Vehicle Based Road Dust Emission Measurements

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Outline

- AP-42 Road Dust Emission Estimation Methods
- TRAKER Road Dust Measurement Method
- TRAKER Calibration with PM_{10} Flux
- TRAKER Results
  - Seasonal Changes in Emission Potential
  - Effects of Sanding and Street Sweeping
  - Emissions Inventory Development

AP-42 Road Dust Emissions Estimation

Silt content and silt loading are surrogates for road dust emissions potential.

Paved Road:

- EF (g/vkt) = *f* (*silt loading, vehicle weight*)

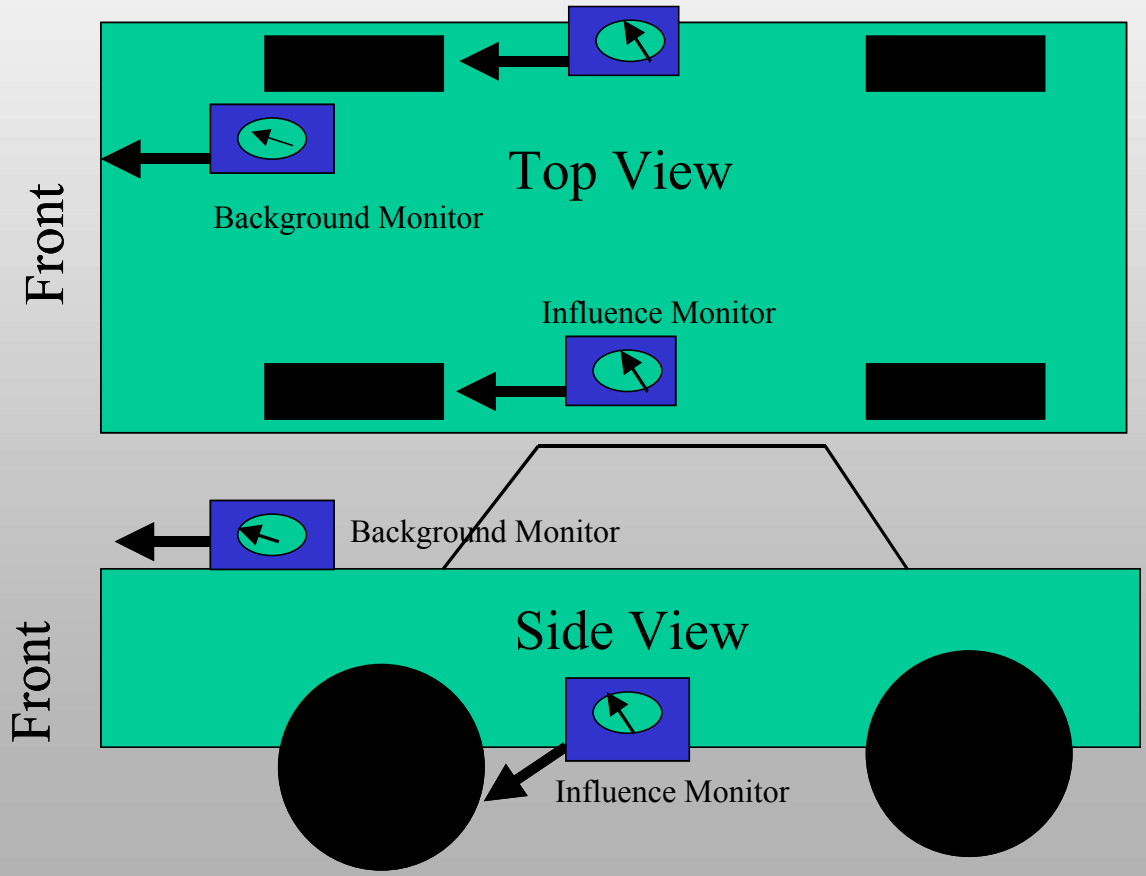
Unpaved Road:

- EF (g/vkt) = *f (silt content, vehicle weight, soil moisture/speed*)

Relative Contribution to PM in NEI

- For Base Year 2001, Paved and Unpaved Road Account for:
  - 50% of PM_{10} emissions
  - 30% of $PM_{2.5}$ emissions
- Measured Transportable Fraction of PM_{10} Emissions:
  - At 100 m: Range from 100% to 15%.

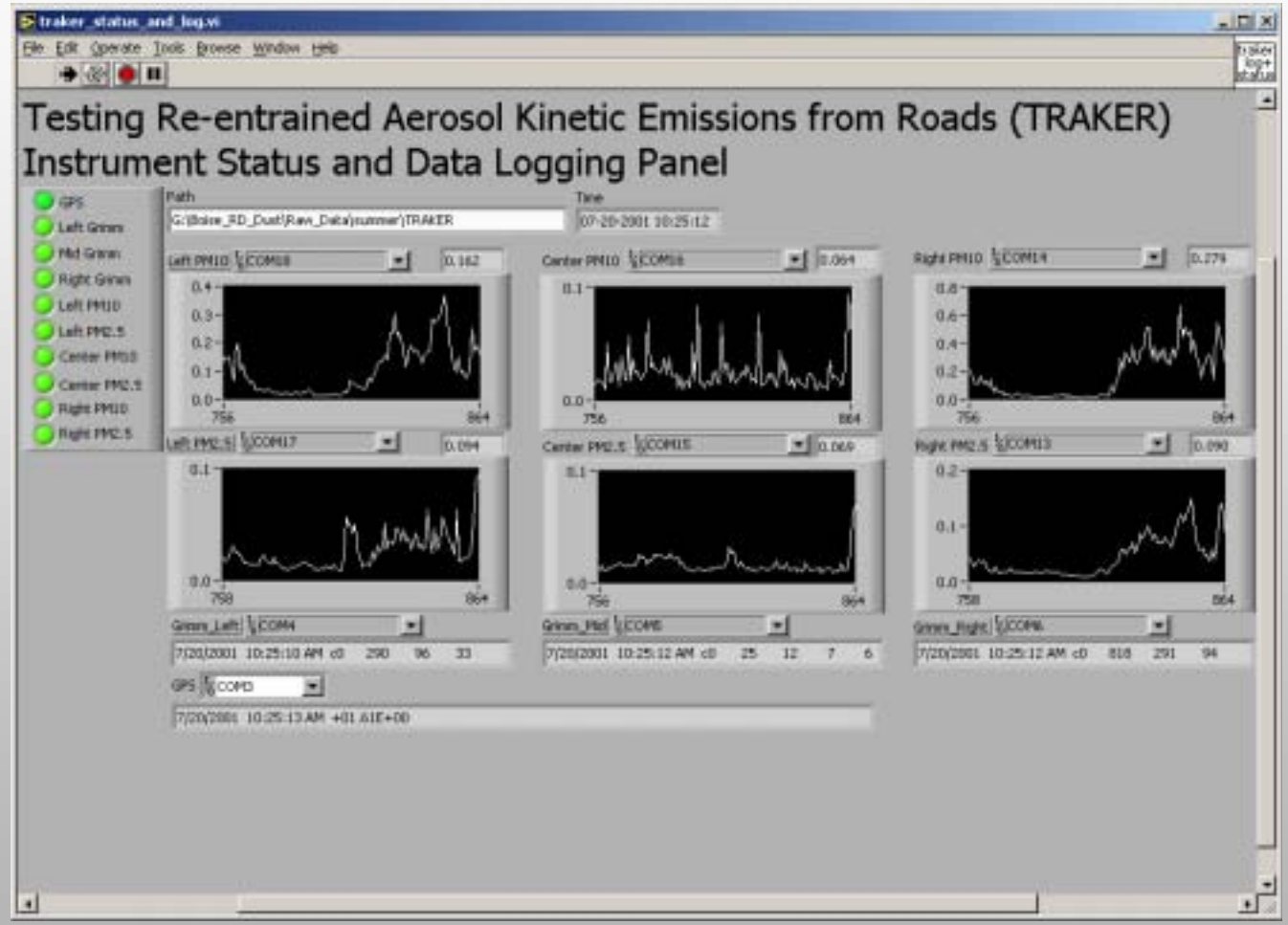
Testing Re-entrained Aerosol Kinetic Emissions from Roads (TRAKER) Measurement Method



- Particle Sensors
  - TSI DustTrak 5830
  - Grimm Particle Size Analyzer 1.108
- GPS
  - Ashtech/Magellan Promark X

Data Acquisition and Processing

- Lab View program displays and logs data from
  - 6 DustTraks
  - 3 Grimms
  - 1 GPS
- Uniform time stamp applied to all data for synchronization
- Data tables are loaded into MS Access for processing and analysis

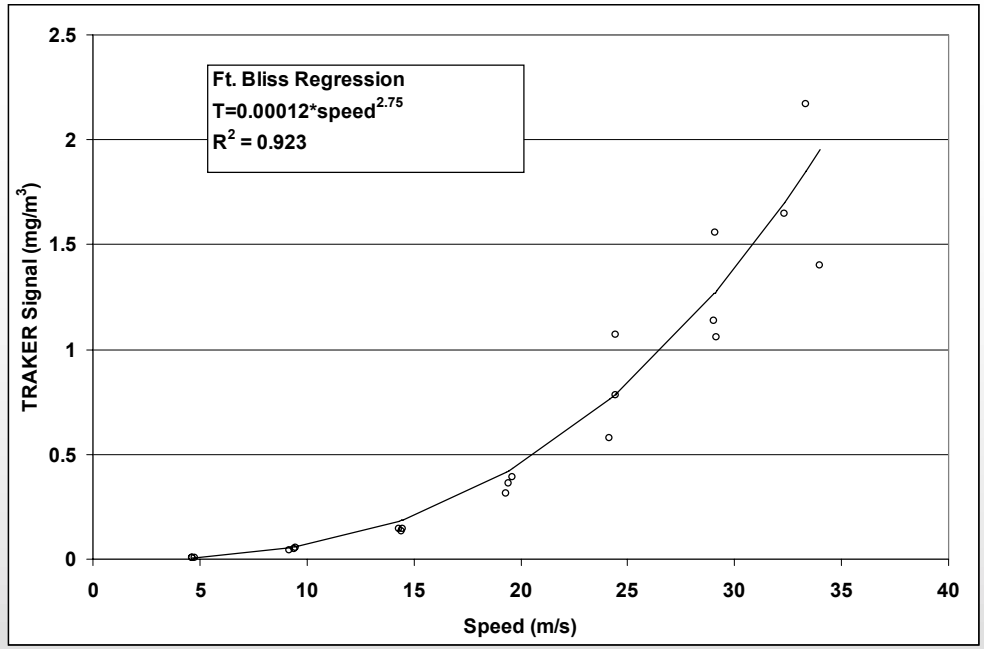


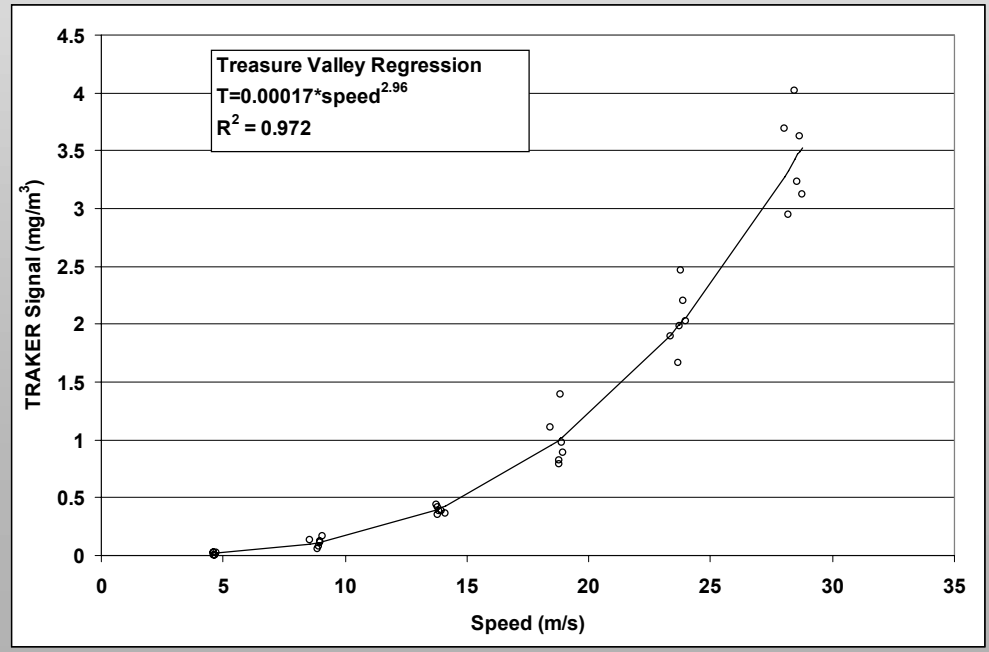
TRAKER Signal vs Vehicle Speed

- $T = C_{tire} - C_{bkgrnd}$
- $T = a\ S^3$

- On the same paved road the TRAKER signal increases with the speed cubed

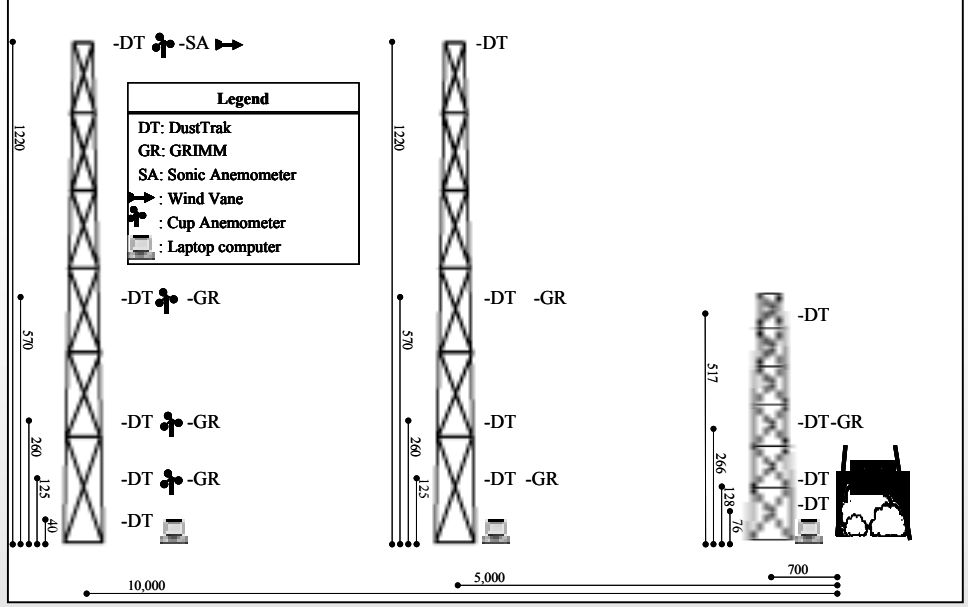
- Factoring out speed leaves a signal proportional to the emission potential of the road.

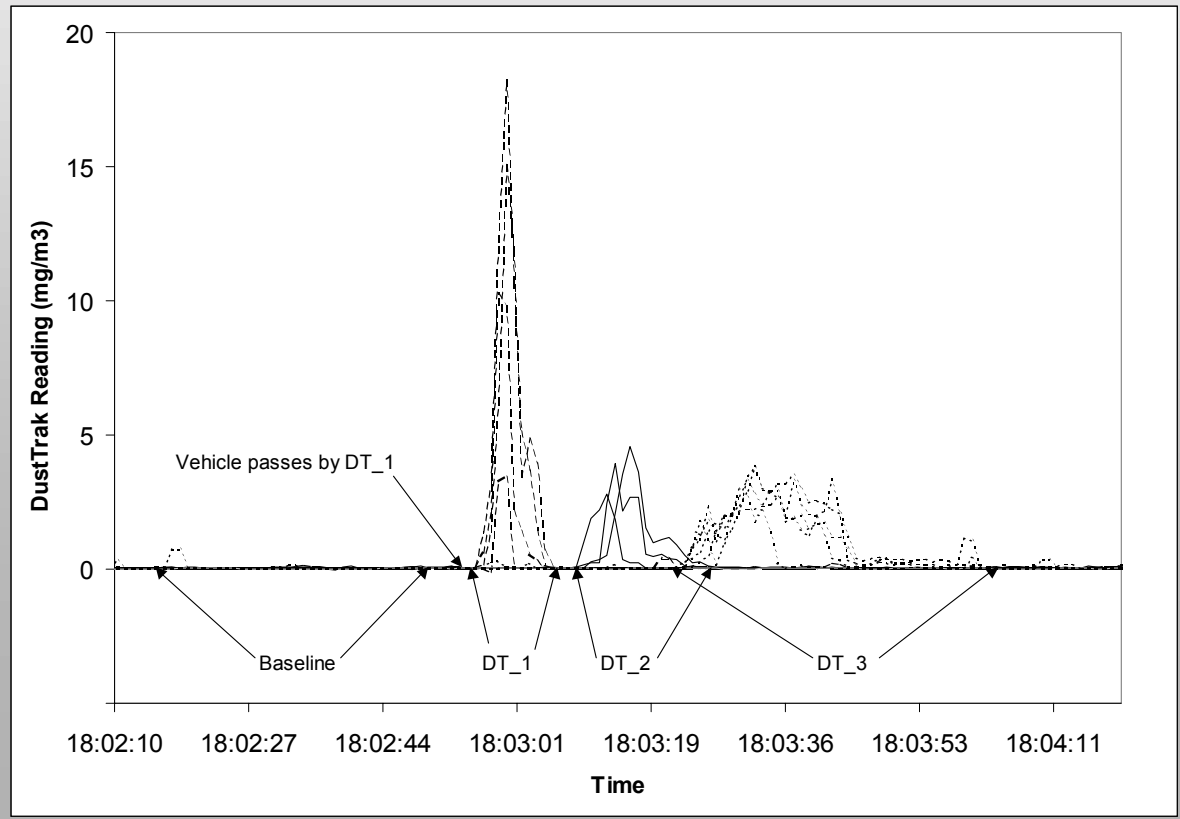




Upwind-Downwind Flux Measurements

Emission factor calculated as horizontal flux of PM_{10} passing instrumented towers

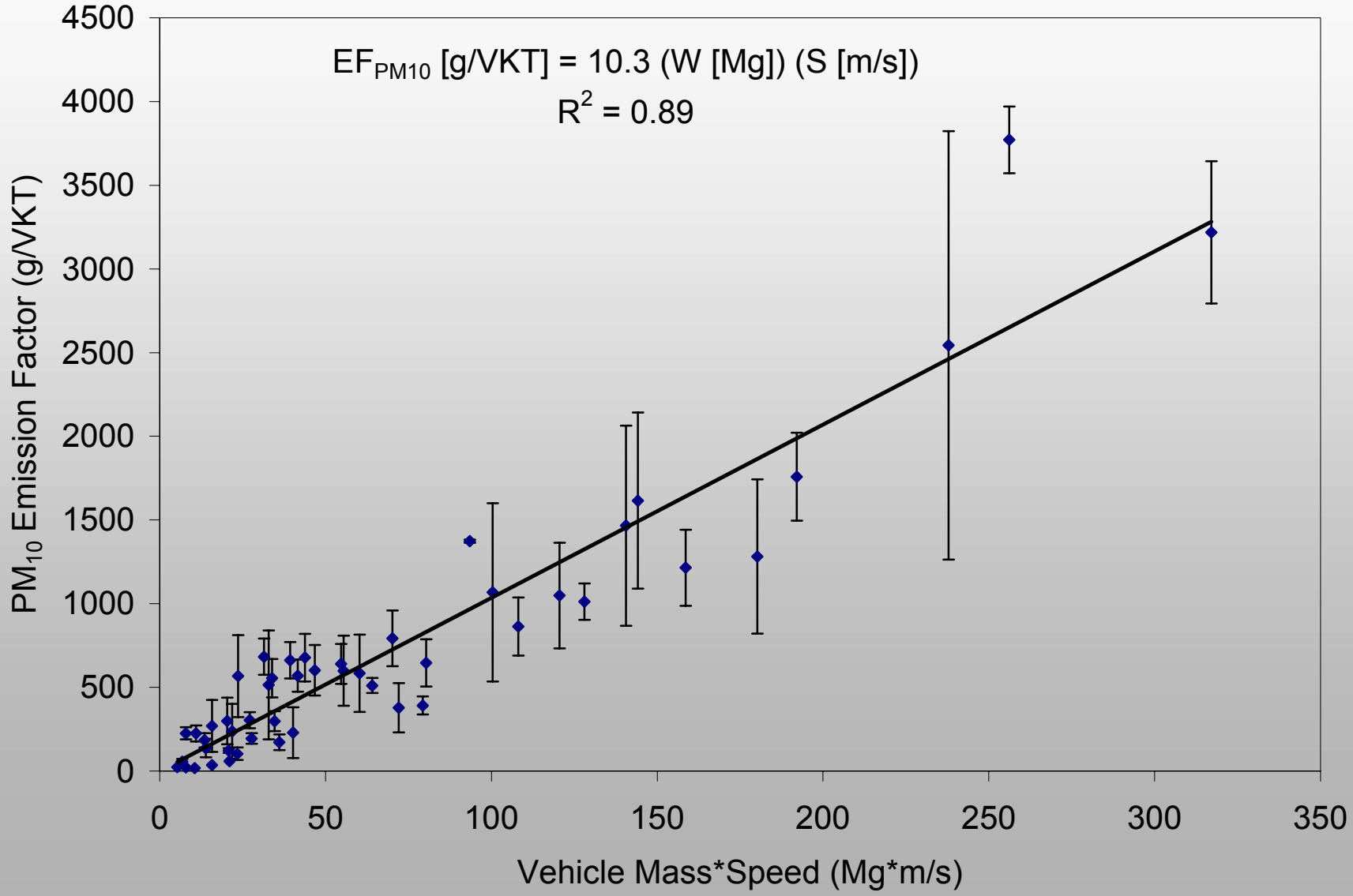




Unpaved Emissions Measured on Flux Towers in Ft. Bliss TX (April 2002)

Vehicle	Weight (kg)	# Wheels
Dodge Neon	1,176	4
Ford Taurus	1,516	4
Dodge Caravan	1,759	4
HUMVEE	2,445	4
TRAKER (Chevy Van)	3,100	4
26’ UHAUL Truck	5,227	6
LMTV	8,060	4
Freightliner (Tractor)	8,982	22
HEMMET	17,727	8
5-ton Truck	14,318	6

$EF_{PM10} = b\ W\ S$


EF_PM10 [g/VKT] = 10.3 (W [Mg]) (S [m/s])
R^2 = 0.89
PM10 Emission Factor (g/VKT)
Vehicle Mass*Speed (Mg*m/s)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
50
100
150
200
250
300
350

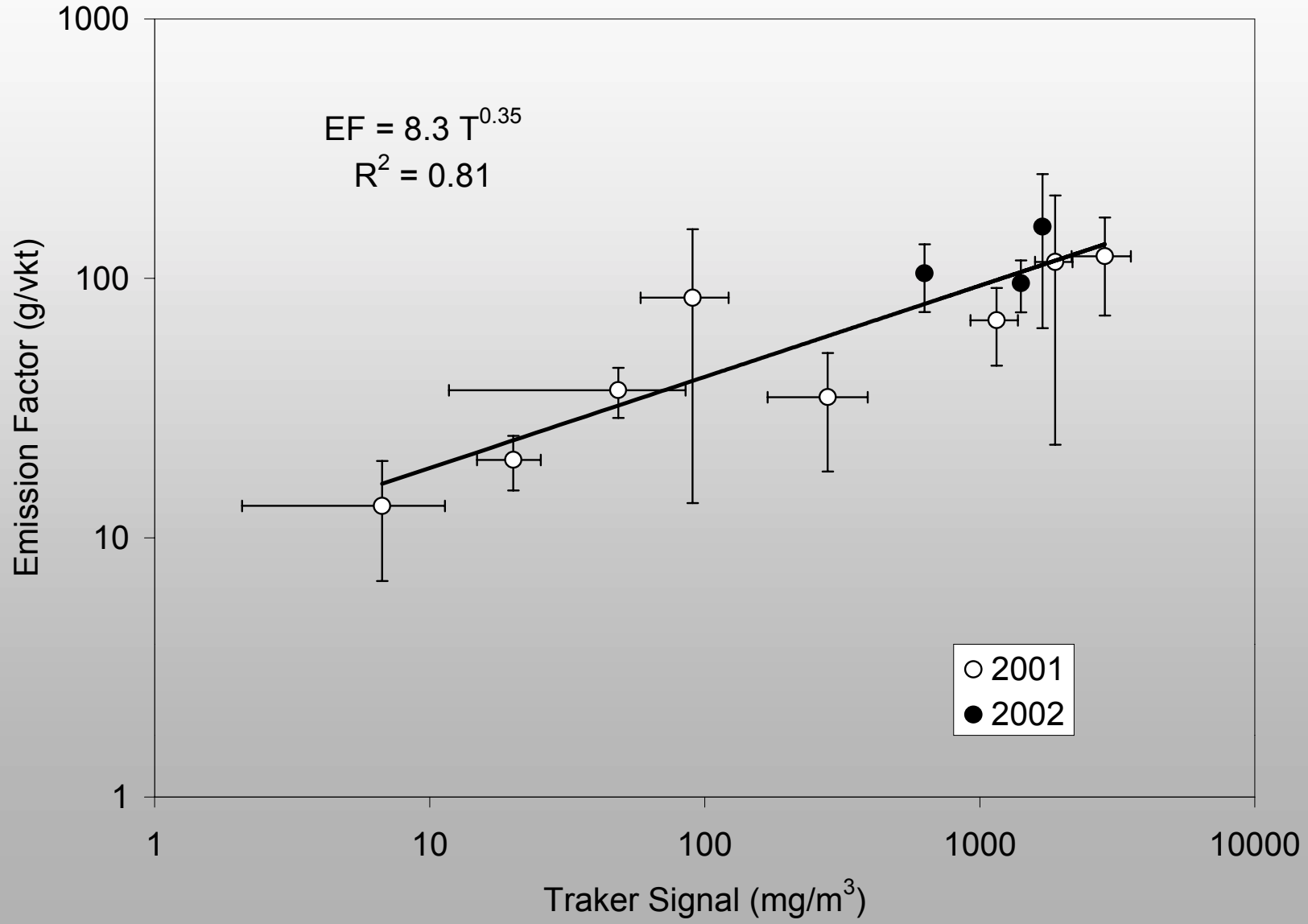
Calibrating TRAKER with Emissions Factors from Tower Measurements

- $T = a\ S^3$ (TRAKER Measurements)
- $EF_{PM10} = b\ W\ S$ (Tower Measurements)

- $EF_{PM10} = k\ T^{1/3}$ (Tower Calibrated TRAKER)

where a, b, and k are empirical constants

Relationship b/w TRAKER and Emissions Factor



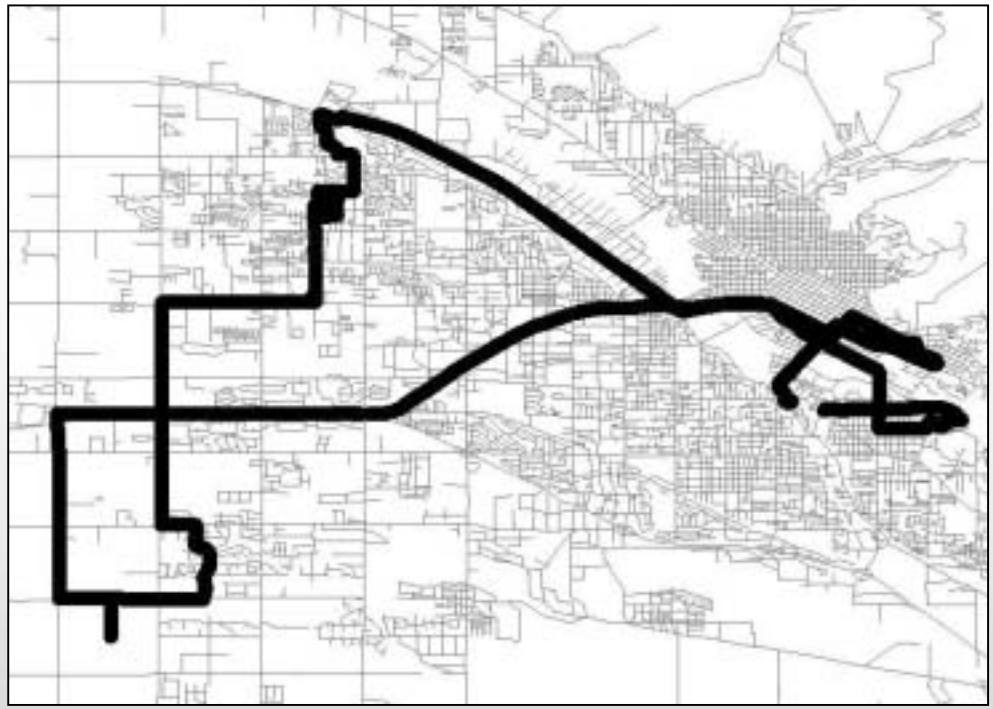
Emission Potential

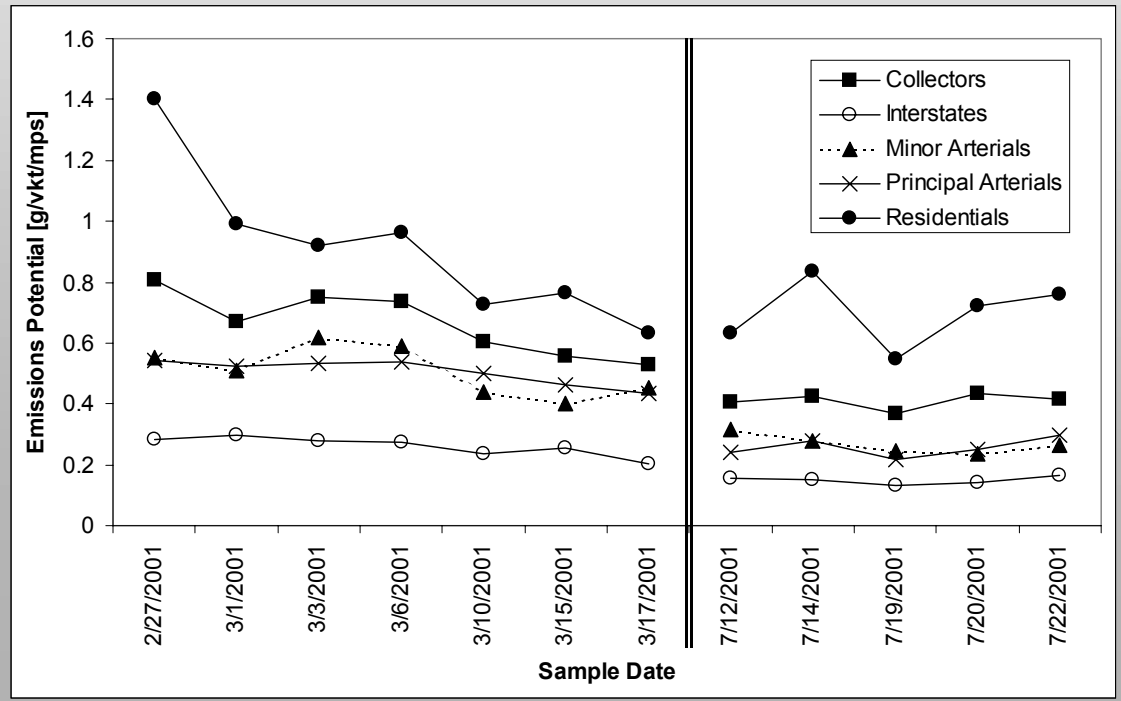
- Roads emit PM based on:
  - Weight of vehicle
  - Speed of vehicle
  - Dirtiness of the road (i.e. Emission Potential)

- Emission Potential is a property of the road only:

$$EP_{PM10}\left[\frac{\left(\frac{g}{VKT}\right)}{\left(\frac{m}{s}\right)}\right] = \frac{EF_{PM10}}{S} = \frac{kT^{1/3}}{S}$$

TRAKER Results: Seasonal Changes of Emission Potential

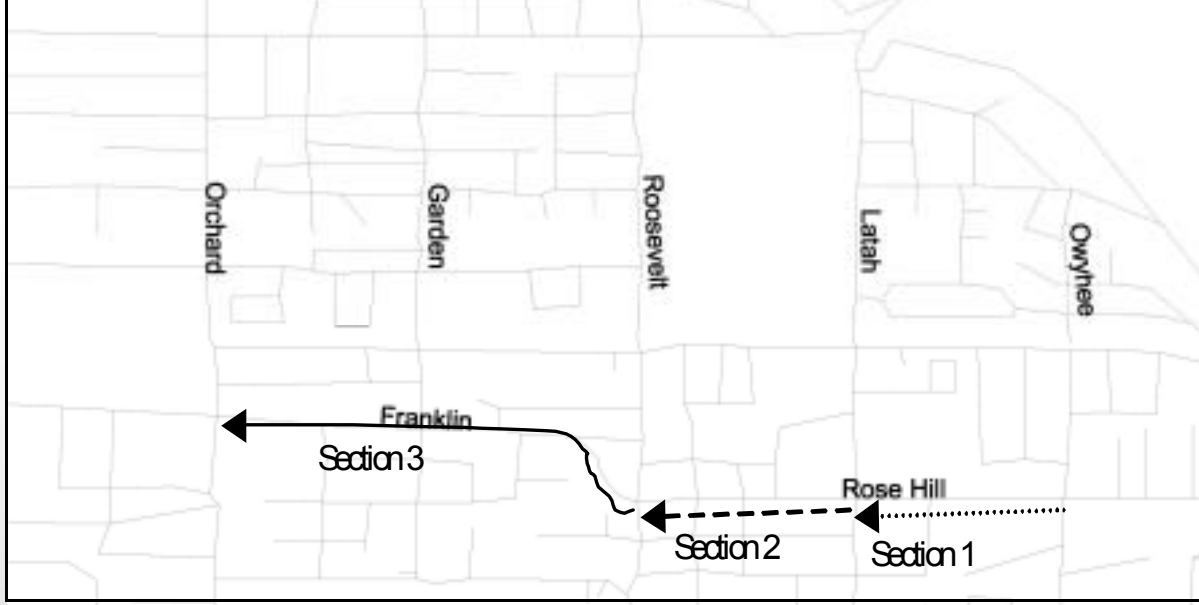




Street Sweeper Efficiency

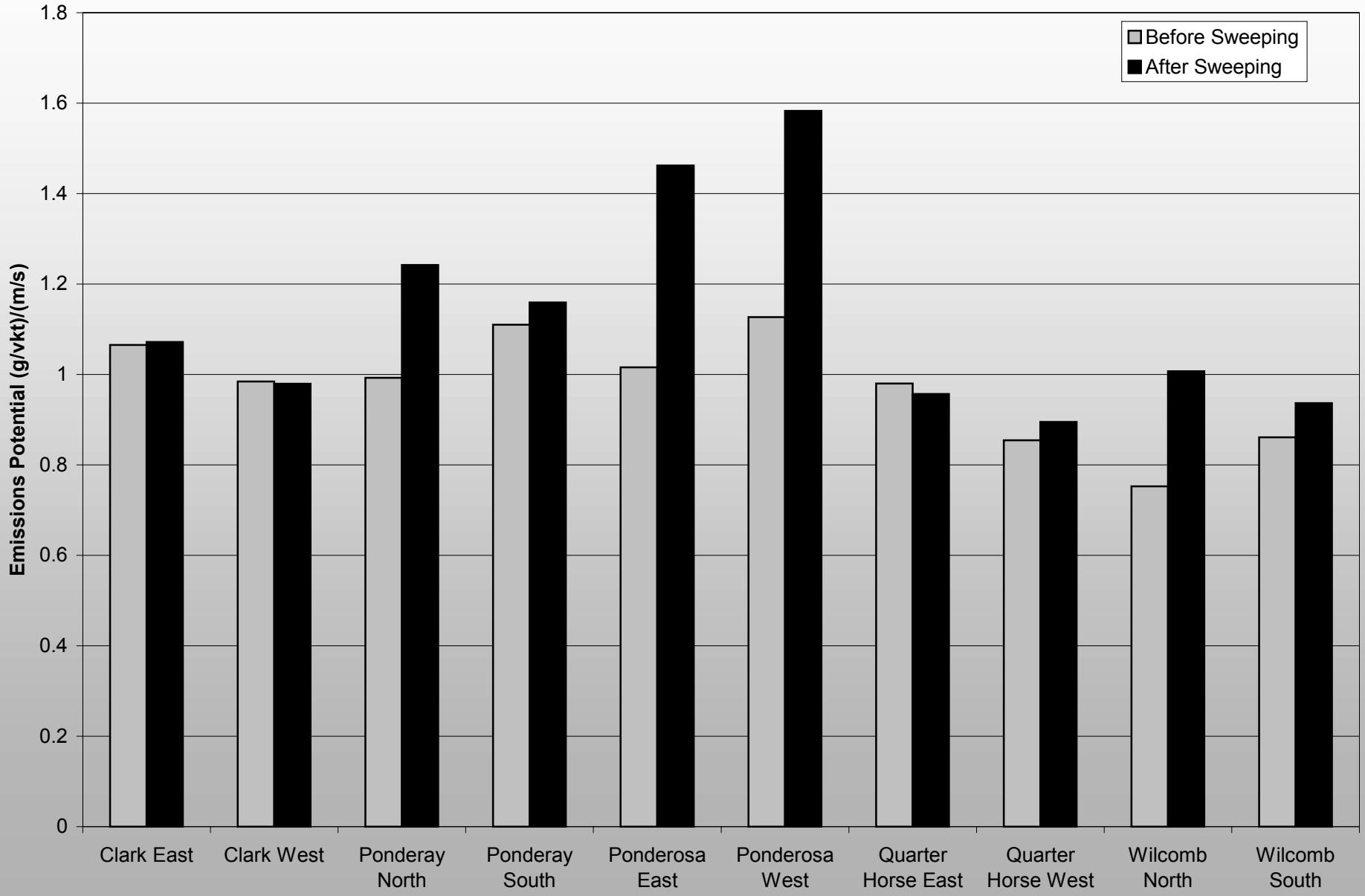
Elgin Whirlwind Street Sweeper

Wintertime Road Sanding and Sweeping Experiment



Time Relative to Treatment

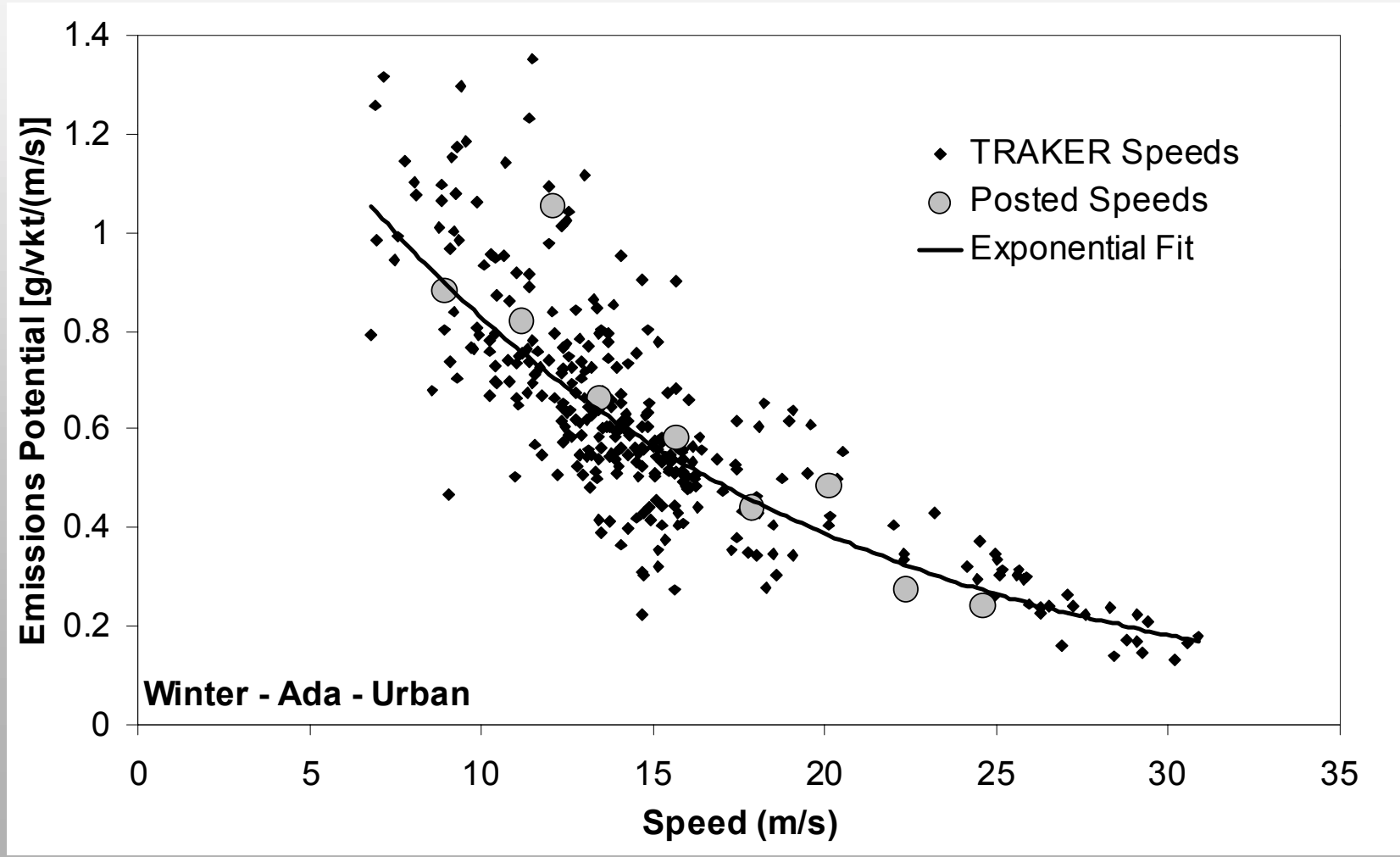
Relative Effect of Street Sweeping



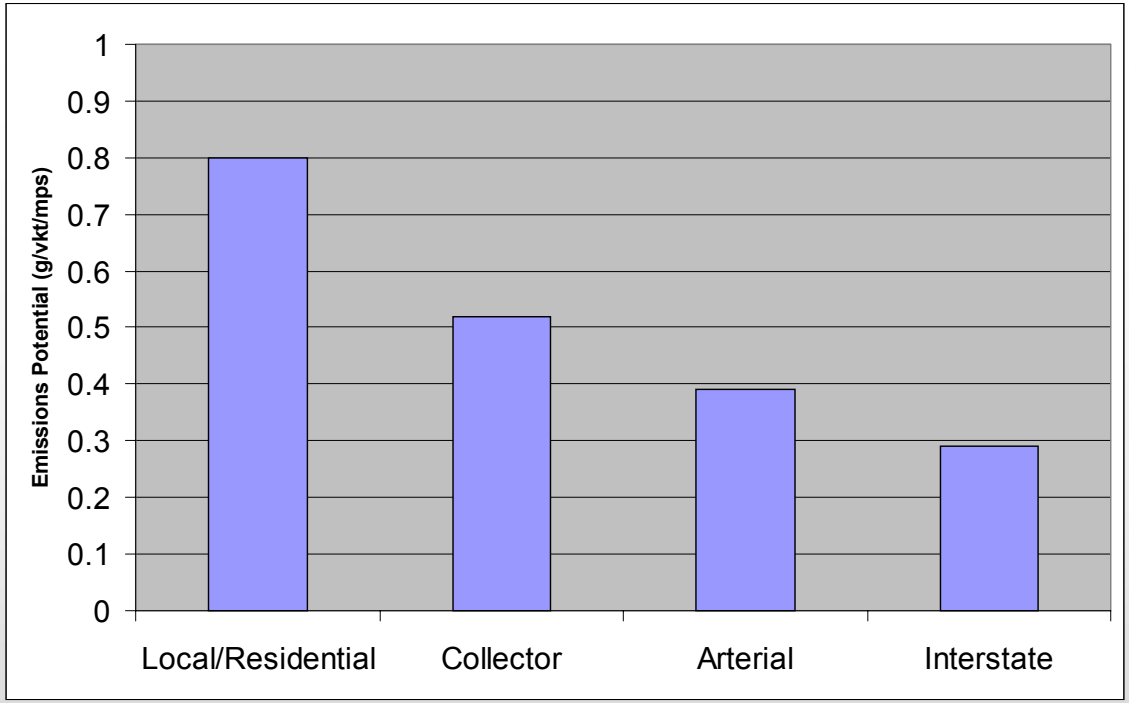
Road Dust EI Development with TRAKER

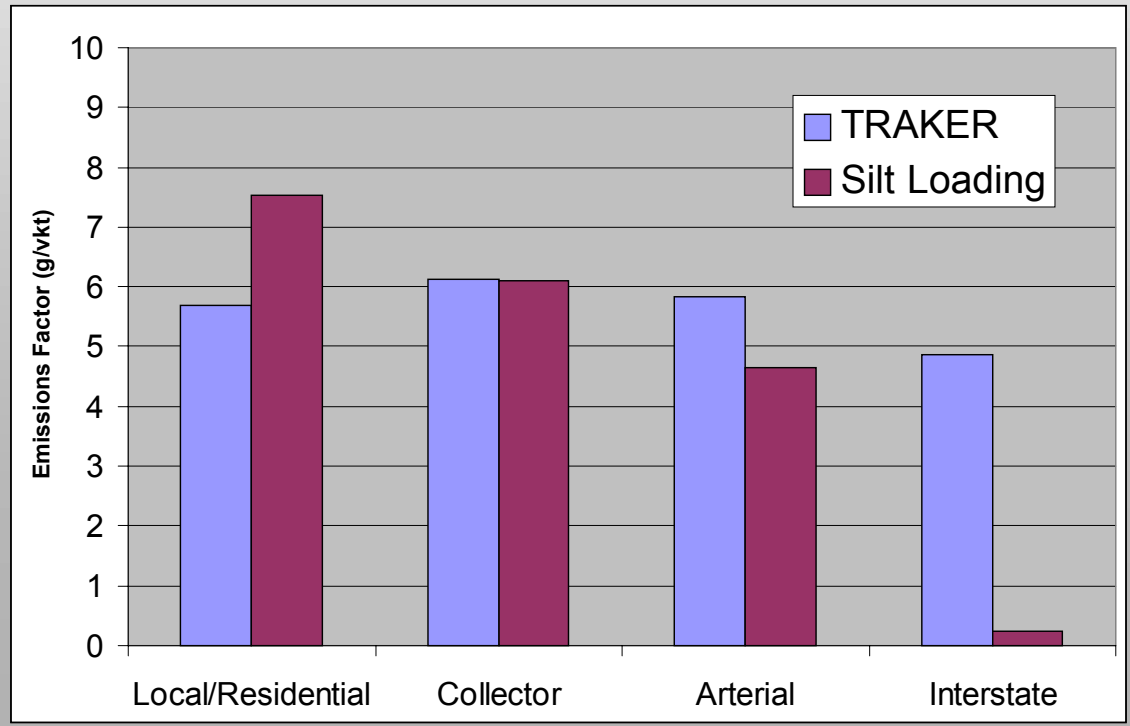
1. Measure TRAKER signal over 500+ km of roads.
2. Calculate emissions factor for each measurement based on TRAKER signal and TRAKER speed
3. Characterize emissions factors by season, road type, speed, and location (i.e. county, urban/rural).
4. Extrapolate emissions factors to all roads in domain based on season, road type, modeled speed, location, and VKT.
5. Apply Average Daily Traffic (ADT) estimates from Traffic Demand and Forecasting Models to create EI.

Emission Potential vs. Typical Road Speed



Emissions Potentials & ***Emissions Factors*** for Paved Roads in the Treasure Valley Idaho

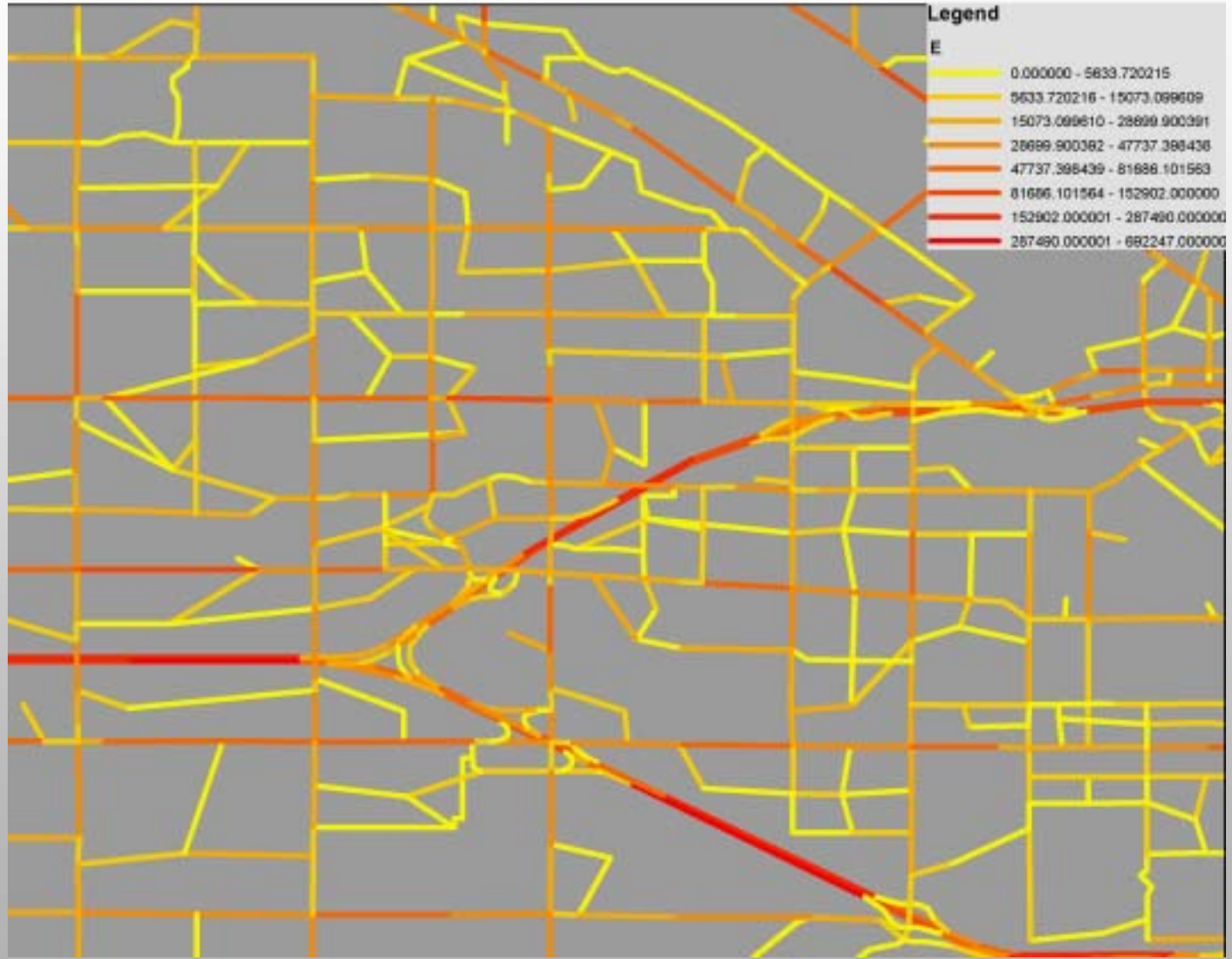




Comparison of Silt Loading vs TRAKER for Ada and Canyon Counties, Idaho (BY 1999)

	TRAKER (Mg/Day)	Silt Loading (Mg/Day)
Summer	59	22
Winter	89	56

Map of Boise Road Dust Emissions



Summary and Conclusions

TRAKER Road Dust Measurement System

- obtains local road dust emission potential by sampling dust suspended by a vehicles tire
- has been calibrated to emissions factors based on unpaved road emissions
- provides significantly higher spatial and temporal resolution of road dust emissions than silt loading
- can be used for to create road dust emission inventories and to evaluate effectiveness of control strategies