

Denver Department of Environmental Health Environmental Quality Division



Air Toxics Trends in the Denver Region: A Decade of Progress (mostly)

Air Quality Issues in the Rocky Mountain Region

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**Denver
Environmental Health**

Overview

- Denver air toxics have decreased significantly
- Real-world observations and predicted decreases (i.e. emissions inventories) are in agreement
- Toxics role as ozone/haze precursors remains an important focus

Air Toxics Monitoring History

- 1973, 1980, 1984 – short term studies
- 1987-1988 – EPA led Denver IEMP study
 - Daily averages and diurnal exploration
- 1996-2008 – Rocky Mtn Arsenal VOC monitoring
- 2000-01, 2002-03 – CDPHE air toxics monitoring
- 1996, 2003, 2006 – 6-9am ozone precursors
- 2005-06 – Denver Community Air Toxics
- 2007-08 – Boulder Community Air Toxics

Long-Term Air Toxics Trends

Pollutant	Monitoring Station	Oldest Data ---- ($\mu\text{g}/\text{m}^3$) ----- >>>> Most Recent Data					
		1987-88 IEMP ¹		CDPHE Toxics ²		Rocky Mtn Arsenal ³	
		Jun - Sep 1987	Nov - Feb 1987-88	Sep 2000 - Sep 2001	May 2002 - Apr 2003	2002 RMA	2007 RMA
Acetaldehyde	Auraria	5.3 [5.4]	2.0 [1.5]				
	CAMP			4.3 [3.8]	4.1 [3.5]		
Formaldehyde	Auraria	4.6 [4.4]	3.0 [2.2]				
	CAMP			7.7 [7.3]	8.1 [6.7]		
Benzene	AQ1	--				2.0 [1.6]	1.0 [0.9]
	Auraria	14.4 [12.2]	12.1 [7.5]				
	CAMP	--		3.2 [3.1]	3.1 [2.8]		
Toluene	AQ1	--				5.2 [4.1]	2.7 [2.1]
	Auraria	28.1 [23.5]	32.1 [13.8]				
	CAMP	--		8.3 [8.0]	9.4 [7.7]		
Carbon Tetrachloride	AQ1					[0.9]	[0.7]
	Auraria	1.6 [1.2]	NA				
	CAMP			0.5	<0.5		

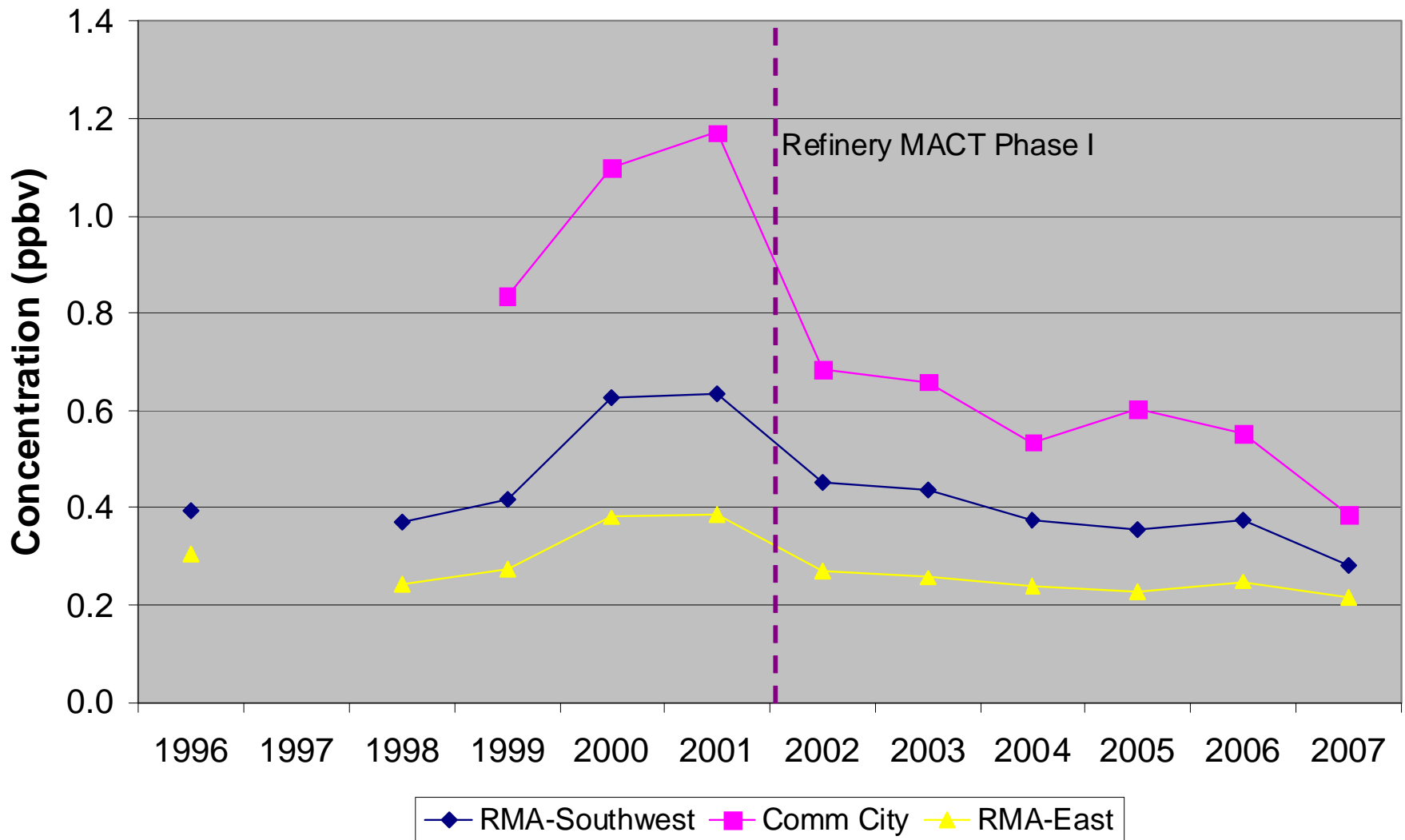
mean and [median] concentrations shown in table

¹ Komp, 1989. 7,17, and 24 hour average samples obtained at three locations in Metro Denver.

² Data obtained from CDPHE.

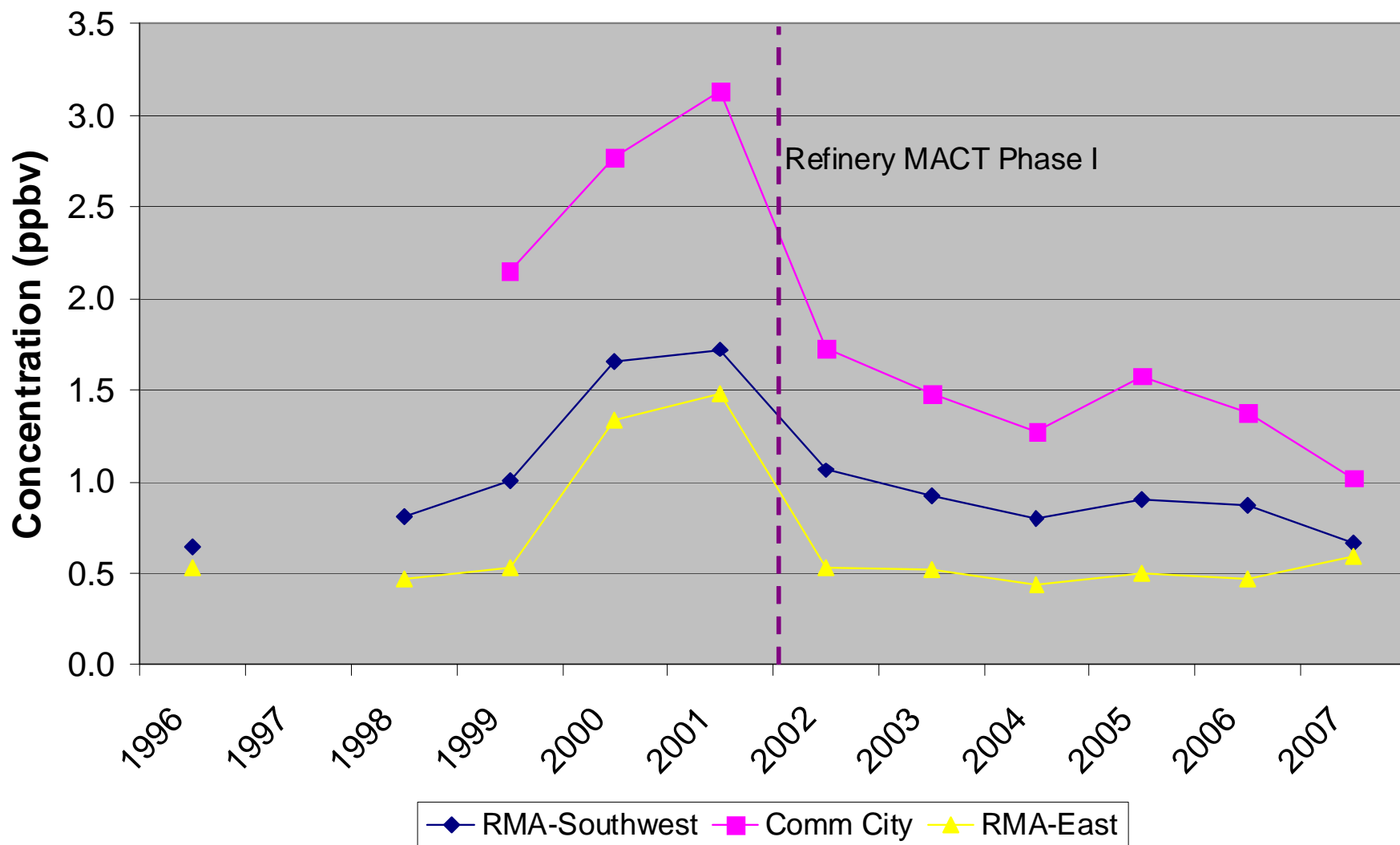
³ Data obtained from Remediation Venture Office at Rocky Mountain Arsenal.

1996-2007 Mean Benzene @ Rocky Mtn Arsenal



- Benzene monitoring at RMA meant to describe urban background
- Median trends less pronounced than mean trends except RMA-East

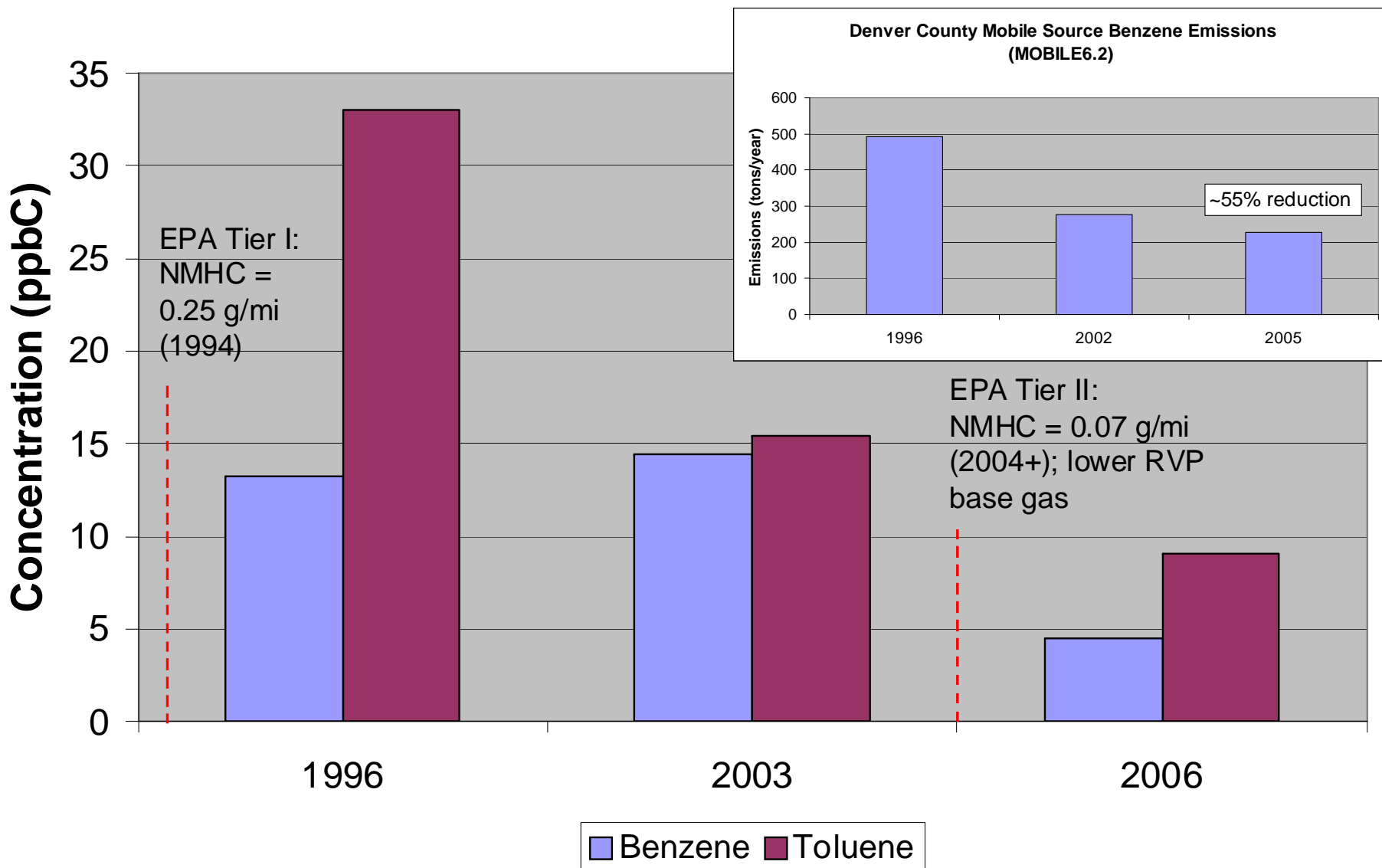
1996-2007 Mean Toluene @ Rocky Mtn Arsenal



Since 2002, benzene-to-toluene ratios ~ 0.4 – 0.45; “fresh” mobile source signature

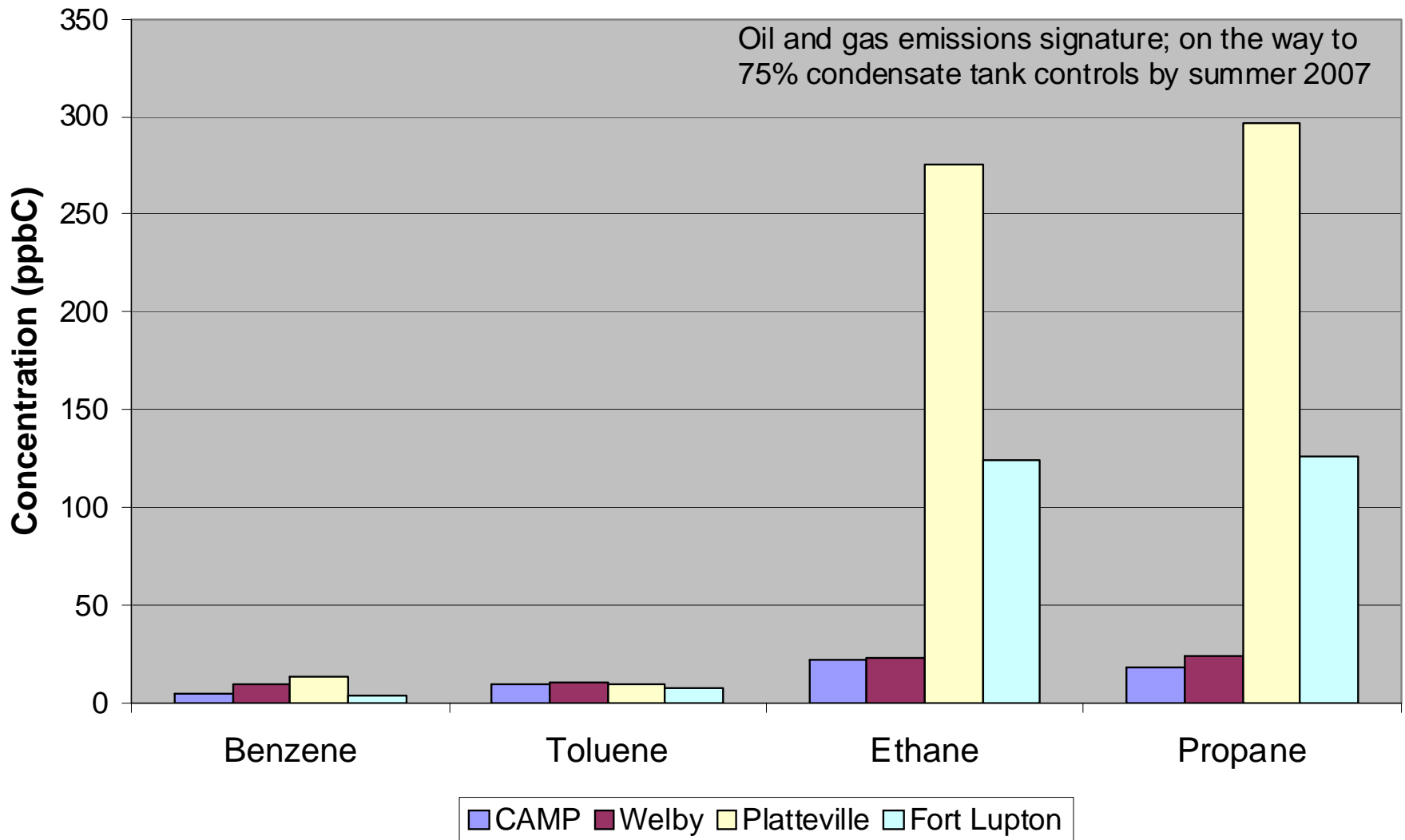
Source: <http://www.cdphe.state.co.us/rma/AirMonitoring/DataMappingApp.asp>

CAMP 6-9am Benzene and Toluene Trends 1996-2006



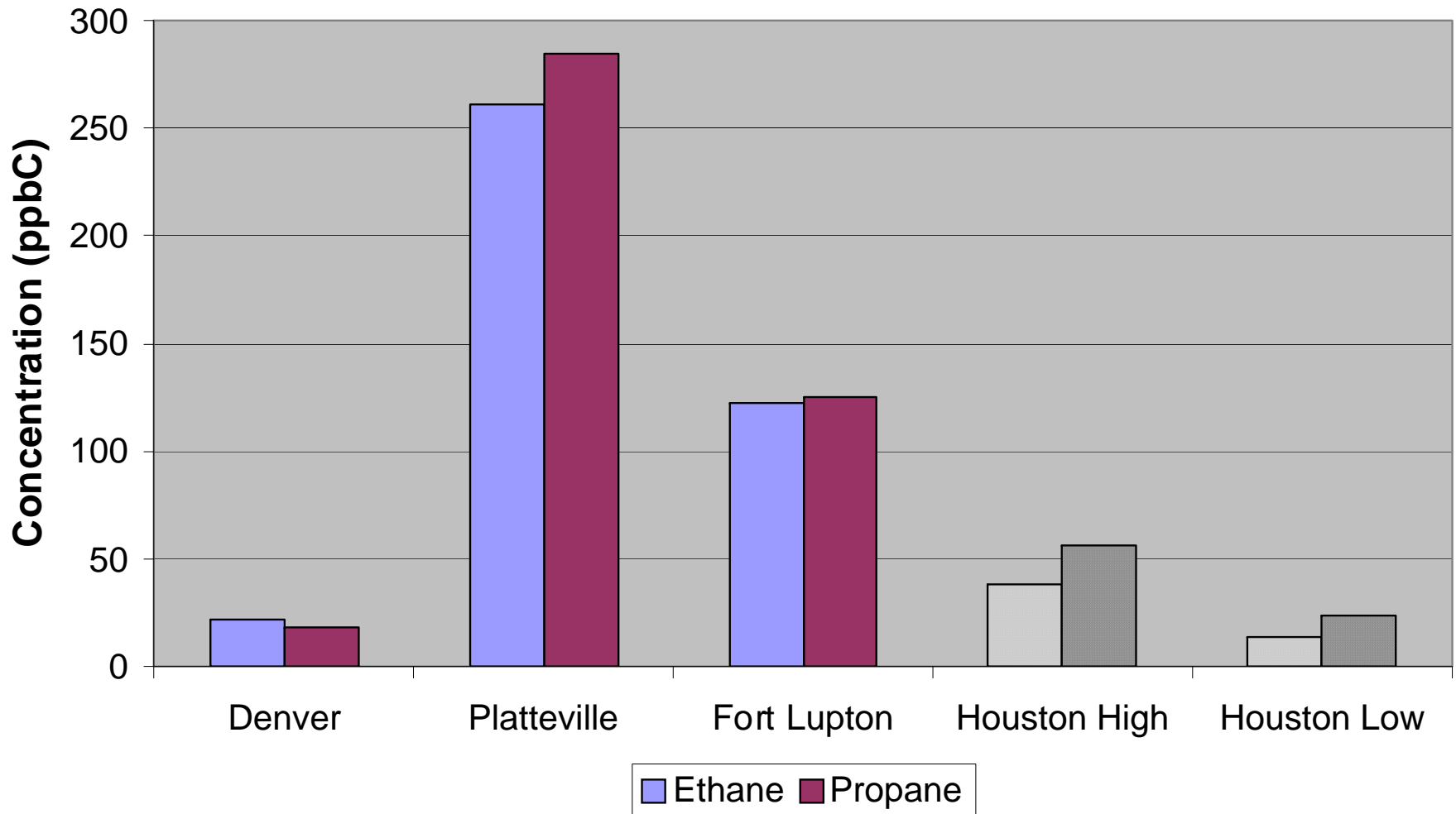
Much of the reductions at CAMP were from onroad mobile sources

2006 6-9am SNMOC Denver Non-Attainment Area



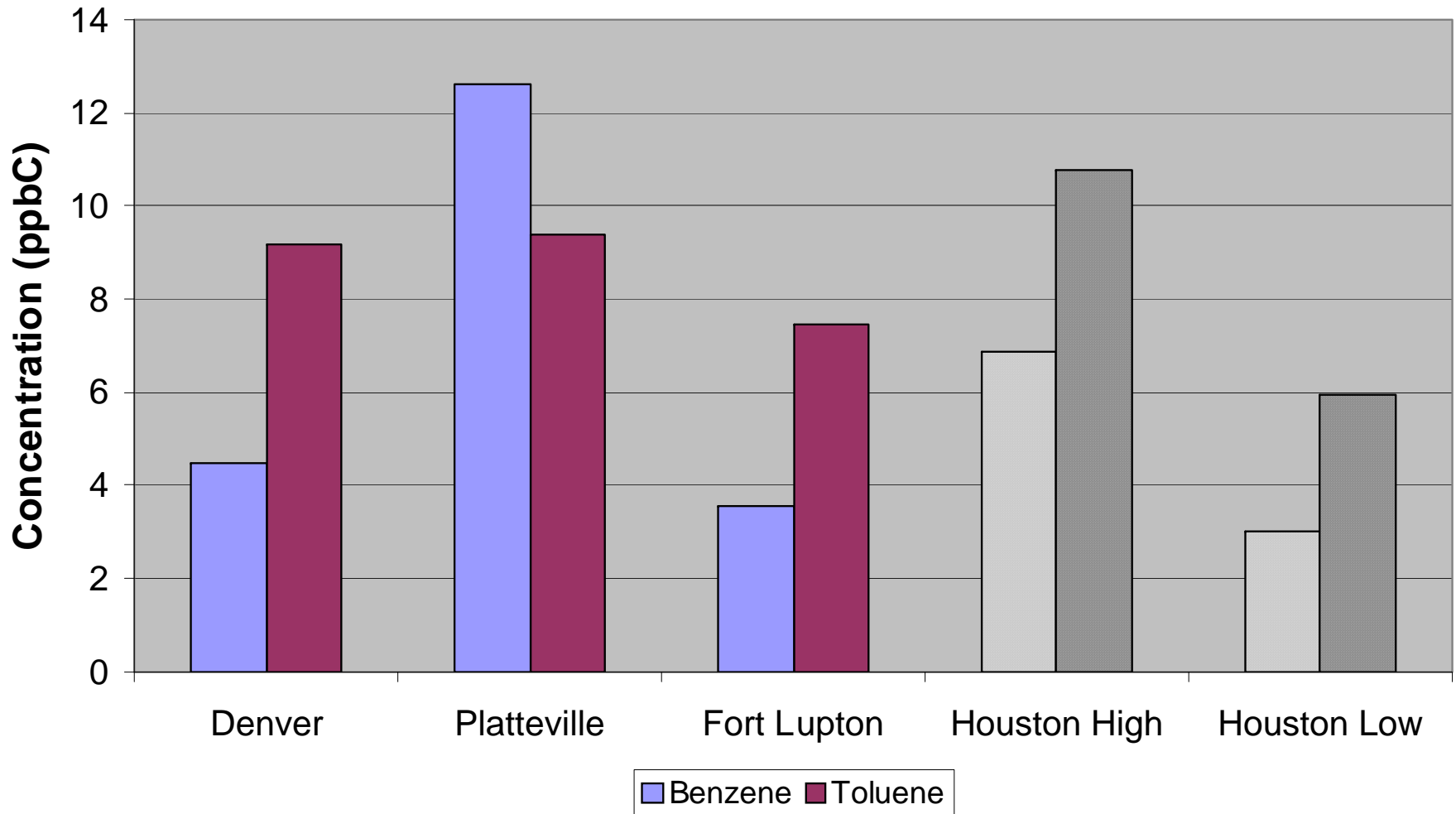
Meteorology and S Platte River flows complicate ozone modeling

6-9am Avg Concentration Comparisons Colorado vs. Houston, TX Ethane and Propane (Jun-Jul 2006)



Morning meteorological differences between cities play a big role

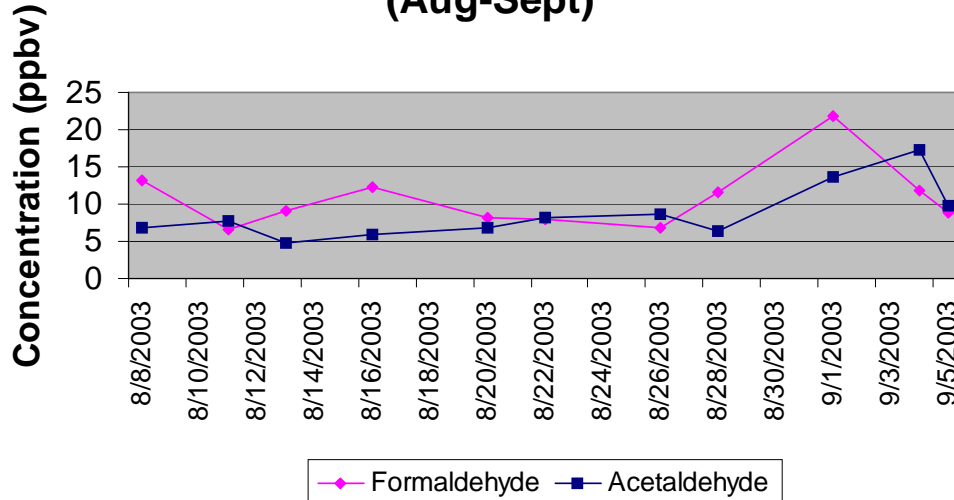
6-9am Avg Concentration Comparisons Colorado vs. Houston, TX Benzene & Toluene (Jun-Jul 2006)



Similar concentrations despite vast differences between areas

Short-Term Carbonyl Data Cloud the Picture

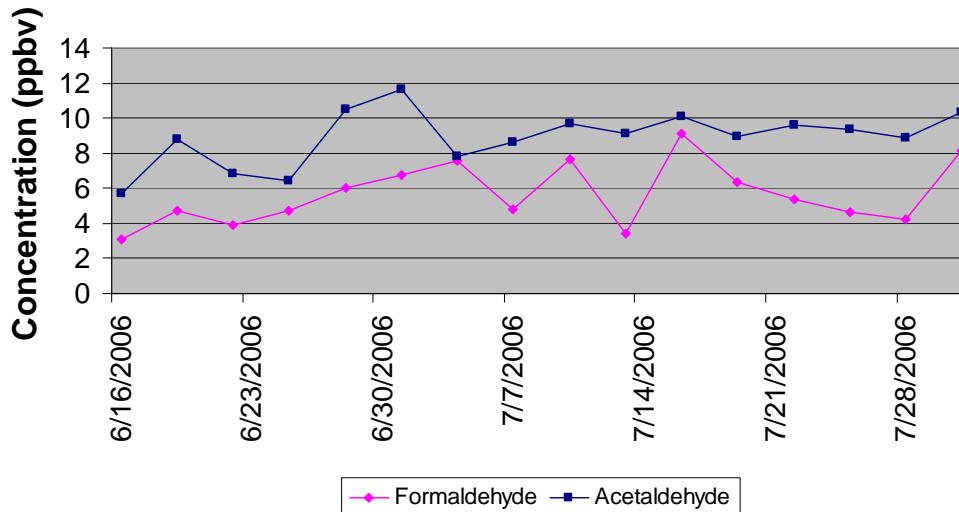
2003 6-9am Carbonyls Downtown CAMP (Aug-Sept)



Expect most aldehydes to be formed photochemically

Aldehydes for both years are higher than expected for 6-9am average

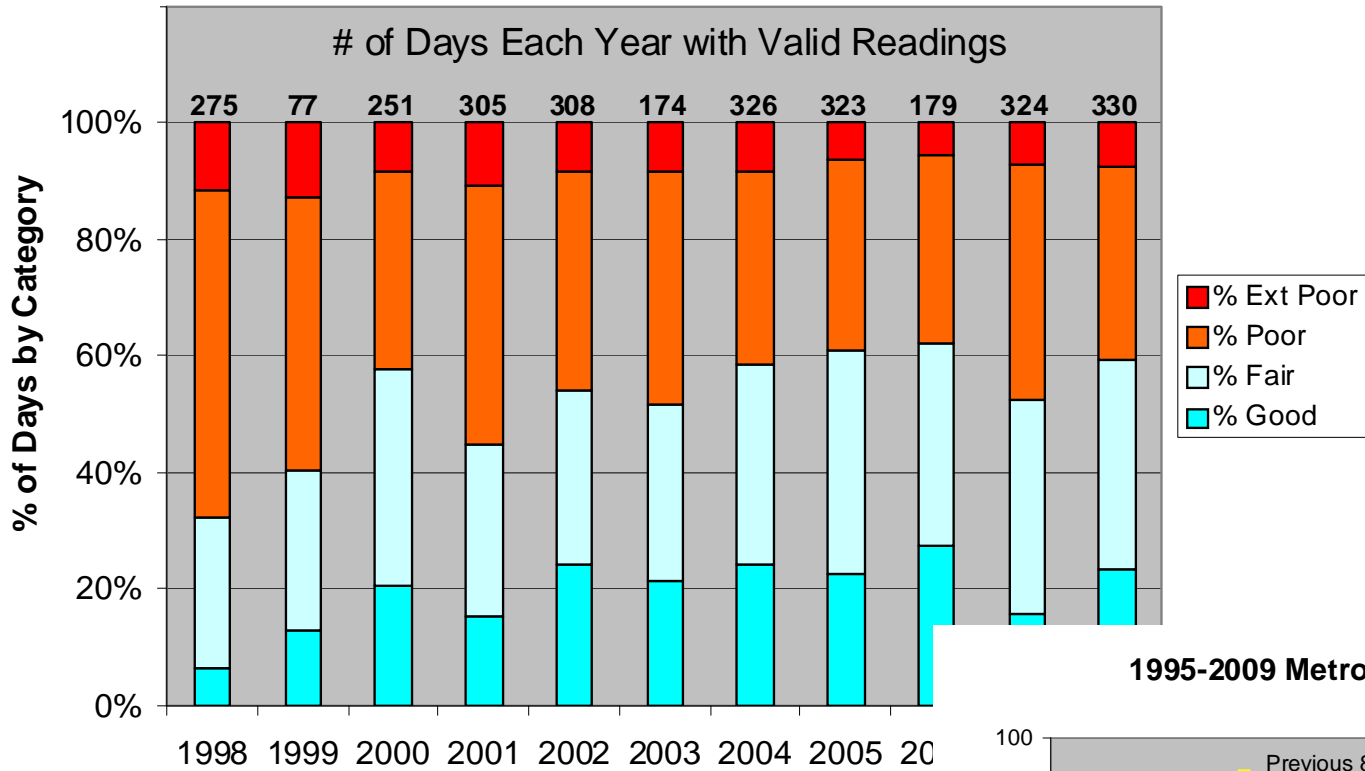
2006 6-9am Carbonyls Downtown CAMP (Jun-Jul)



Acetaldehyde always higher than formaldehyde in 2006, reversing historic patterns

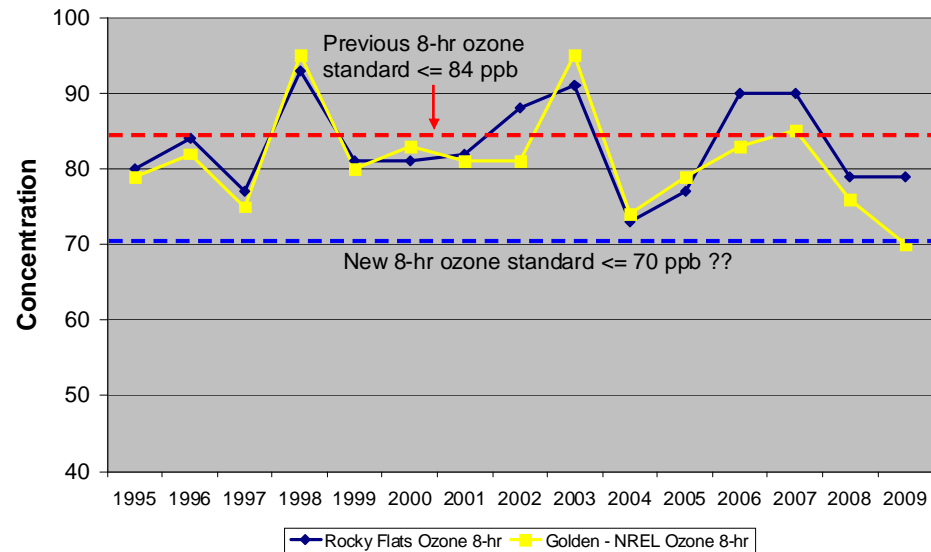
If true, primary emissions are much higher than inventories suggest

Visibility Trends in Denver 1998-2008

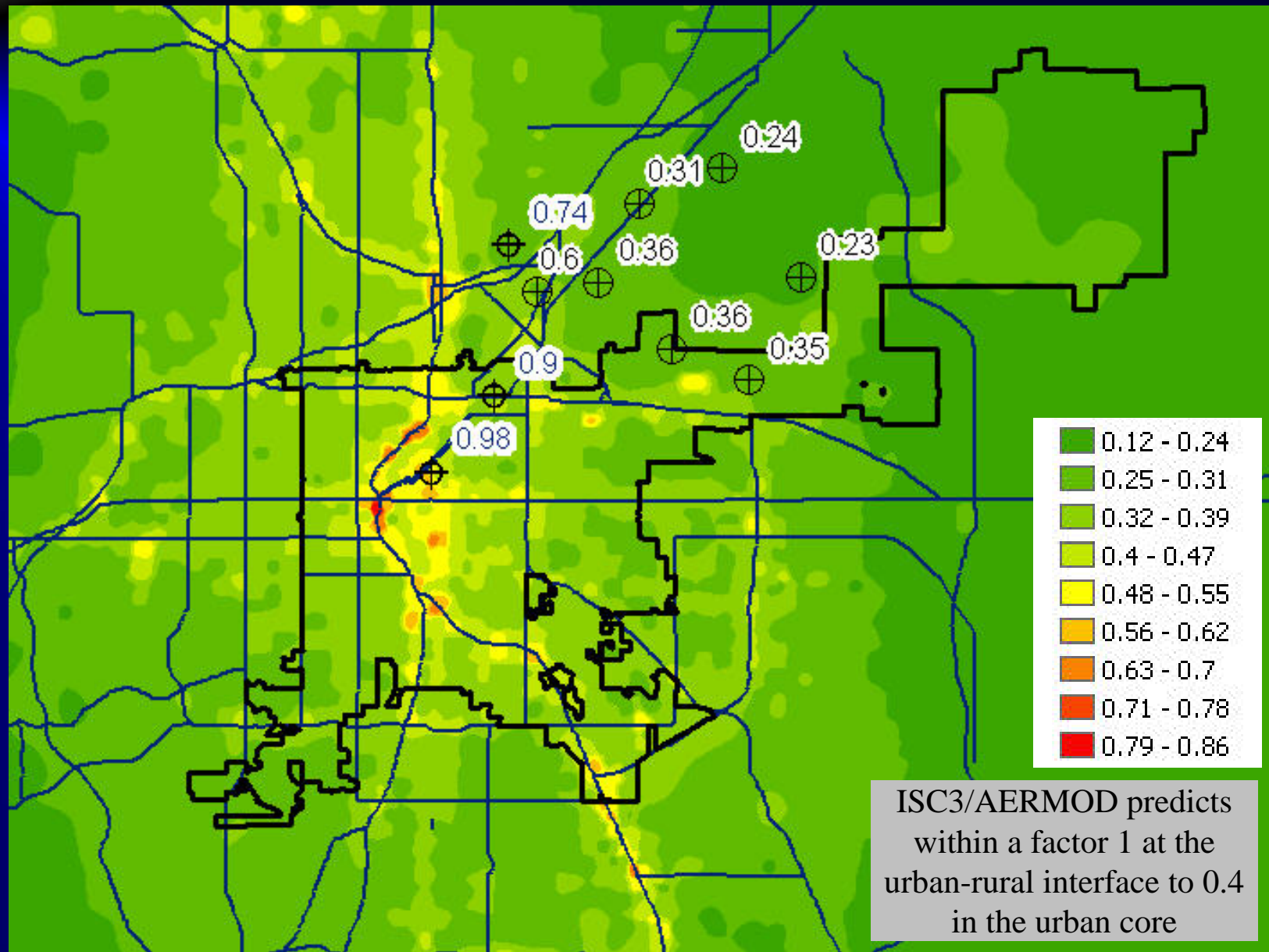


Despite significant reductions of ozone precursors, ozone trends are flat.

1995-2009 Metro Denver Ozone Trends

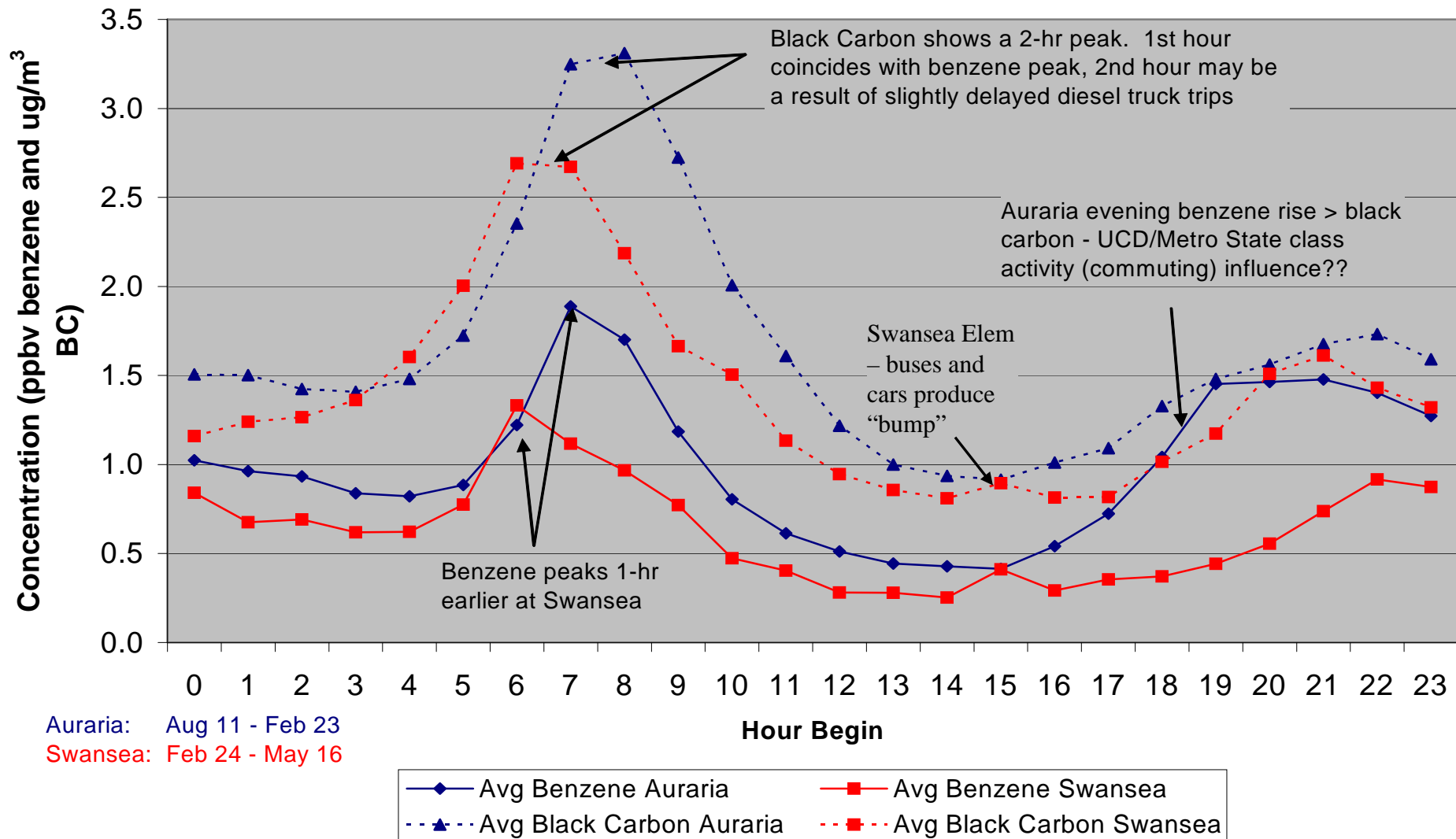


Denver's Air Toxics Assessment



Real-Time Air Toxics Monitoring

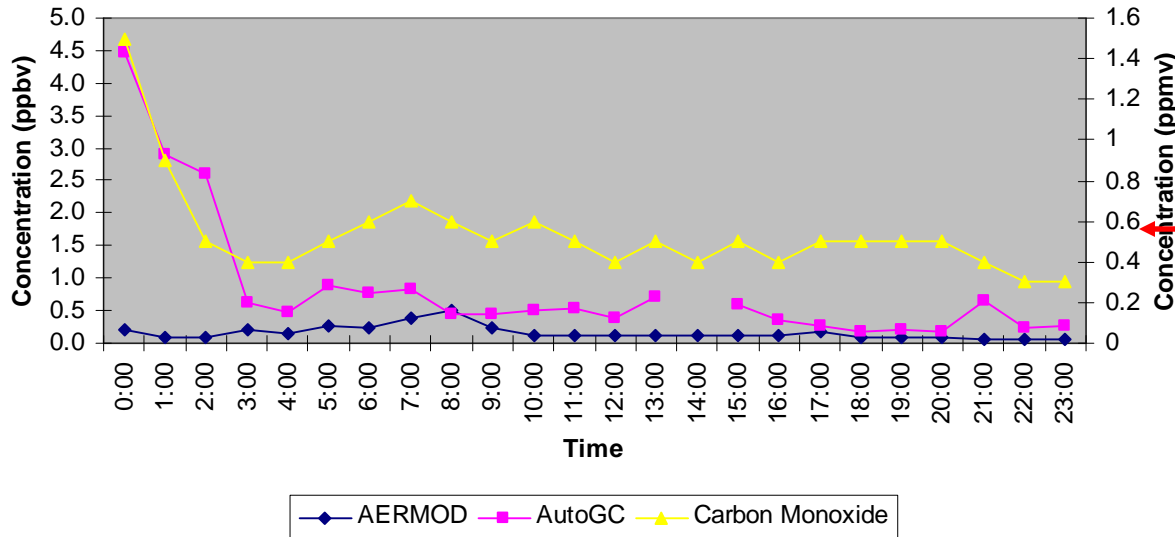
Hourly Average Concentrations Benzene and Black Carbon



Real-Time Toxics Data at Swansea

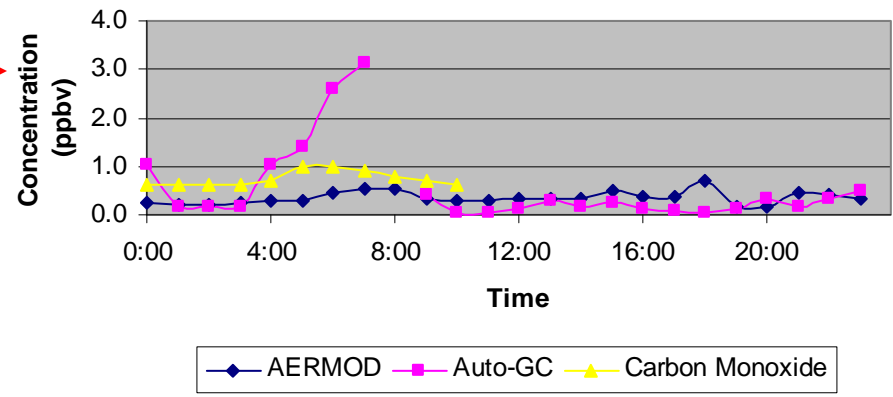
Rockies vs Giants game – ended at 10 pm night before; slug delayed 2 hrs; signature suggests mobile sources

Predicted vs Observed Benzene Concentrations Sunday April 23, 2006



N-ly winds all day; non-mobile source influence observed for benzene since carbon monoxide did not respond accordingly

Predicted vs Observed Benzene Concentrations Saturday April 29, 2006



Conclusions

- Air toxics concentrations have decreased significantly over two decades
 - BTEX decreased 75-80% from late 1980's
 - Carbonyl compounds less clear
- On-road emissions inventories match observed trend
- Despite significant reductions in precursors, ozone and visibility trends are flat