

# **Comparison of Remote Sensing Measurements of On-Road Vehicle Emissions in Chicago and Denver with MOBILE6 Predictions**

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## Objectives

- **Compare MOBILE6 predictions with measurements of in-use tail pipe emissions from a large number of vehicles**
- **Identify potential reasons for differences**

## **CRC Project E-64 Multi-Pronged Evaluation of MOBILE6**

- **Re-analysis of tunnel studies with MOBILE6**
- **Ambient/Inventory Reconciliation**
- **Comparison with Heavy-Duty Chassis Dynamometer Test Data**
- **Comparison of MOBILE6 Diesel Fuel Consumption Estimates with Fuel Sales**
- **Comparison of MOBILE6 with RSD results**
- **EIIP Guidance on mobile source inventory evaluation procedures**

## University of Denver Road-Side Remote Sensing Studies: Chicago, Denver

- Part of larger measurement campaign (CRC E-23)
- Chicago
  - 1997 – 2000 at Algonquin Rd. to I-290
  - ~ 4 days in September
- Denver
  - 1999 – 2001 at I-25 ramp to 6<sup>th</sup> Av.
  - ~ 3 days in January
- 15,000 – 18,000 unique vehicles / year / site
- Data: [www.feat.biochem.du.edu/light\\_duty\\_vehicles.html](http://www.feat.biochem.du.edu/light_duty_vehicles.html)

## RSD Measurements

- Measure CO, HC, NO ratios to CO<sub>2</sub> in exhaust plume as vehicle passes
- Convert to g/gal based on fuel properties
- License plate matching for vehicle registration data (“type”, fuel, home, VIN)
- Speed, Acceleration → est. VSP

# RSD Measurement



Chicago, 1997

Gary Bishop, U. Denver

Methods: NDIR: CO, CO<sub>2</sub>, HC

UV spec: NO

## RSD Vs. MOBILE6

### RSD

- g/gal
- ~ 0.5 sec avg., single vehicle
- Single, fixed location

### MOBILE6

- g/mile
- Avg. by facility type, vehicle class

## MOBILE to RSD Comparisons

- **Limit comparisons to:**
  - CO/NO and HC/NO ratios
  - Relative changes in HC, CO, NO with vehicle age
- **Match RSD fleet with MOBILE6 vehicle classes using registration database and limited VIN lookup**



## **MOBILE to RSD Comparisons (cont.)**

- **Match fuel parameters, I/M parameters, T, RH**
- **Use MOBILE6 “ramp” cycle, hot running emissions**
- **VSP adjustment**

## Vehicle Age Bins

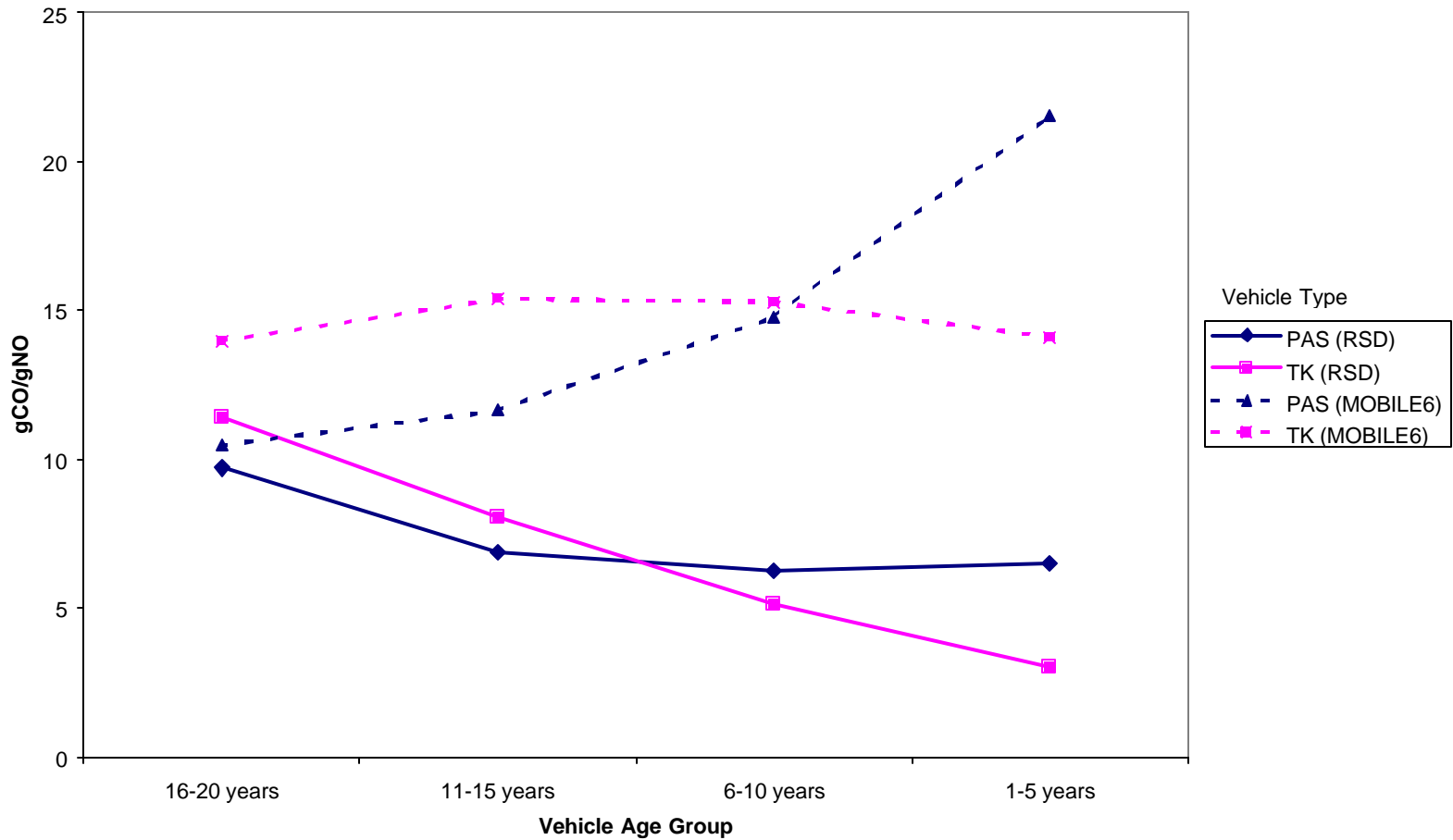
	RSD Observation Year				
Age Group (years)	1997	...	1999	...	2001
1 – 5	1992 – 1996		1994 – 1998		1996 – 2000
6 – 10	1987 – 1991		1989 – 1993		1991 – 1995
11 – 15	1982 – 1986		1984 – 1988		1986 – 1990
16 – 20	1976 – 1981		1979 – 1983		1981 – 1985

## Model Year Bins

	RSD YEAR				
Model Year Group	1997	1998	1999	2000	2001
1992 – 1996	1 – 5 yrs	2 – 6 yrs	3 – 7 yrs	4 – 8 yrs	5 – 9 yrs
1987 – 1991	6 – 10 yrs	7 – 11 yrs	8 – 12 yrs	9 – 13 yrs	10 – 14 yrs

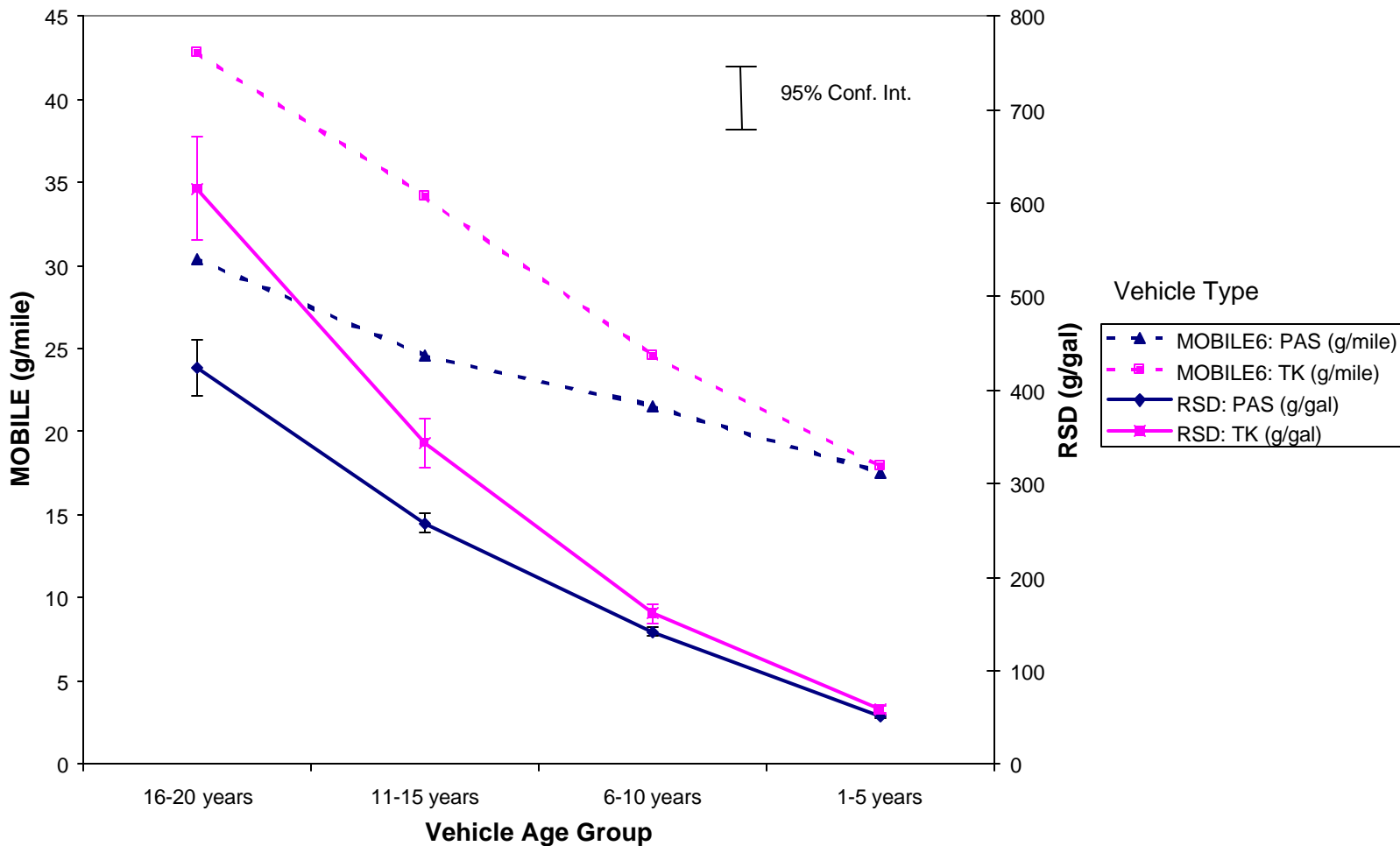
# CO/NO Ratio: Denver

CO/NO Ratio  
Denver, 1999-2001



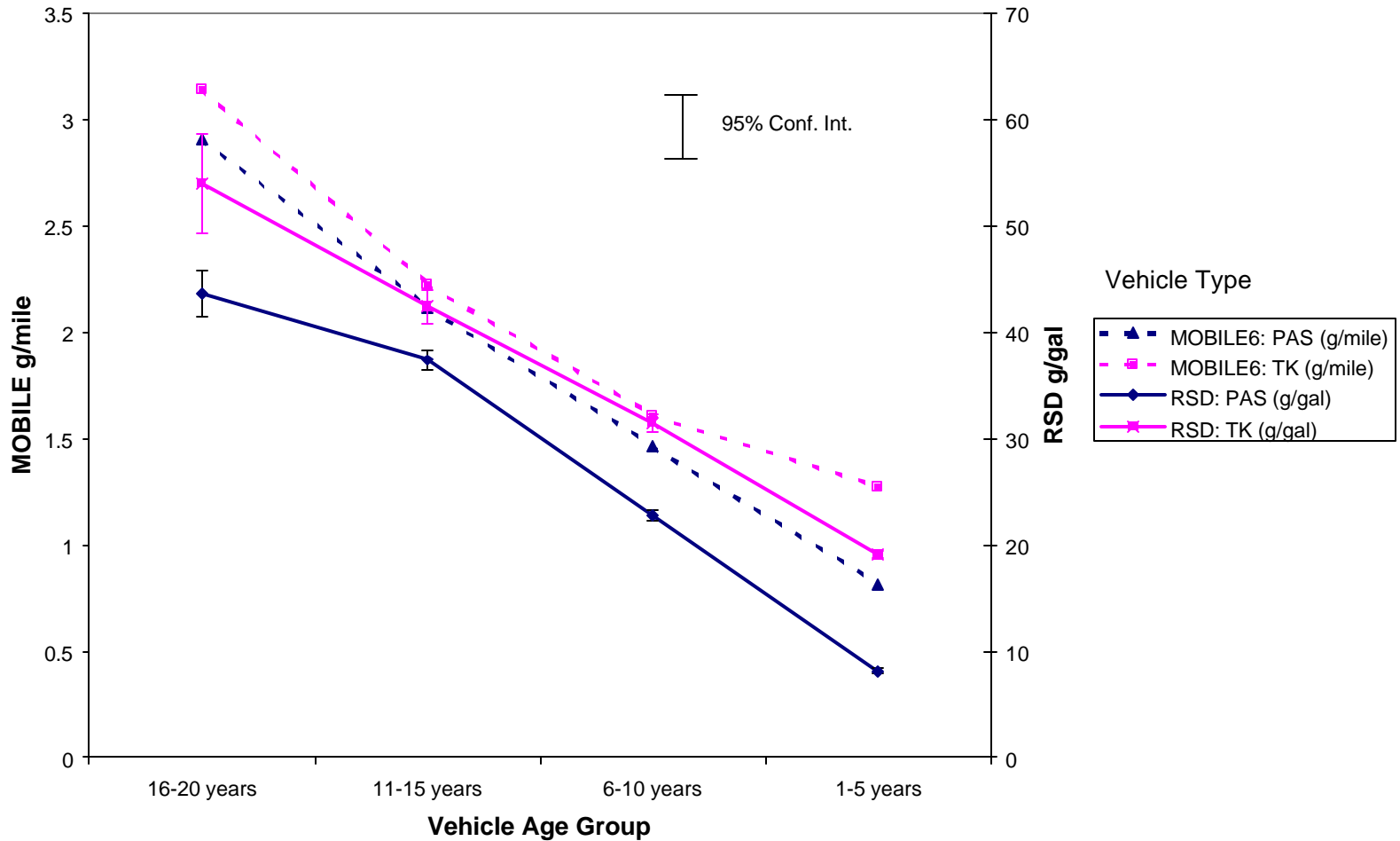
# CO Emission Factors

CO Emission Factors: Denver 1999-2001



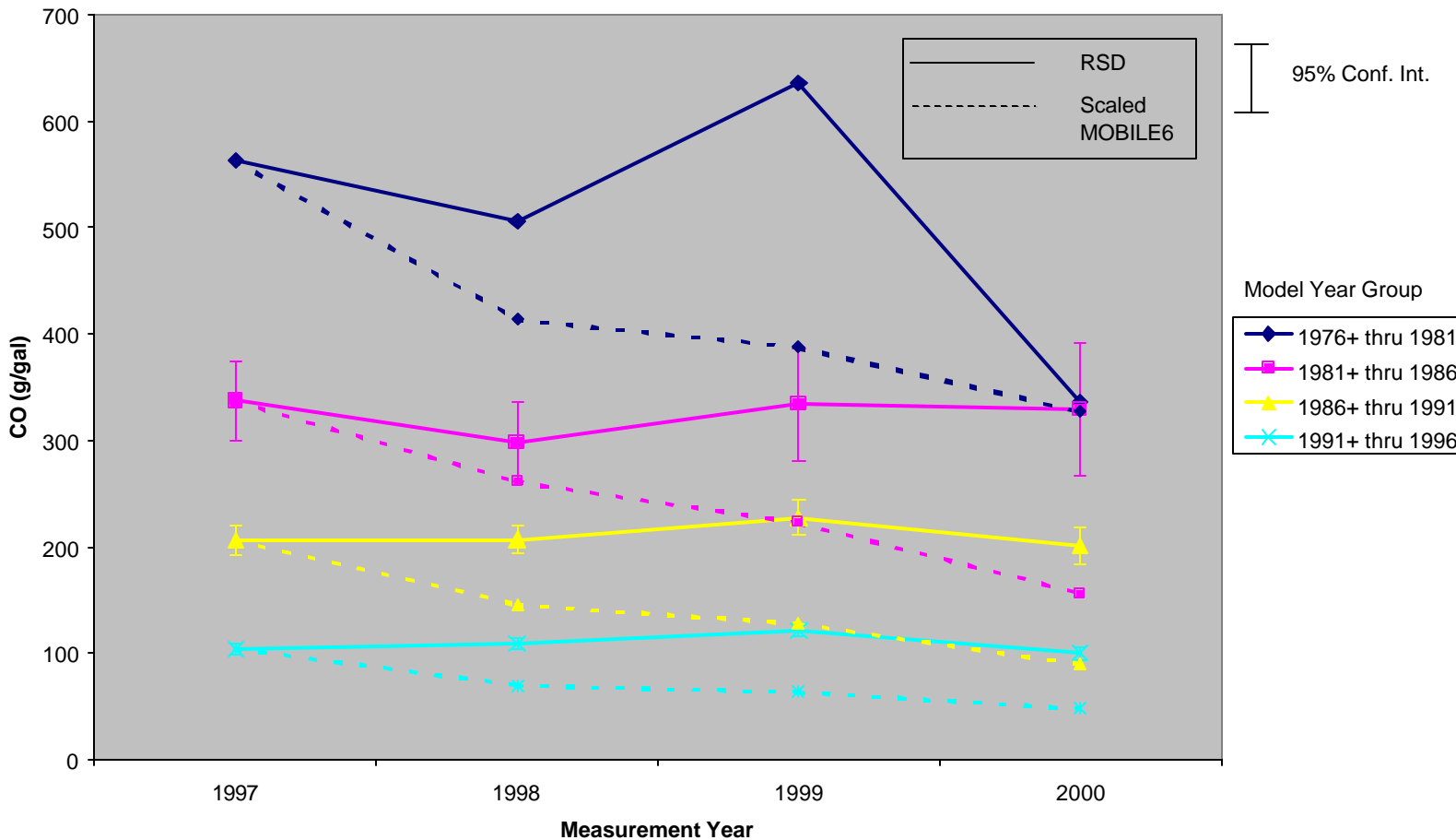
# NO Emission Factors

NO Emission Factors: Denver 1999-2001



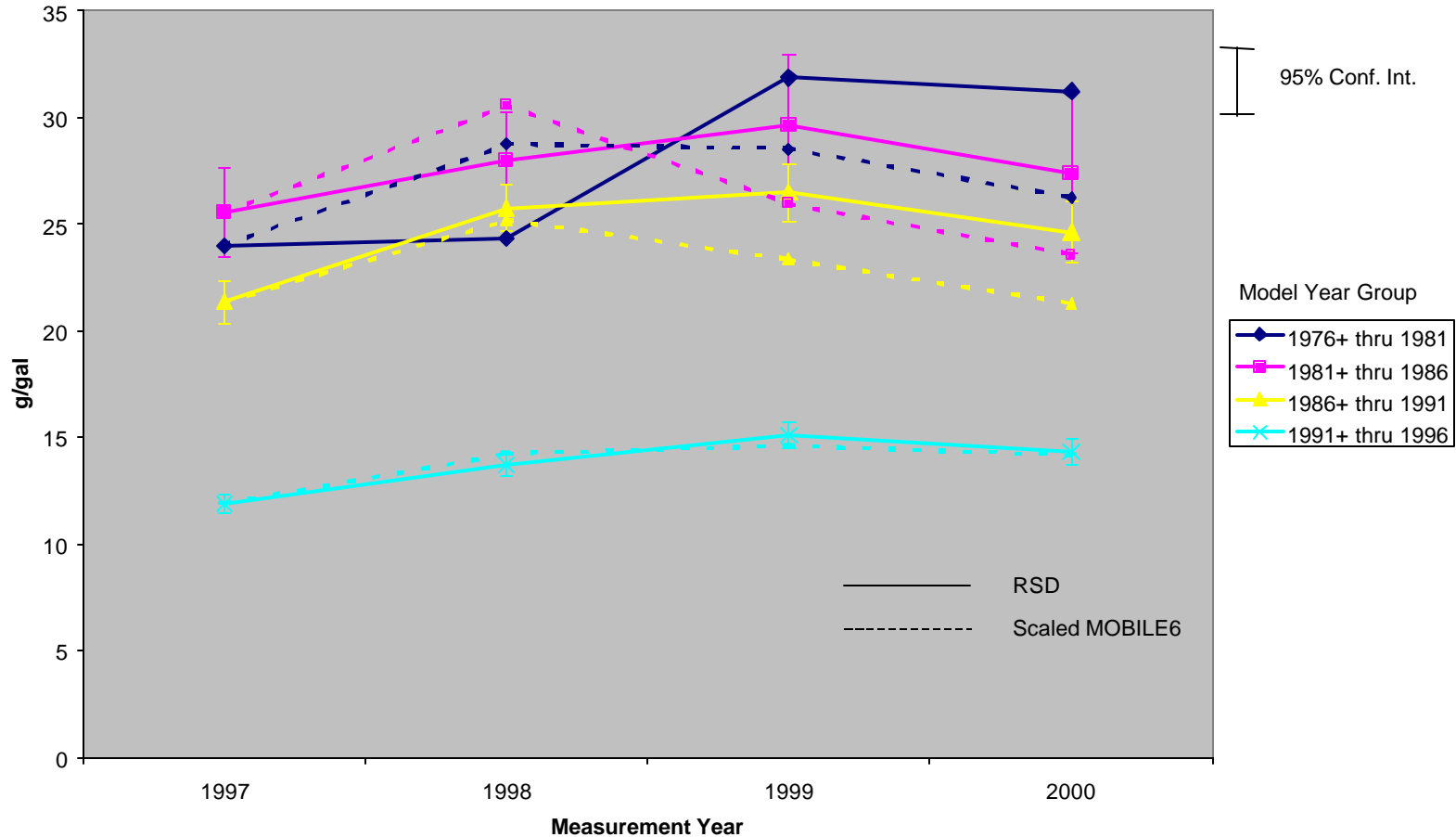
# CO Emissions Deterioration: Chicago

CO Emissions Deterioration  
Chicago (Private Vehicles)



# NO Emissions Deterioration: Chicago

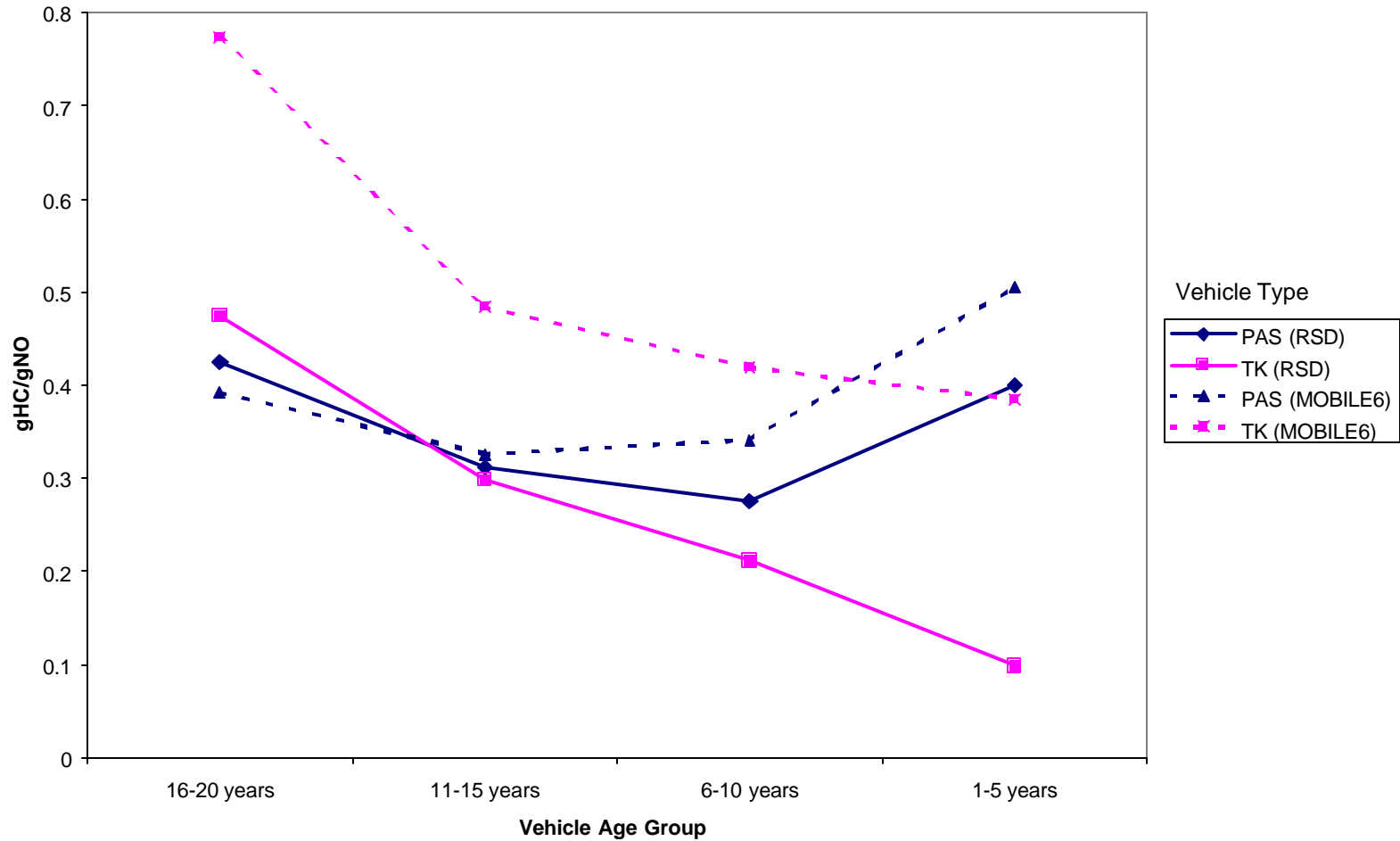
NO Emissions Deterioration  
Chicago, Private Vehicles





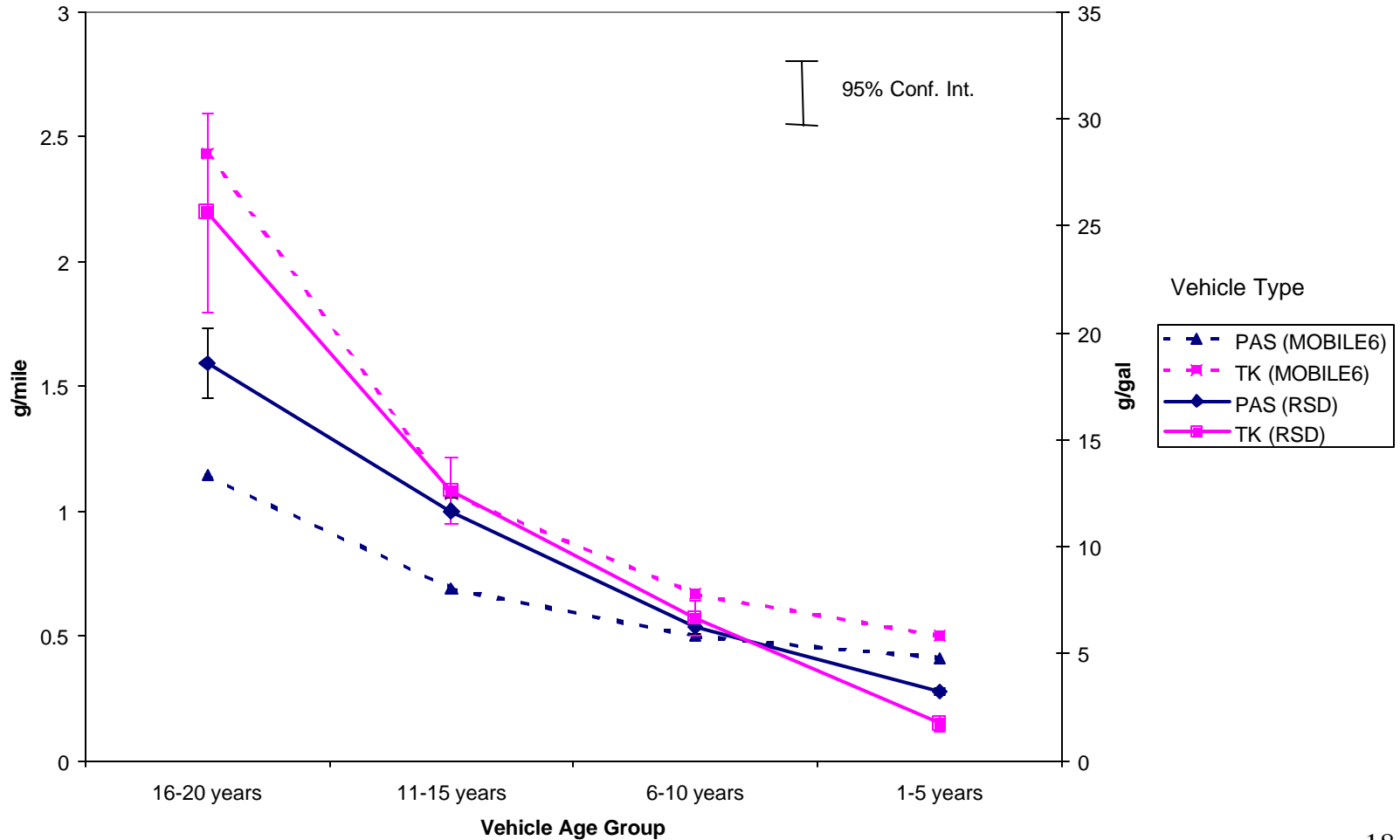
## HC/NO Ratio: Denver

HC/NO Ratios: Denver, 1999 - 2001



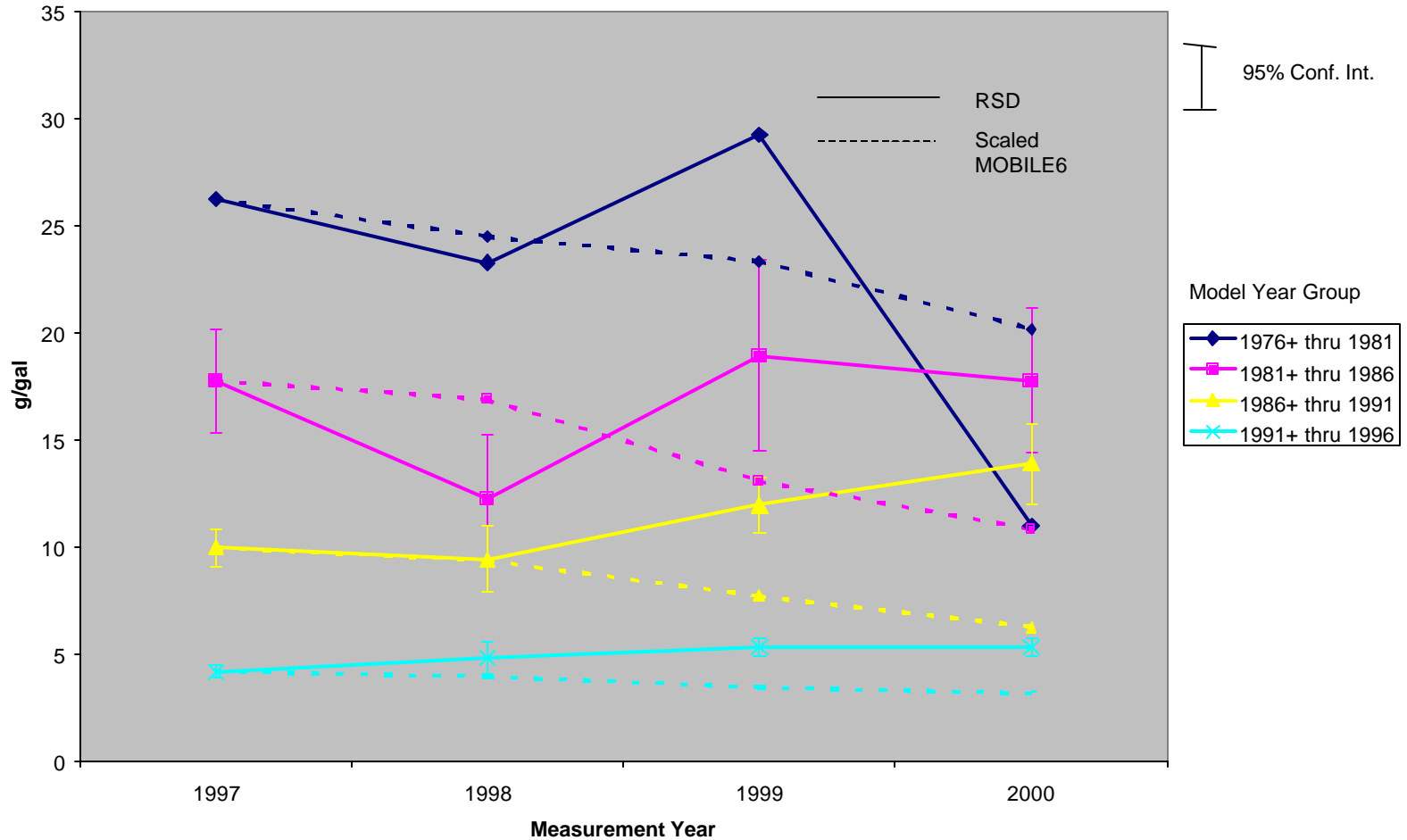
# HC Emission Factors: Denver

HC Emission Factors: Denver, 1999 - 2001



# HC Deterioration: Chicago

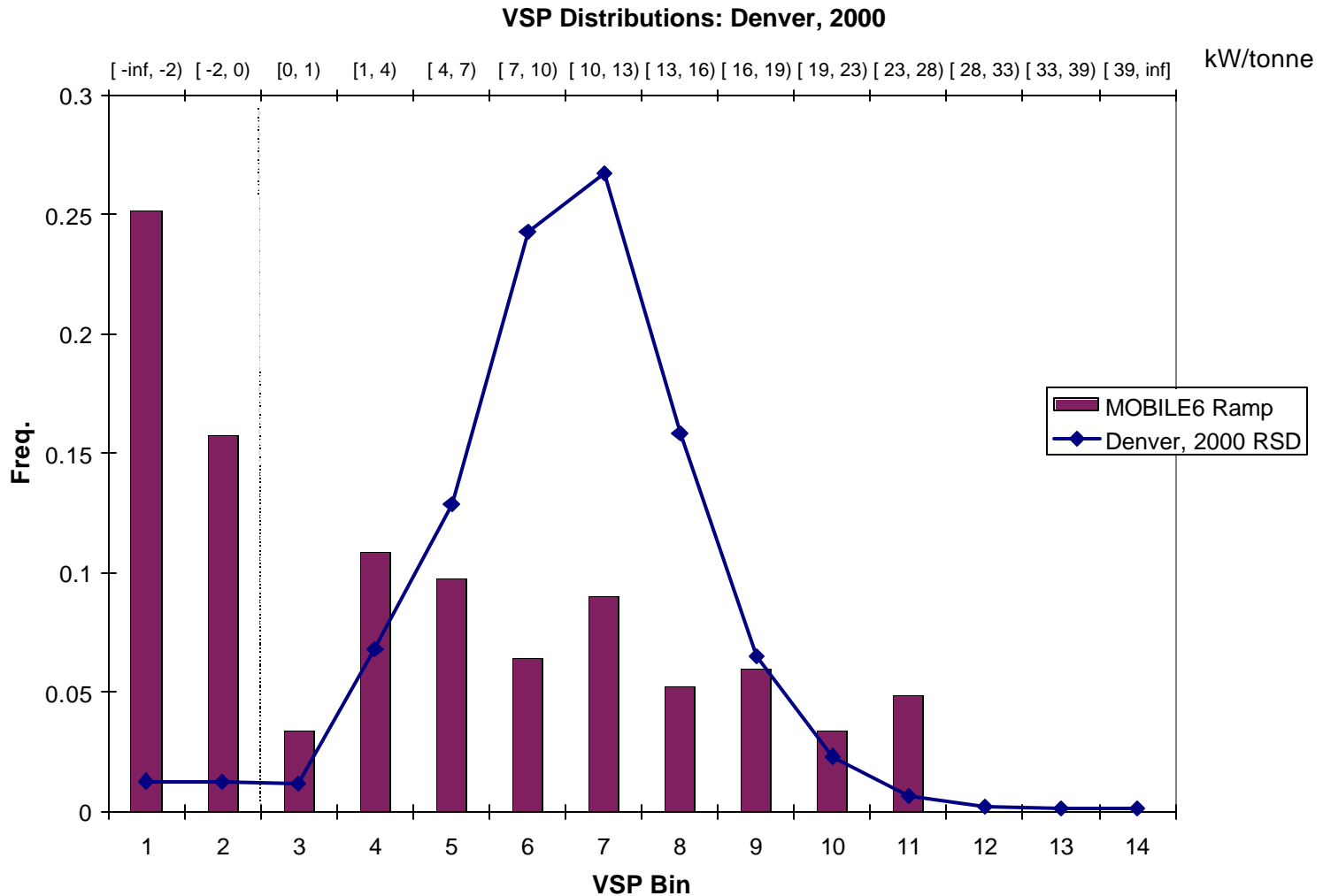
## HC Deterioration Chicago Private Vehicles



## VSP Adjustment

- **Vehicle Specific Power: instantaneous power/weight ratio at time of RSD measurement (kW/tonne)**
- **Estimated from observed speed, acceleration, road grade**
- **Assumes average vehicle characteristics**
- **g/gal emissions sensitive to VSP**

# VSP Distribution: Denver

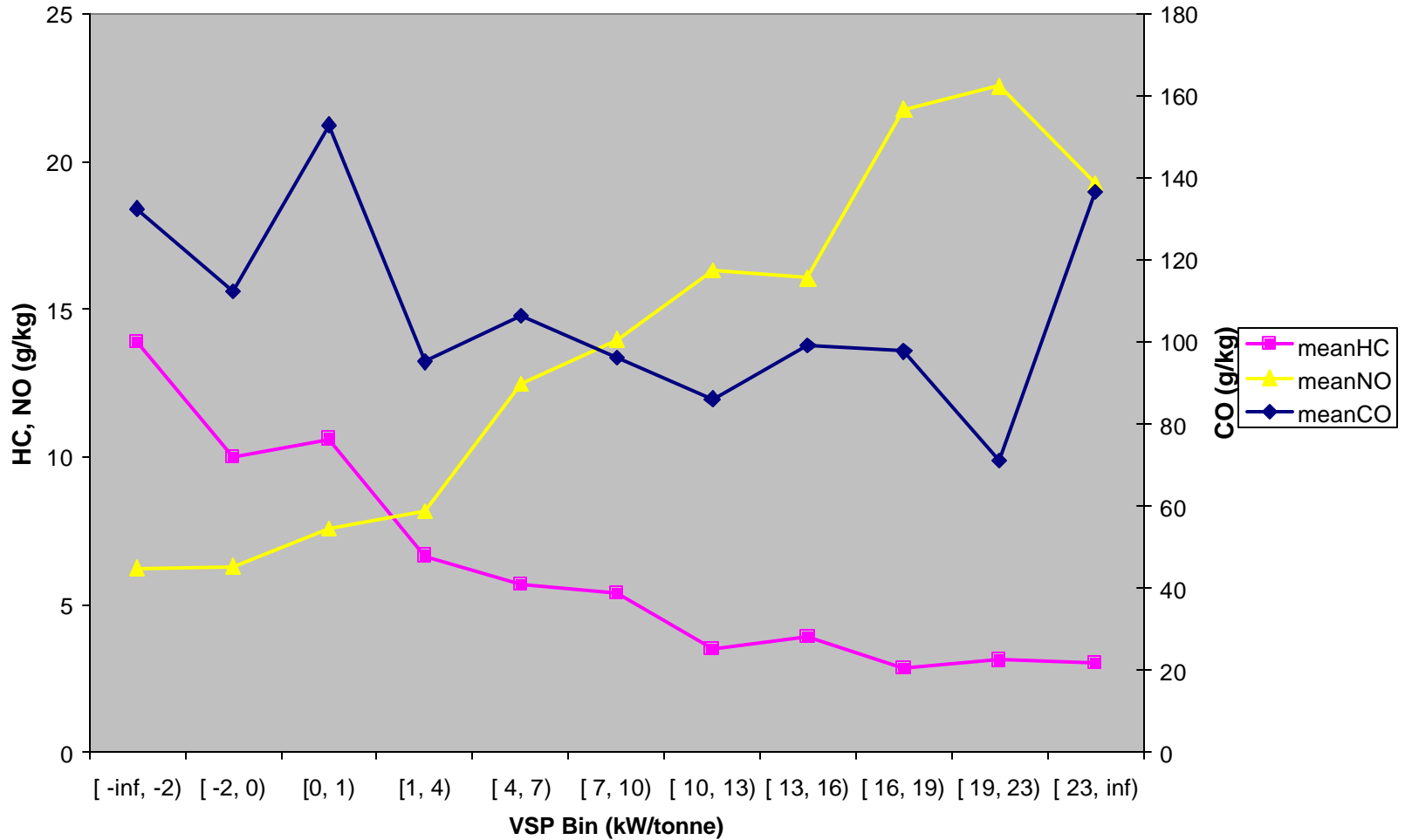


## VSP Variations in RSD Data

- Only minor variations with vehicle age bin
- VSP distributions similar in each RSD measurement year (but increased congestion in Denver, 2001)

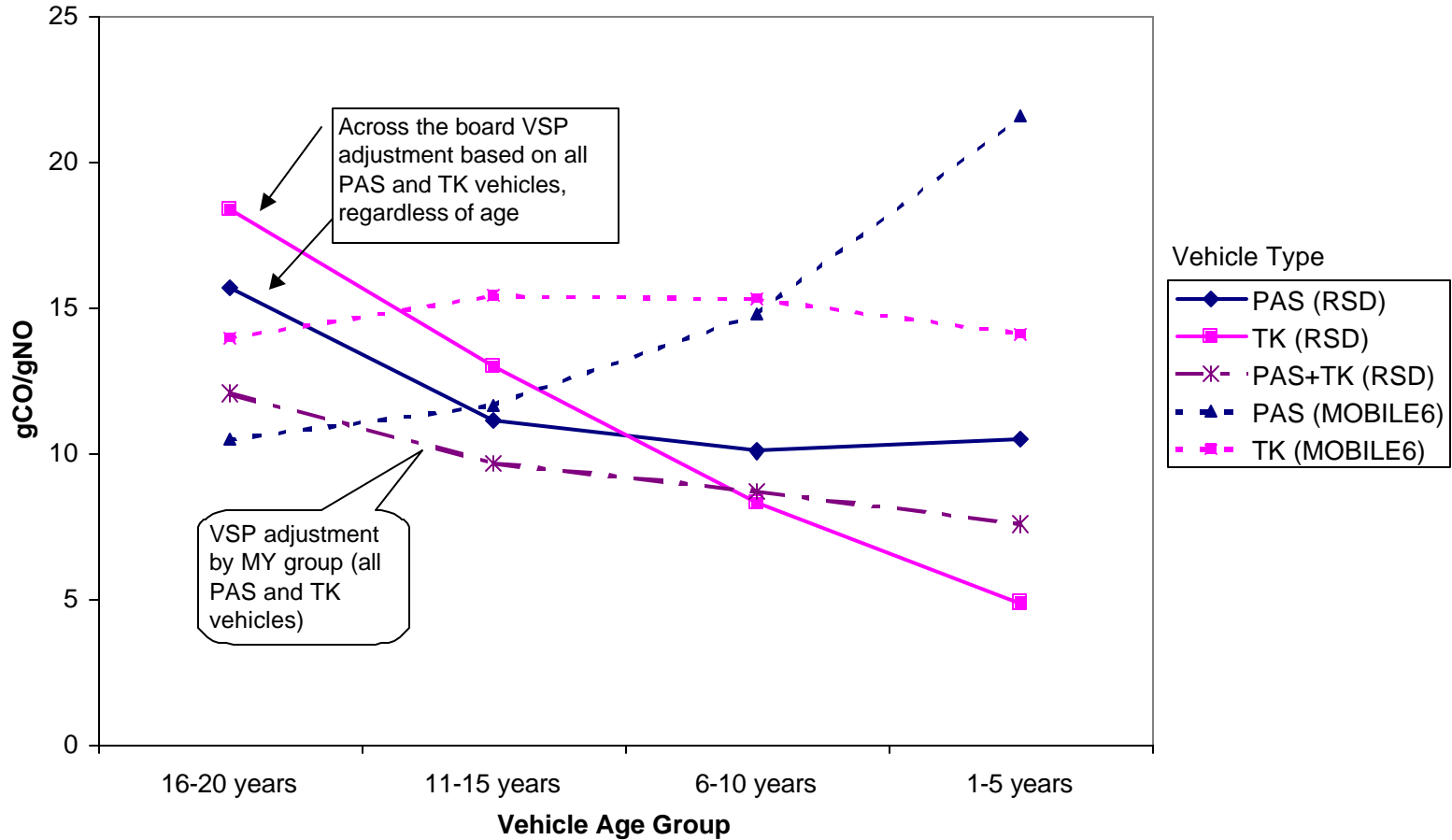
# Emissions by VSP Bin

Chicago, 2000



# VSP Adjusted CO/NO

VSP Adjusted CO/NO Ratio  
Denver, 1999-2001





## Issues/Caveats

- **HC off-sets applied to RSD**
- **Comparisons limited to ½ sec “snapshot” of emissions at a specific location**
- **VSP adjustments do not account for vehicle type**
- **Mapping to MOBILE6 vehicle classes is approximate**

## Summary: CO/NO

- **MOBILE6 predicts greater increase in CO with vehicle age than is observed in RSD data**
- **Better agreement for age dependence of NO**
- **MOBILE6 CO/NO ratios exceed RSD for newer vehicles**

## Summary: HC/NO

- **Mixed results depending on vehicle type, age, and VSP adjustment**
- **Better agreement of trend with vehicle age than for CO**
- **Data appear more variable**

## Summary: Temp. & RVP Adjustments

- **Combination of temp. and RVP changes resulted in lower predicted CO and HC in 2000 compared to 1997 in Chicago**
- **RSD data showed no corresponding change in observed CO and HC**

## Conclusions

- **MOBILE6 predicts smaller CO reductions in newer vs. older model years than is seen in the RSD data**
- **MOBILE6 CO/NO up to 3x higher than in RSD data for newer model years**
- **HC/NO results are mixed**
- **MOBILE6 temperature/RVP adjustments appear inconsistent with RSD data**

## **Acknowledgements**

- **Coordinating Research Council**
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- **EPA, OTAQ**