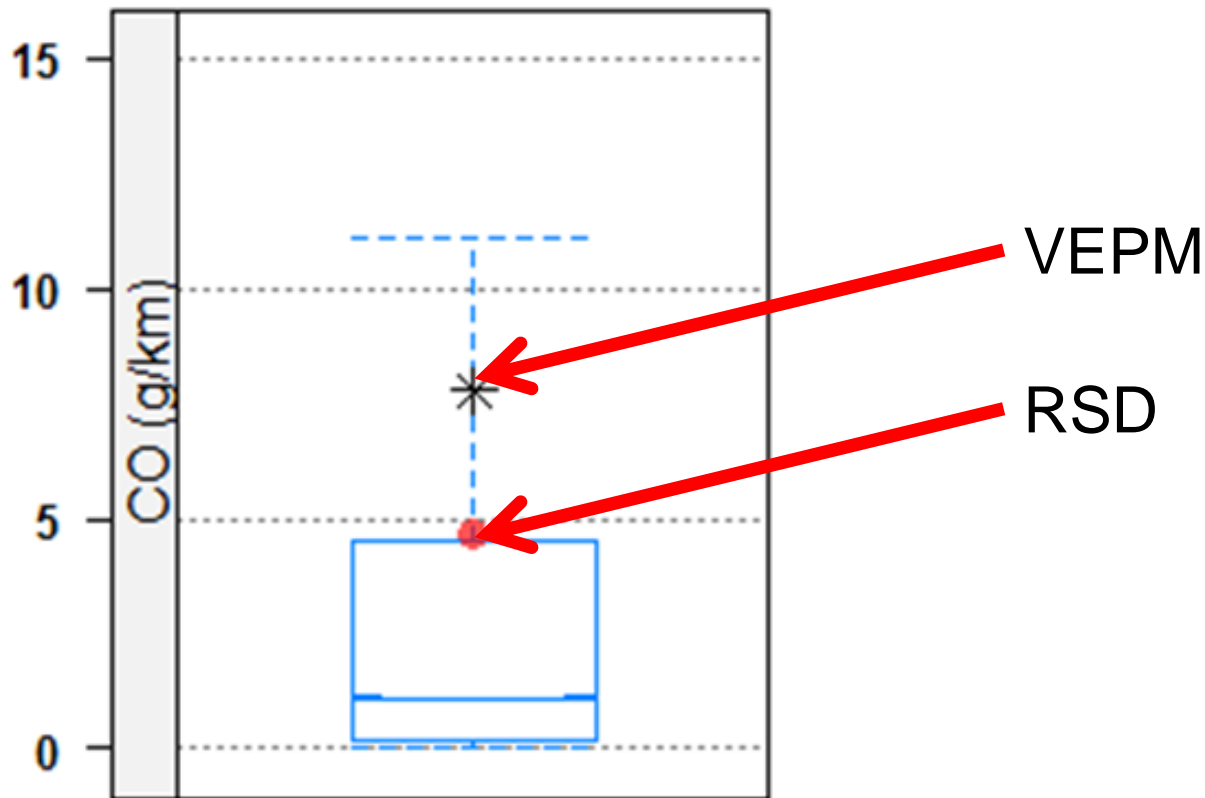


Figure 3: Comparison of fleet average RSD and VEPM CO emission factor.



# CO by vehicle type

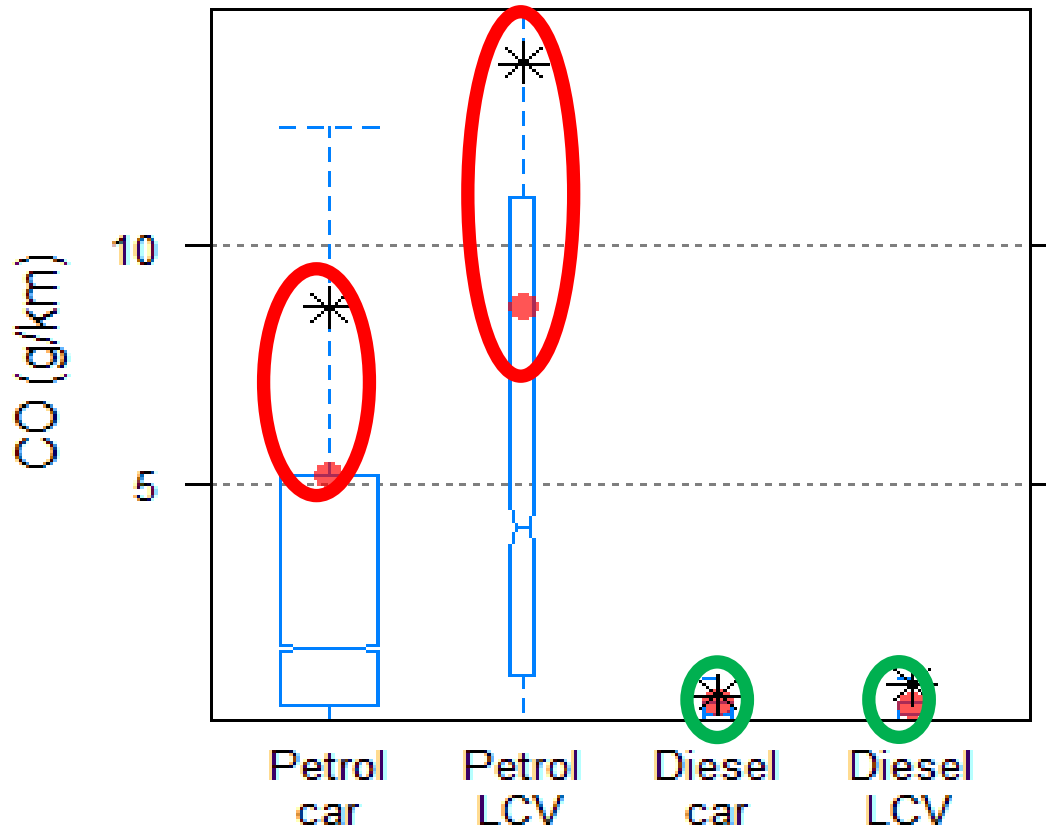


Figure 4: Comparison of RSD and VEPM CO emission factor by vehicle type.



# CO by vehicle type

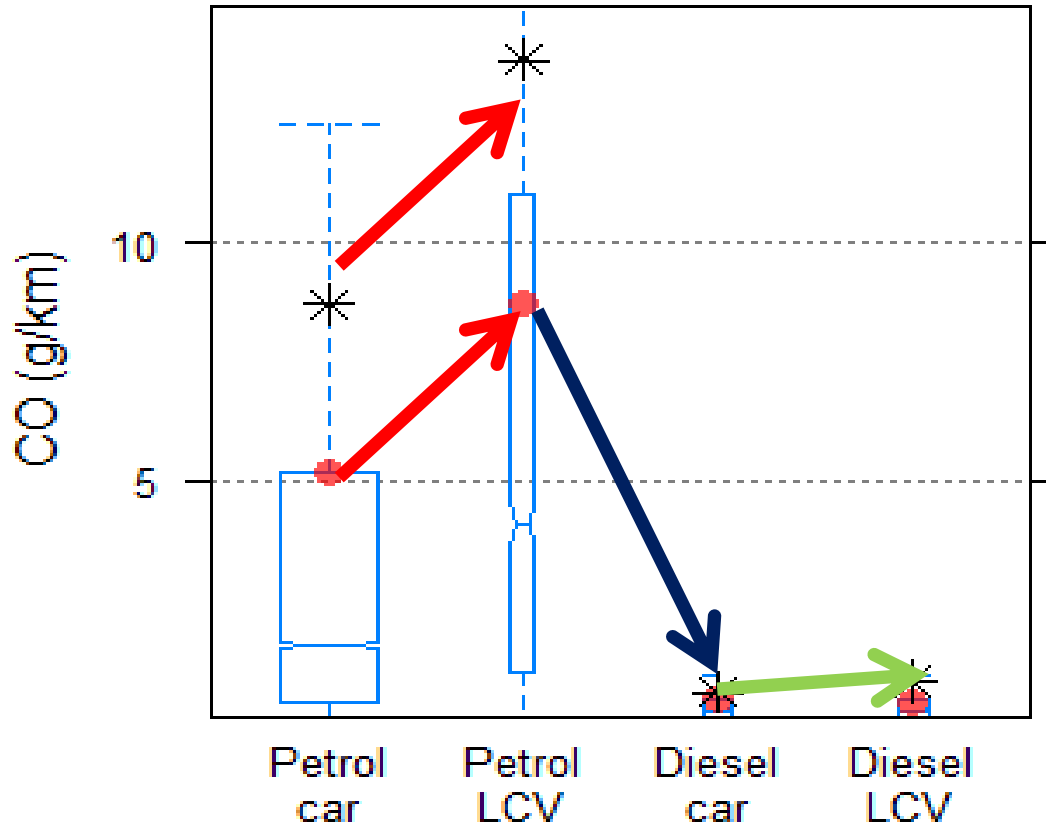


Figure 4: Comparison of RSD and VEPM CO emission factor by vehicle type.





## Summary of Results – Traffic light criteria

Ratio VEPM/RSD	Colour
<b>&lt;0.50 or &gt;2.0</b> (more than 100% diff)	<b>Red</b>
<b>0.50-0.67 or 1.5-2.0</b> (between 50 and 100% diff)	<b>Orange</b>
<b>0.67-1.5</b> (less than 50% diff)	<b>Green</b>



## Summary of Results

	<b>Petrol Car</b>	<b>Petrol LCV</b>	<b>Diesel Car</b>	<b>Diesel LCV</b>
<b>CO</b>	1.7	1.6	1.5	2.4
<b>HC</b>	0.7	1.1	0.3	0.2
<b>NO<sub>x</sub></b>	1.0	1.4	0.6	0.5
<b>PM<sub>10</sub></b>	8.2	21.0	0.5	0.7

5 Green  
7 Orange  
3 Red



## Review of Project Objectives

- To verify that the VEPM is providing **useful and realistic estimates** of light duty vehicle emissions and
- To **increase stakeholder confidence** in the emission data produced by VEPM.





## Recommendations for Future Work

- Put the findings of this study in context **with VKT travelled by each vehicle class**.
- Consider the **variation of emission factors with speed**. – probably only practical only for petrol cars.
- Review implications of red cells (HC emission factors from diesel vehicles and on PM10 emission factors from petrol vehicles) which show **relatively large differences** between VEPM and RSD estimates.
- Evaluate validity of RSD PM10 emission factors given the **limitations of open-path monitoring** of particulate matter.
- Extend RSD emission factors to **heavy duty diesel vehicles**.
- Investigate the causes of and potential implications of **day-to-day and site to site variation** in RSD emissions factors.
- Plan future RSD monitoring programmes to **fill knowledge gaps** identified in this study
- Re-run VEPM vs RSD for **future years** (e.g. 2011)



## Acknowledgements

- Martin Unwin (NIWA) - data analysis
- Auckland Council
  - Funding 2005 RSD monitoring
  - Funding Task 1 - data analysis
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- NZTA
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