Measurement of PM_{10} Emission Rates from Roadways in Las Vegas, Nevada Using a SCAMPER Mobile Platform with Real-Time Sensors

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Introduction

- Quantifying PM Emissions from Paved Roads are Important Because:
  - Significant contributor to exceeding standard in many air basins
  - Estimated inventories of geologic PM are higher than measured concentrations
  - Emissions due to paved roads are a major component of geologic emissions

- Emission Inventories are Difficult to Determine Because:
  - Fugitive nature leads to high uncertainties for emission factors
  - Current inventories are based on an empirical equation derived from upwind-downwind sampling from primarily industrial roads
  - Modeling is required to determine emission factors from upwind-downwind concentrations
  - PM concentration differences are small between upwind and downwind locations for most roads

Objectives

- Develop a More Accurate and Cost-Effective Approach for Measuring PM_{10} Emission Factors for Paved Roads
- Determine PM_{10} Emission Factors for Various Roadway Types

Approach Inspiration

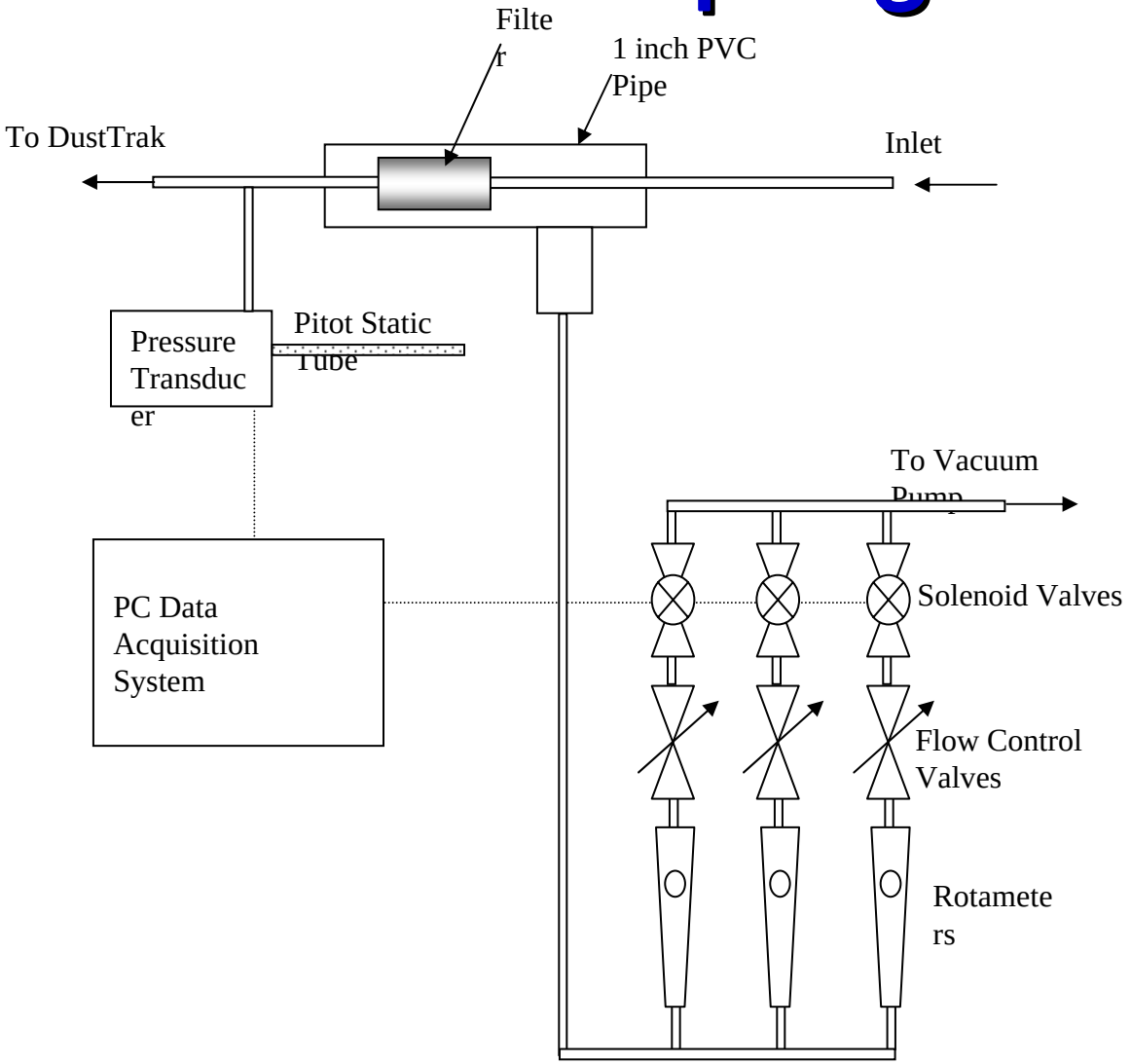
Approach

- Measure PM Directly in Front of and Behind a Test Vehicle with an Isokinetic Sampling Probe
- Use Real-Time Sensors to Accumulate Large Amounts of PM Data Quickly
- Calibrate Real-time Sensors with Filter Collection.
- Determine the Variability of PM behind the Test Vehicle
- Determine Emission Factors Based on the Concentration Within the Vehicle's Wake

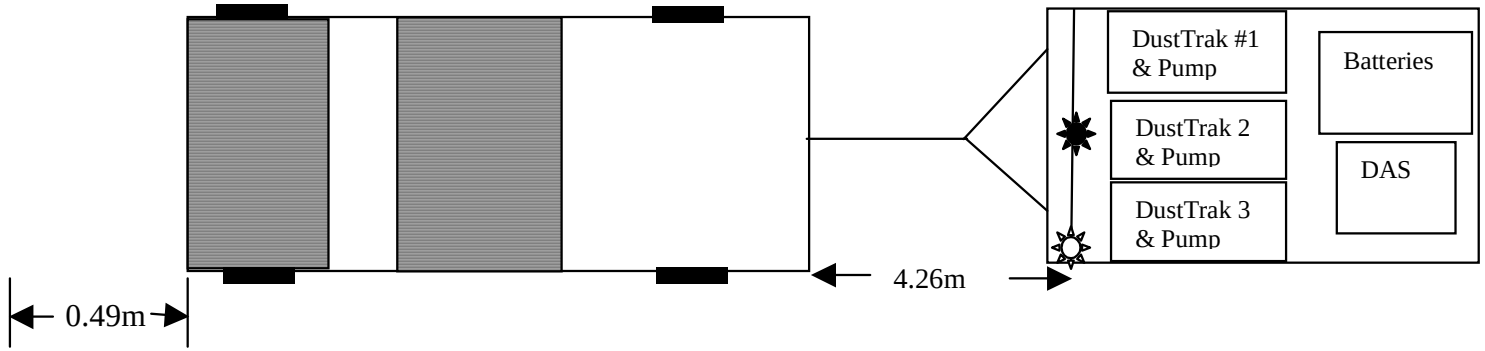
Experimental Design

- DustTrak PM Optical Scattering Sensors
- Isokinetic Sampling Probe
  - Provide isokinetic sampling from 0-60 mph
  - Slow sample flow without creating a virtual impactor
- Inlets Located in Front of Test Vehicle and on Small Trailer Towed Behind it
- Low Volume PM10 Sample Collected Simultaneously
- Approach Designated SCAMPER: System of Continuous Aerosol Monitoring of Particulate Emissions from Roadways

Isokinetic Sampling Probe



Sampling Design for Wake Characterization



- DustTrak #1 Inlet (1.98 or 2.59 m above ground)
- DustTrak #2 & #3 Inlets (0.78 & 1.98 or 2.59 m above ground)

Isokinetic Sampling Probe Mounted on Front of Test Vehicle

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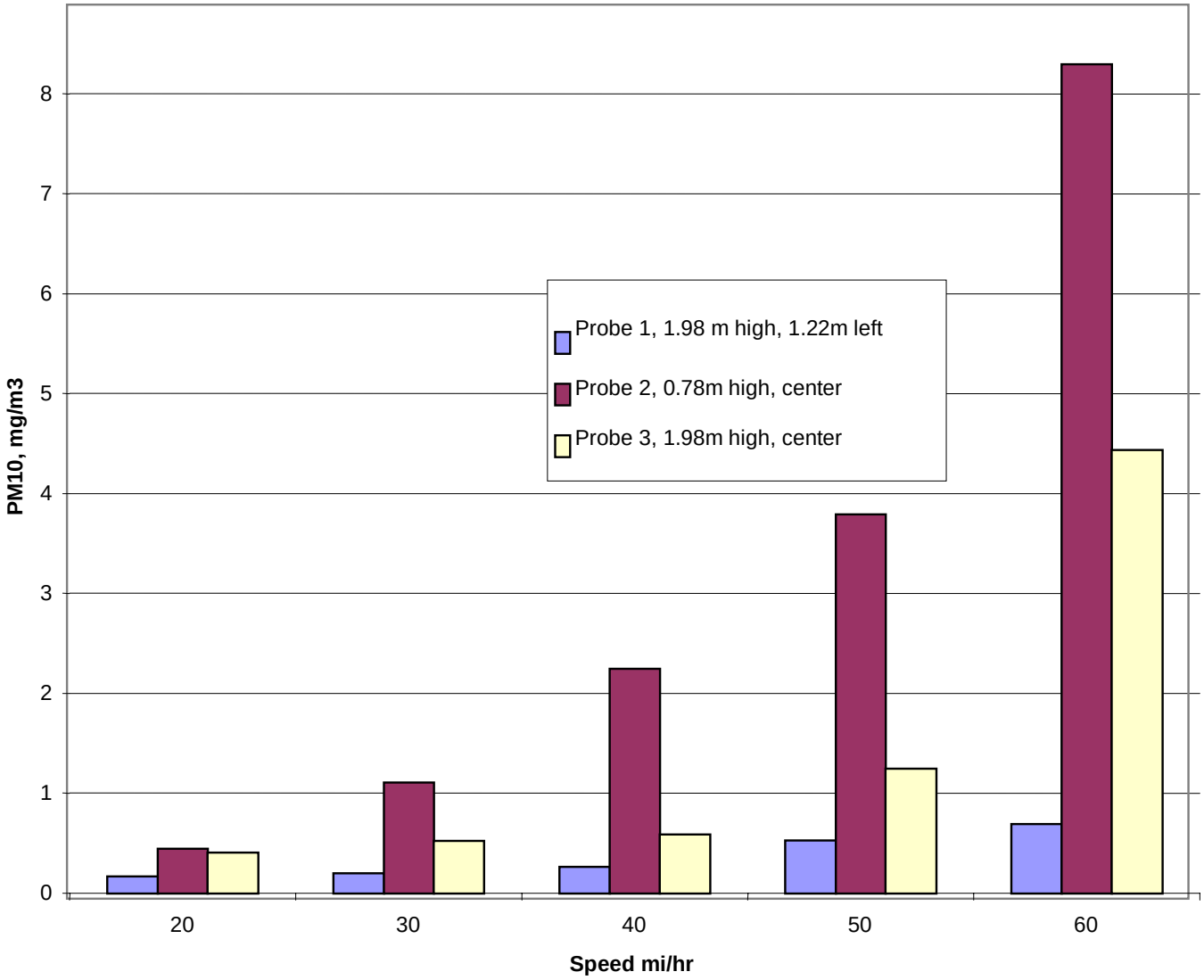
Test Trailer and Isokinetic Sampling Probes

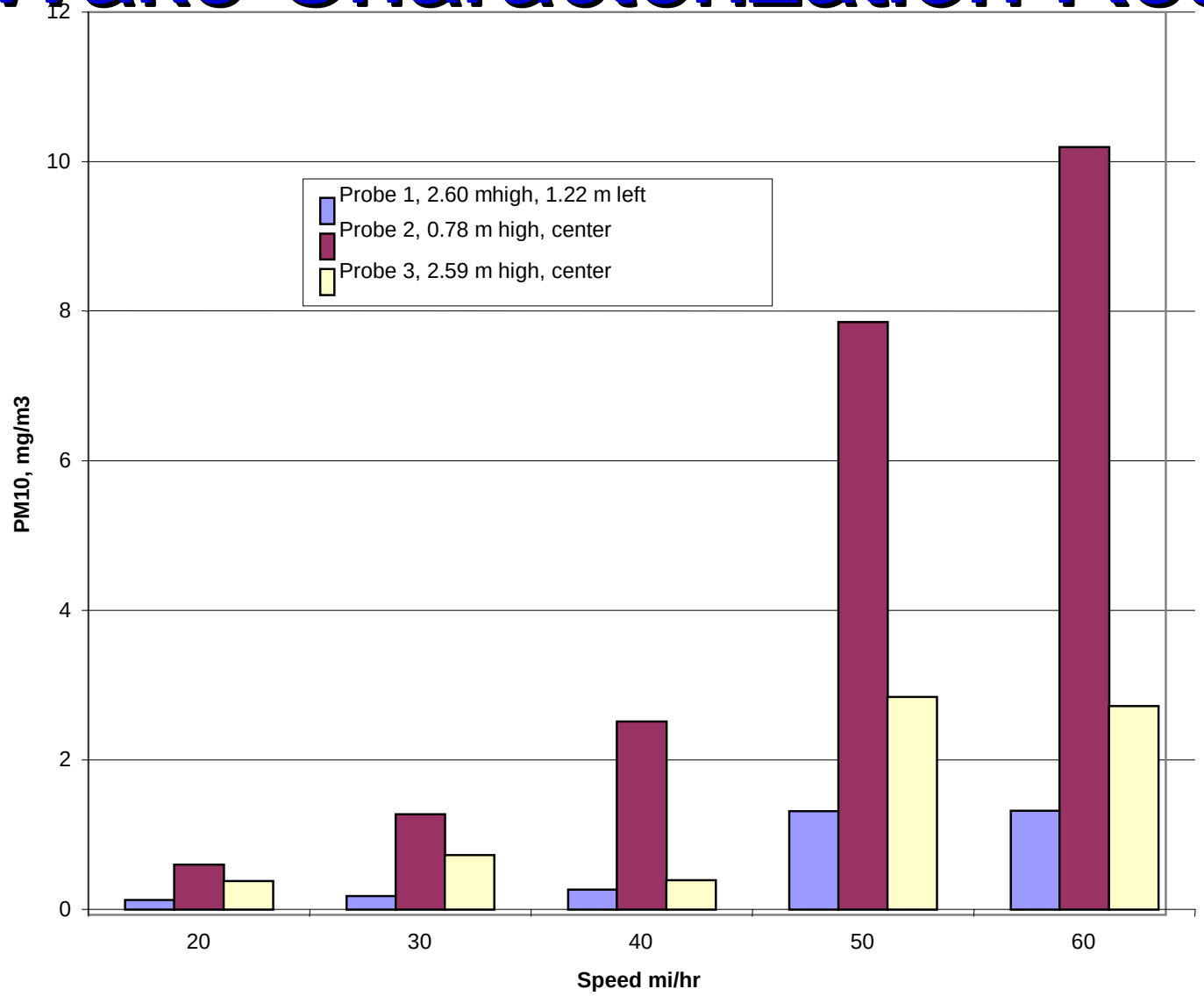
Wake Characterization

- Test on Unused Deteriorating Paved Road to Provide High PM Concentrations
- Measured PM Concentrations at a Variety of Test Points On the Trailer Relative to a Reference Test Point
- Fully Characterized the Wake PM Concentrations at Speeds from 10-60 mph

Wake Characterization Results



Wake Characterization Results



Wake Characterization Results

- The precision of the measurement (with three DustTraks sampling from the same point).
- The homogeneity of the PM within the vehicle's wake with respect to the vehicle's speed.
- The vertical and horizontal extent of the plume as a function of vehicle speed and cross wind.
- The optimum sampling position.
- Exhaust PM10 could not be detected

Emission Factor Measurements

- Performed Repeated Measurements Over Test Loops in Southern California.
- Tested All Types of Roadways and Speeds
  - **Freeway**
  - **Arterial**
  - **Collector**
  - **Local**
- **Calculated Emission Factors Based on Frontal Area (Wake Size) For Various Road Type Segments.**

Emission Factor Calculation

- **ER (mg/m) = ($PM10_r$ –$PM10_f$) * c *A_f**

  where:

  ER = PM10 Emission Rate

  $PM10_r$ = PM10 concentration, rear DustTrak

  $PM10_f$ = PM10 concentration, front DustTrak

  c = Calibration factor to relate DustTrak response to filter-based PM10 mass measurement

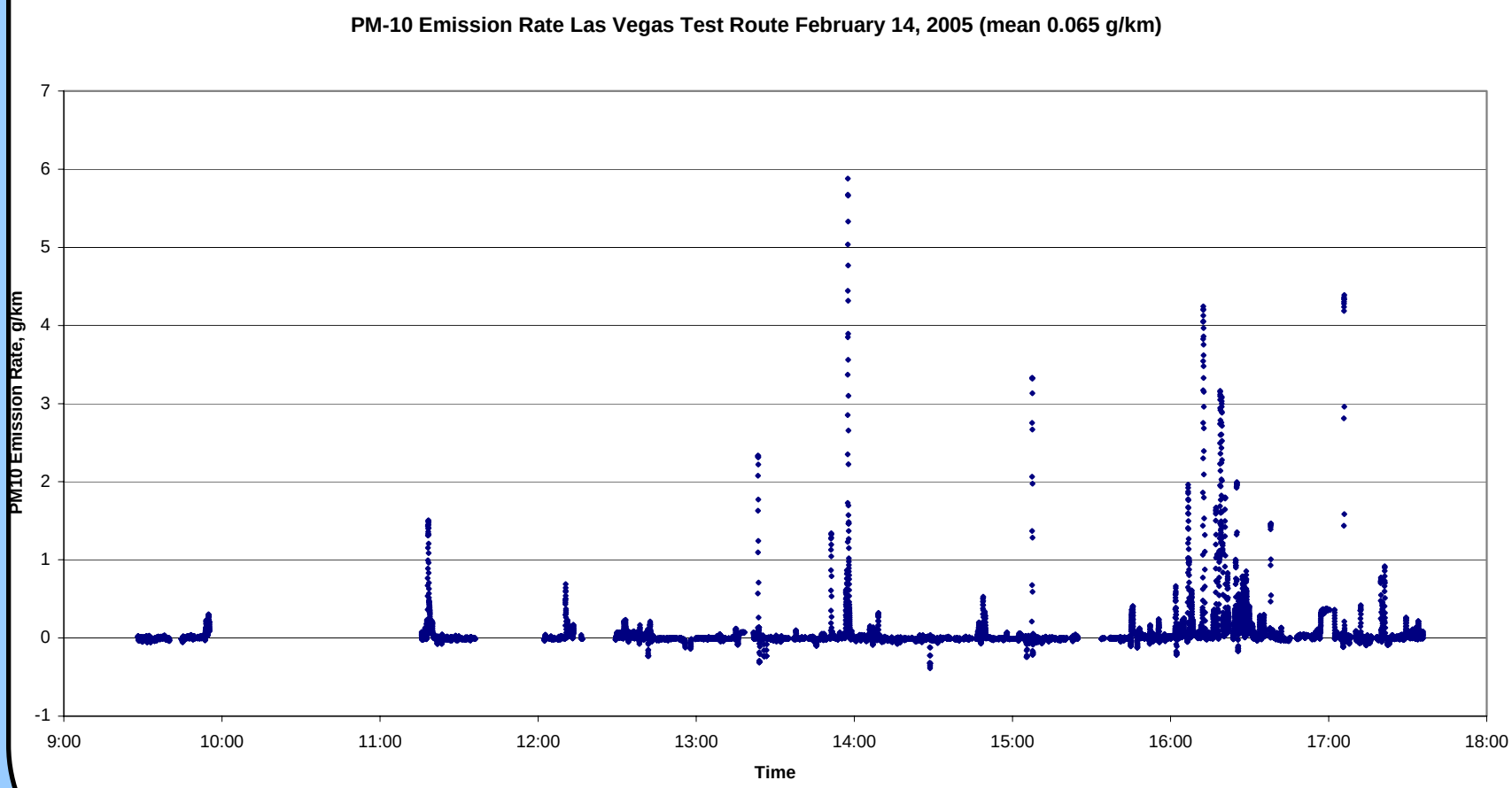
  A_f = Frontal area of the test vehicle

Comparison With Other Studies Using Southern California Data

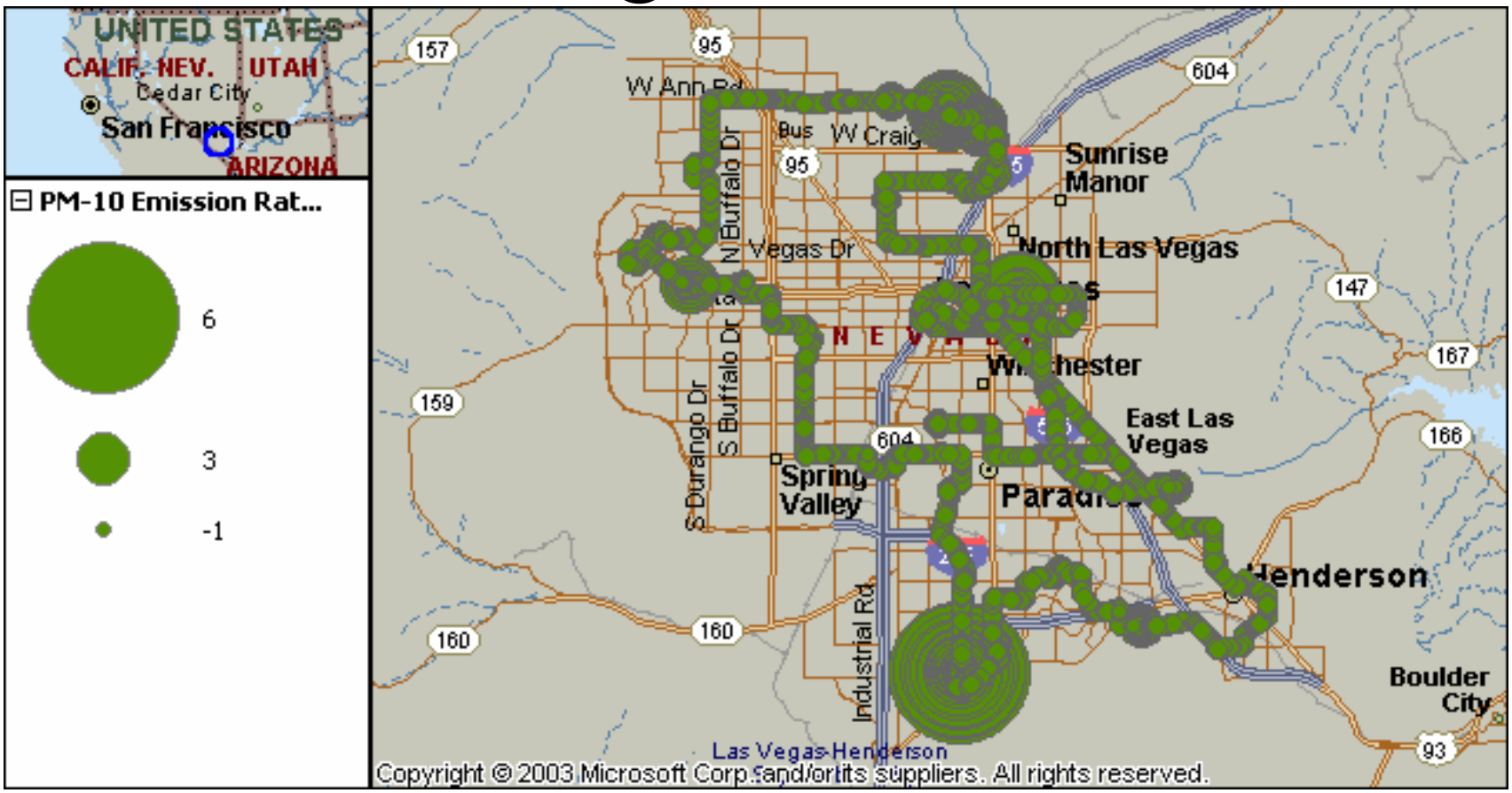
Study	Road Type	Emission Factor (g/VKT)	Emission Factor (lbs/VMT)
This Study	Freeway-local	0.06 – 0.13	0.00022-0.00047
Venkatram and Fitz, 1998 [4]	Freeway-local	0.1-0.3	0.00036-0.0011
Cahill et al., 1995 [19]	Intersection	<0.3	<0.001
Claiborn et al., 1995 [8]	Freeway-local	0.5 to 34	0.0018-0.12
Harding Lawson, 1996 [6]	Freeway-local	0.03 to 180	0.00011-0.65
AP-42 Default[a]	Arterial-local	0.08-0.53	0.00030-0.0019
ARB Default	Arterial-local	0.10-0.61	0.00036-0.0022

a: From silt loadings measured in southern California, assuming 2 ton vehicles

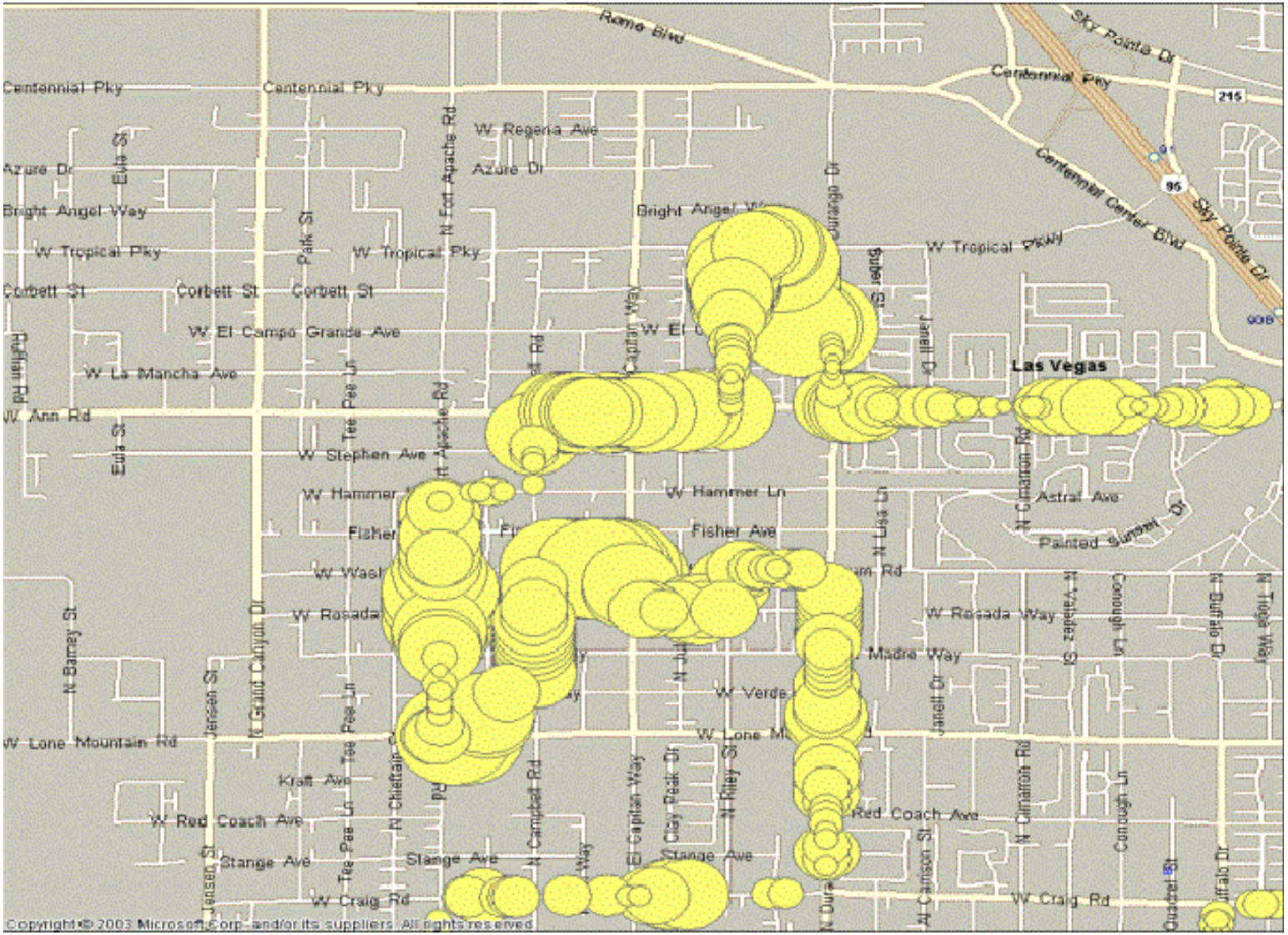
Time Series Emission Rates for Las Vegas Test Route (all road types)



PM10 Emission Rate Plotted on Las Vegas Test Route



PM10 Emission Rate Plotted



Conclusions

- On-Board Real Time Measurement is a Viable Method to Characterize PM Emissions form Vehicles on Paved Roads
- Measurements in Southern California were Lower than Those Predicted by the AP-42 Empirical Equation
- Advantages of the Method are:
  - Low cost
  - No upwind-downwind calibration required
  - DustTrak (light scattering sensor) calibrated to PM10 mass measurement during sampling
  - Ability to easily collect large amounts of data
  - Ability to easily determine PM “Hot Spots”

Conclusions

- **Results Showed That Small Fractions of Roadways are Responsible for Most of the PM10 Emissions.**
  - **These areas would be difficult to locate with scattered silt sampling.**
  - **Allows compliance efforts to focus on problem areas**
- **The Method has a Precision of Approximately 20% Based on Repeated Test Runs of Routes.**
- **Comparison with the DRI "TRAKER" Approach Based on over 700 Miles of Co-Sampling is Pending.**

Acknowledgements

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