

# The Weekend Ozone Effect – The Weekly Ambient Emissions Control Experiment

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# Acknowledgments

## Sponsors

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## Participants/Technical/Logistical Assistance

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- California Air Resources Board
- Caltrans
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- Envair
- ENVIRON
- Freeman, Sullivan, Inc.
- Sonoma Technology, Inc.
- South Coast Air Quality Management District
- Wiltech

# The Problem

Ambient ozone levels are as high or higher on weekends than on weekdays in many urban U.S. locations, despite much lower emissions of the ozone precursors (hydrocarbons, carbon monoxide, and nitrogen oxides)

Why?

# Ambient Observations

- Of 78 southern California monitoring sites in five air basins, 28 had statistically significant **higher** Sunday O<sub>3</sub> levels, while 49 of the remaining 50 sites showed **no significant WD/WE differences**.
- Average Sunday NO<sub>x</sub> and VOC concentrations at all monitoring sites were 25-41% and 16-30% **lower** than on weekdays, respectively.

## Policy Question

- These large WE emission reductions allow decision-makers to ask “What if” questions regarding how emission reductions influence ambient ozone concentrations.

# Policy Questions

- Which is the most effective and least costly means of reducing ambient ozone in urban locations – NO<sub>x</sub> controls, VOC controls, or both?
- When highest average ozone levels fall on weekends, how do you design an effective strategy to reduce ambient ozone levels?

# Overview

- Study Design
- Hypotheses tested in study
- Study Activities
- Conclusions

# Overall Study Approach/Design

- Meet with government/industry groups throughout study period to share information (<http://www.arb.ca.gov/aqd/weekendeffect/weekendeffect.htm>)
- Retrospective Analysis of Ambient Data
- Formulation of Study Hypotheses
- Emission Inventory Development
- Field Study
- Data Analysis
- Air Quality Simulation Modeling
- Publish Results in Peer-Reviewed Literature



# Hypotheses Addressed by Study

<b>Hypotheses</b>	<b>Importance for Ozone Production</b>	<b>Confidence Level</b>
1. NOx emissions reduction		
2. NOx emissions timing (NOx “boost”)		
3. Pollutant carryover near the ground		
4. Pollutant carryover from aloft		
5. Increased weekend VOC emissions		
6. Increased photolysis due to decreased PM		

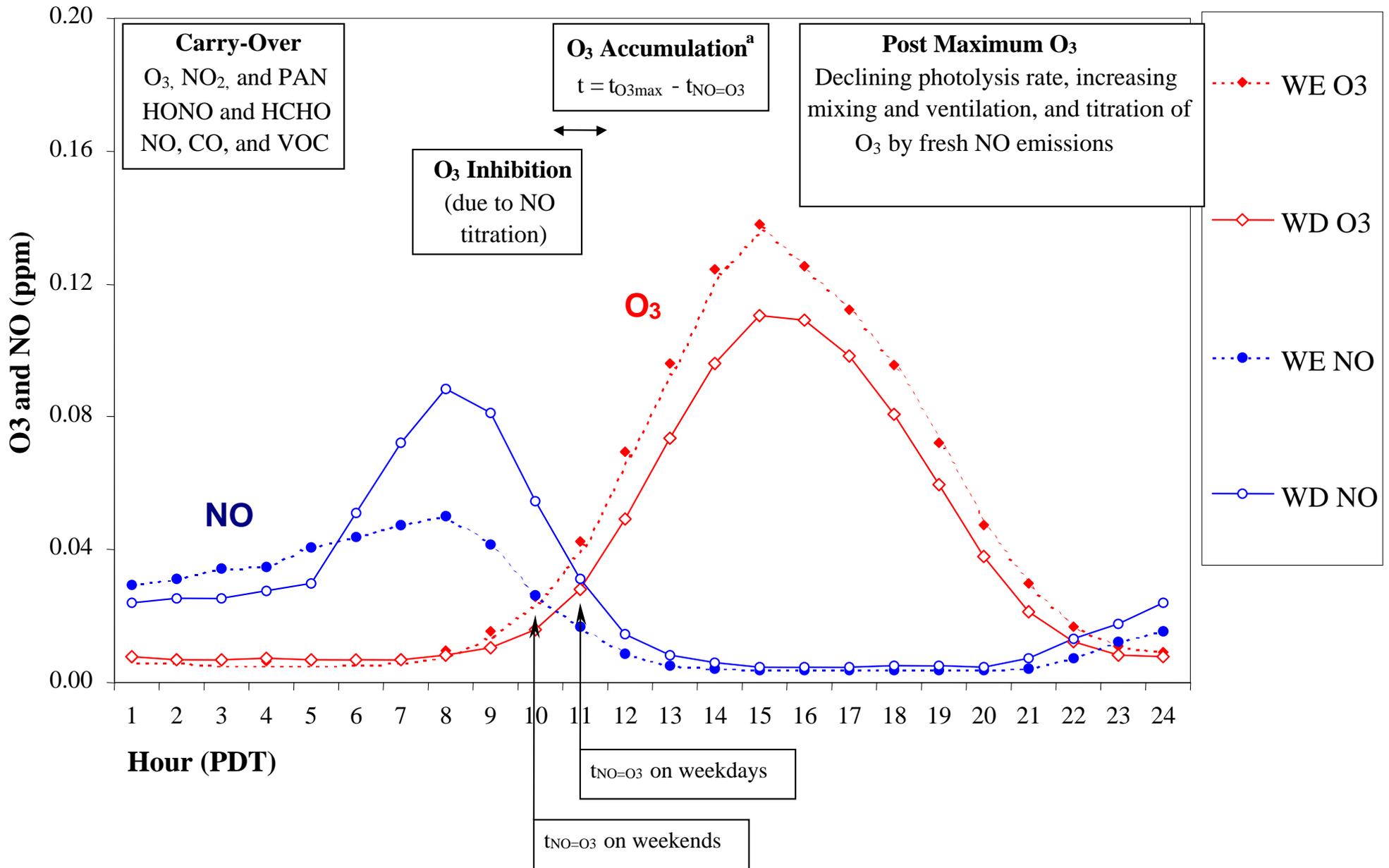
# Summary:

## Weekday/Weekend Emission Inventory Differences

- Truck and bus freeway activity decreased by up to 80% on weekends
- 12-18% reduction in VOC emissions on Saturday and Sunday relative to weekdays
- 35-41% reduction in NO<sub>x</sub> emissions on Saturday and Sunday relative to weekdays
- 30% increase in VOC/NO<sub>x</sub> ratio on weekends relative to weekdays

# Data Analyses

# Azusa, Summer 1995



Mean Wednesday  
 $\pm 1$  sigma

Mean Sunday  
 $\pm 1$  sigma

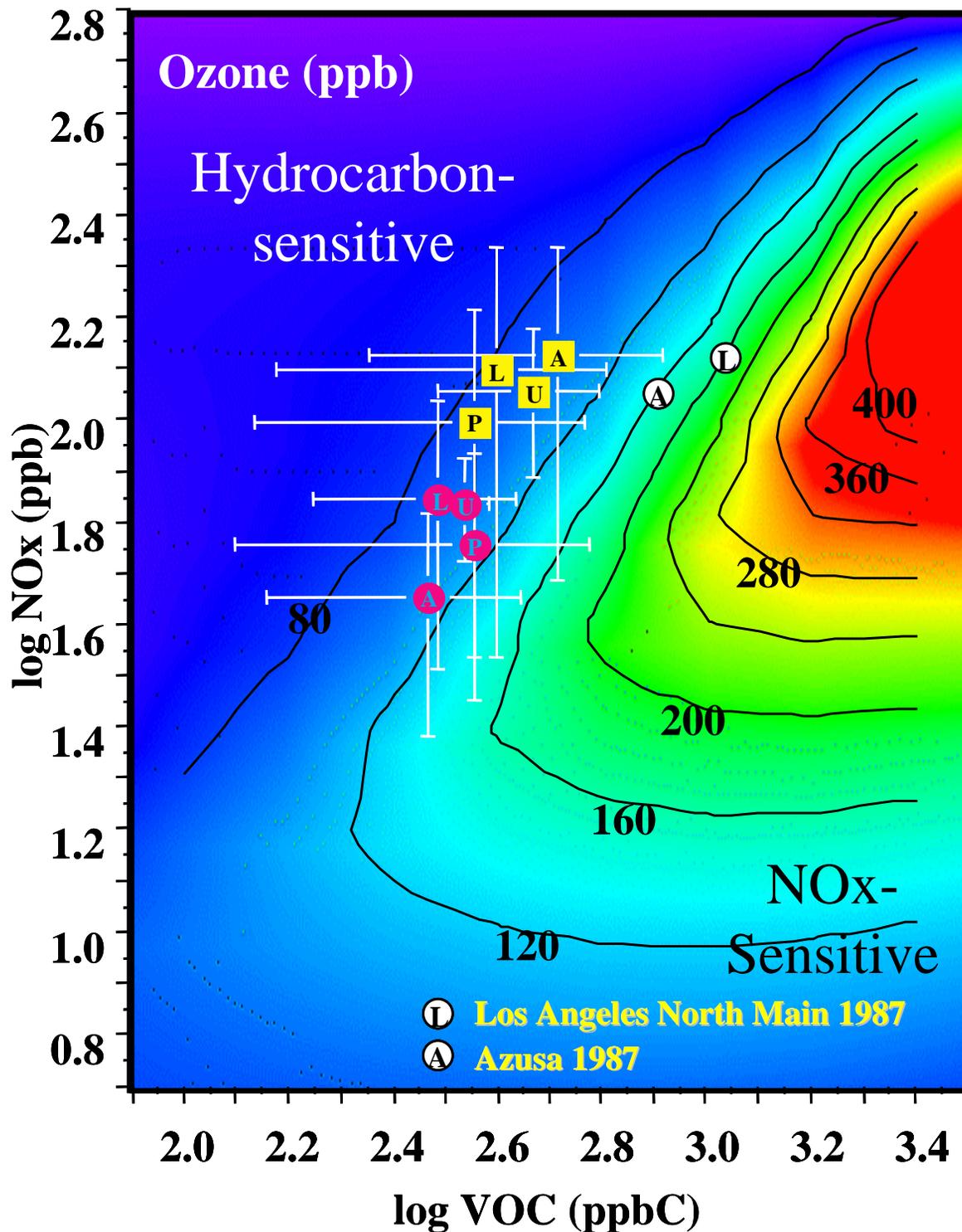
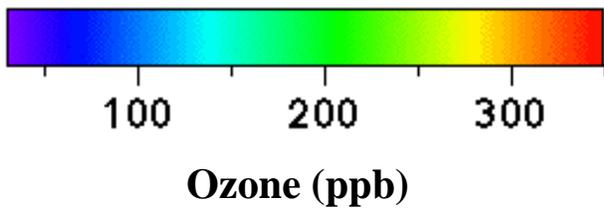
Monitoring Stations

A – Azusa

L – Los Angeles, N. Main

P – Pico Rivera

U – Upland



# **Study Conclusions**

# Results of Hypothesis Testing by Study Investigators

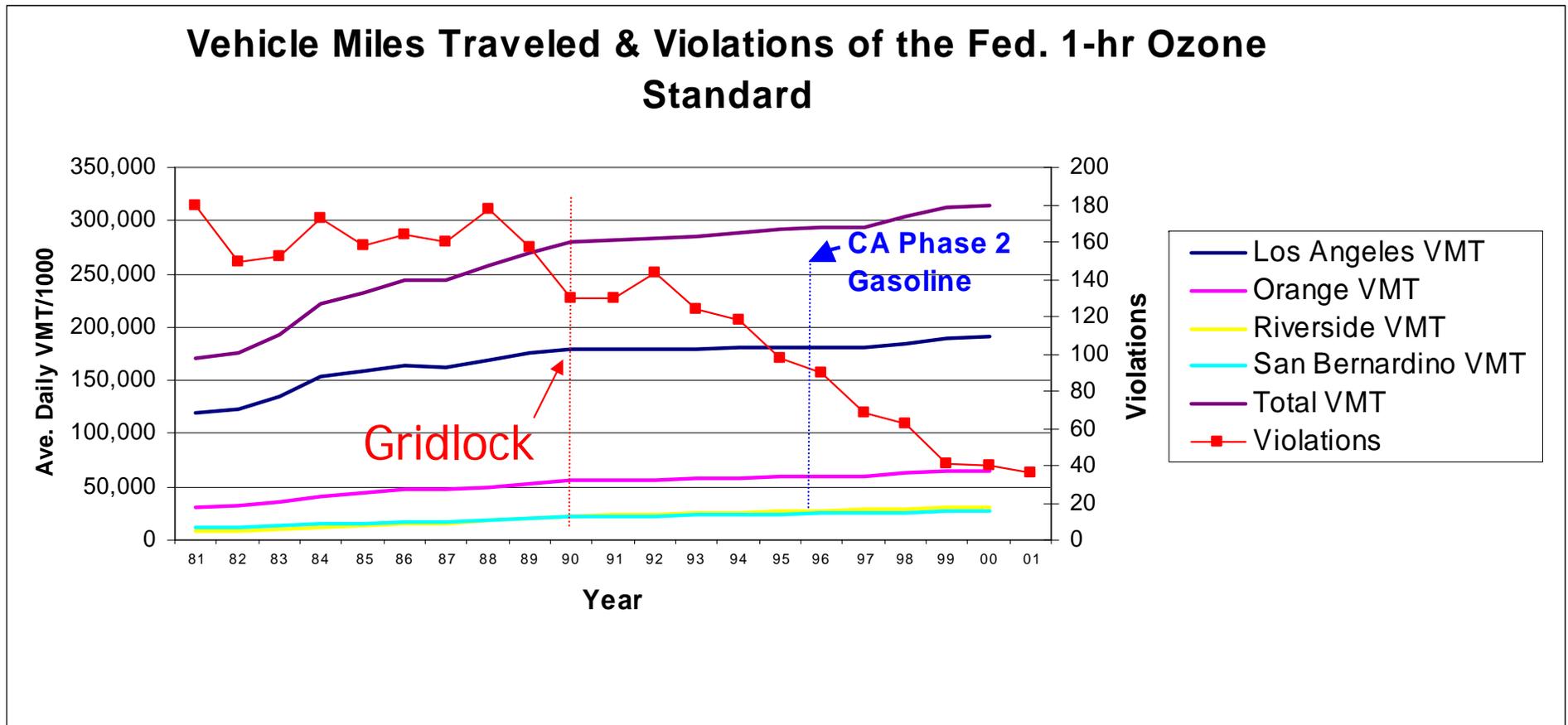
Hypotheses/Supported by Study	Importance for Ozone Formation	Confidence Level
1. NOx emissions reduction – <b>YES</b>	Significant	High
2. NOx timing (NOx “boost”) – <b>NO</b>	Insignificant	High
3. Pollutant carryover near the ground – <b>YES</b>	Small	High
4. Pollutant carryover from aloft – <b>NO</b>	Insignificant	Medium
5. Increased weekend VOC emissions – <b>NO</b>	Small to Insignificant	Medium
6. Increased photolysis due to decreased PM – <b>NO</b>	Small to Insignificant	Medium

Supported by Study Results = **Yes**

Not Supported by Study Results = **No**

# Ozone Trends in the South Coast Air Basin

“Forecasting is difficult, especially when it involves the future.” – Casey Stengel



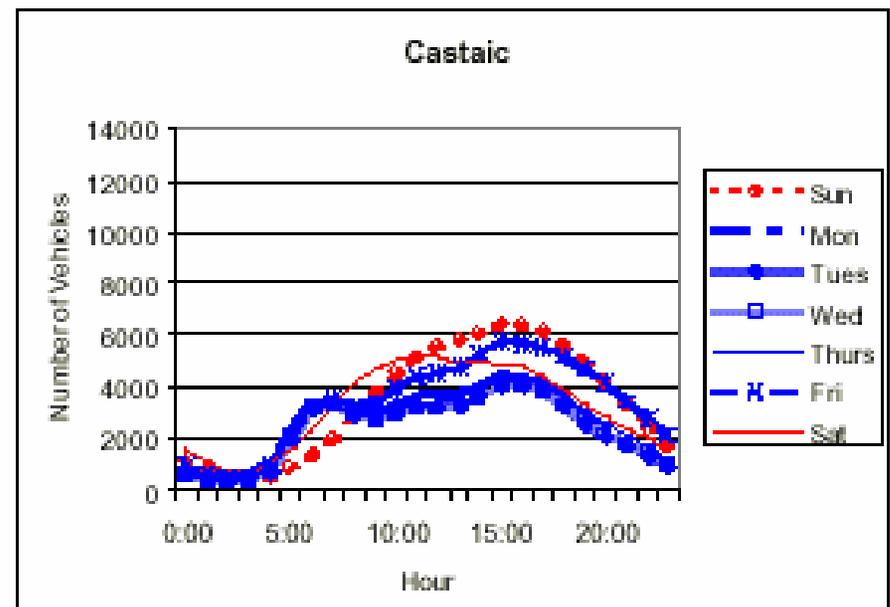
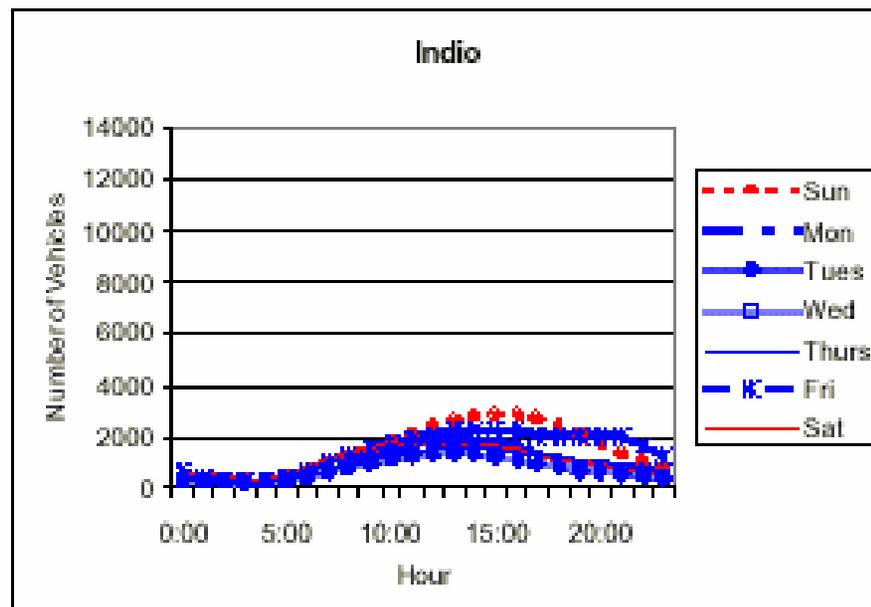
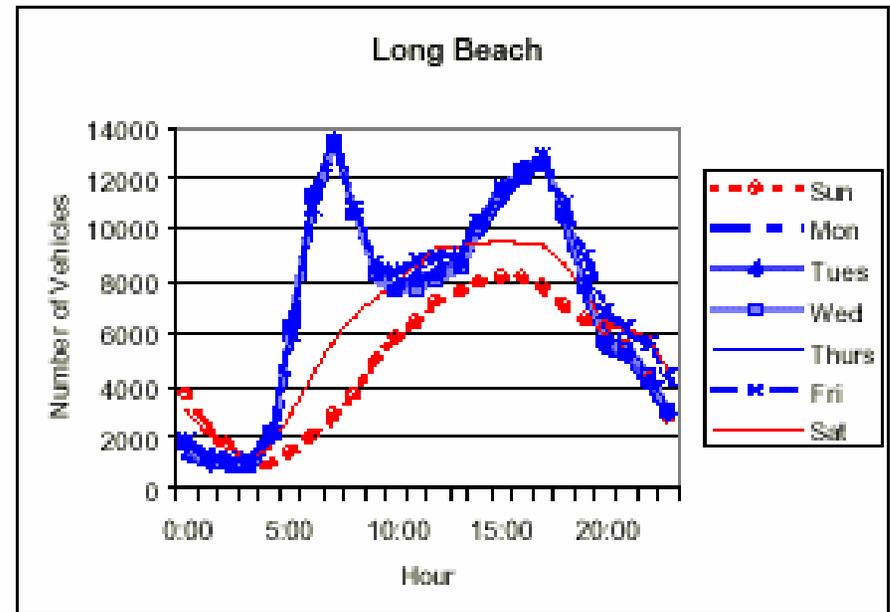
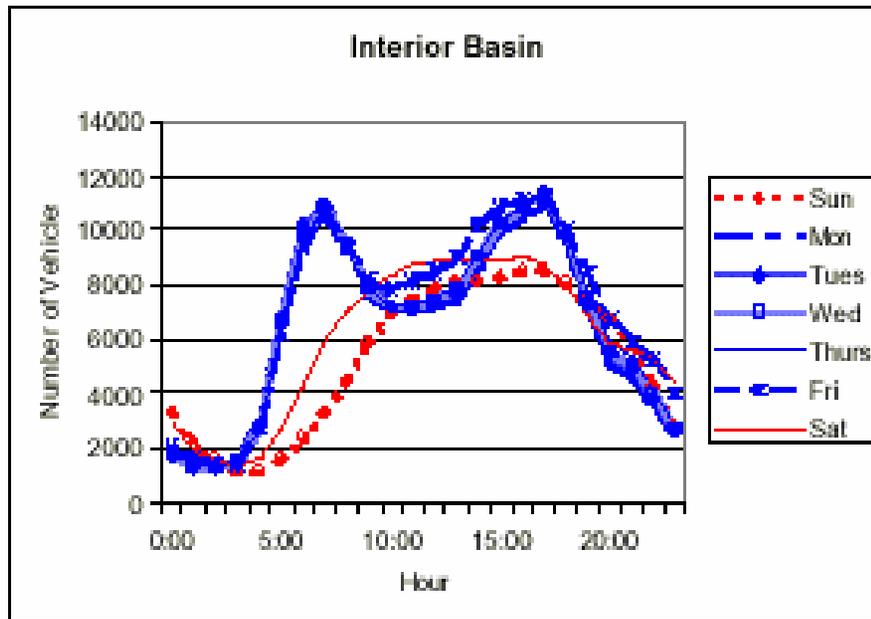
# Observations

- Atmospheric scientists/policy makers can seldom conduct controlled experiments of the kind that are needed to address policy-relevant issues.
- Emission changes that occur every Saturday and Sunday, relative to weekdays, allow us to ask how those changes influence ambient pollutant concentrations.
- This study's data are of such high quality that we are able to observe and quantify differences in emissions and ambient levels of ozone and its precursors, even between Saturdays and Sundays, relative to weekdays.

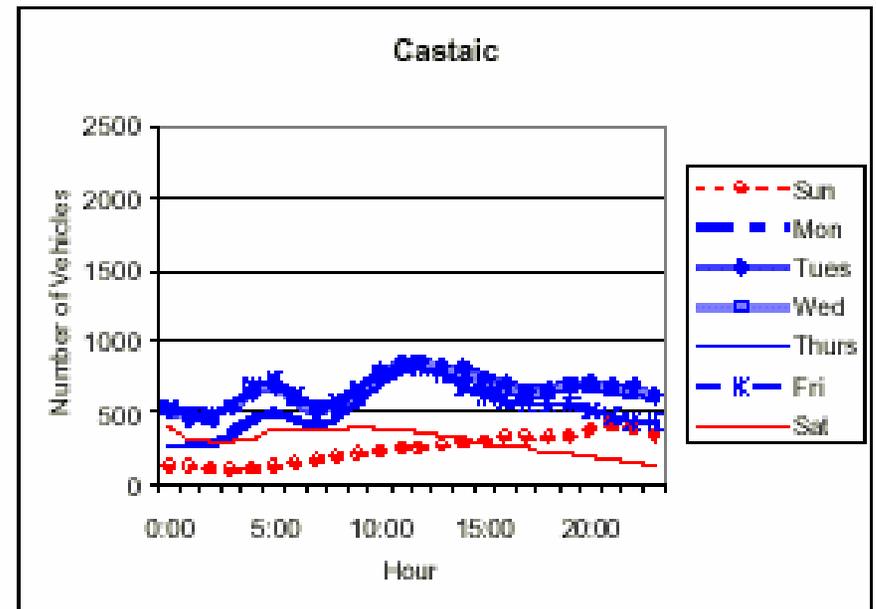
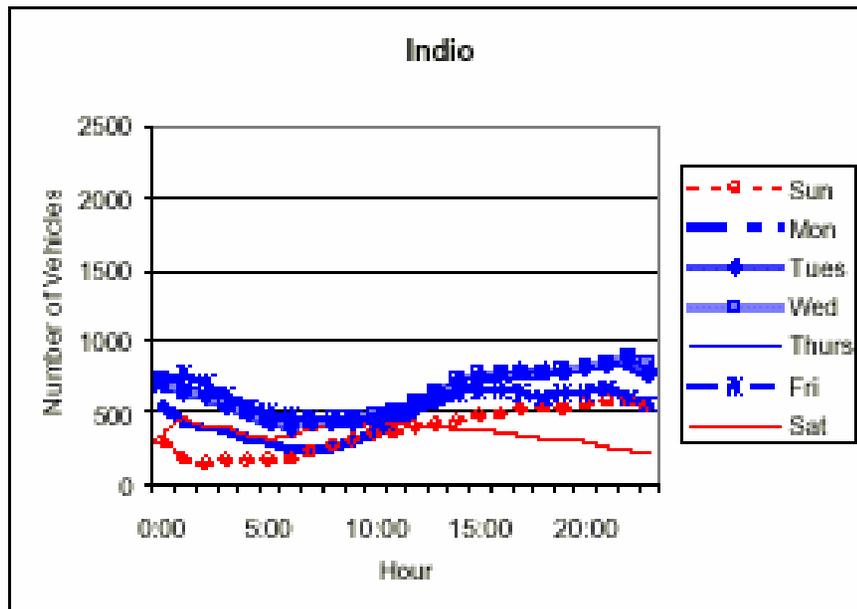
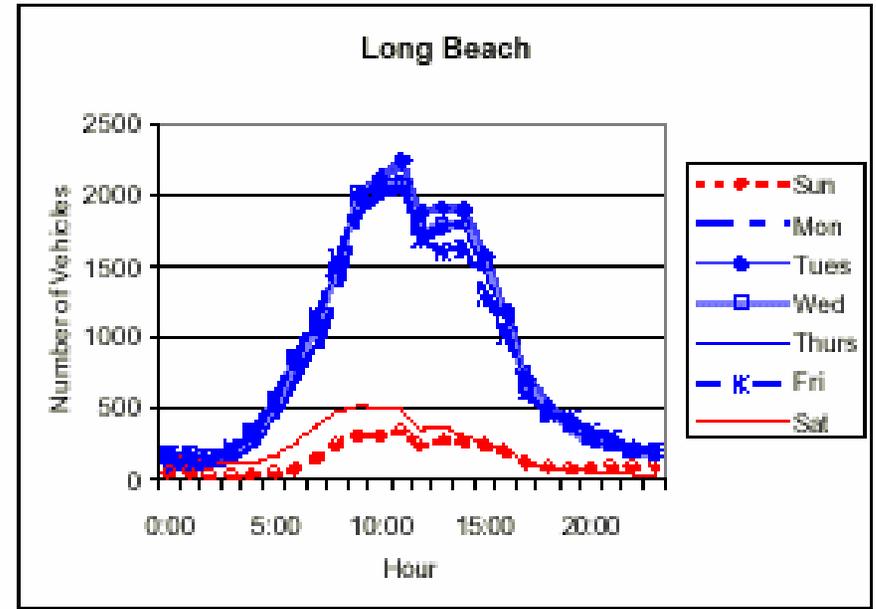
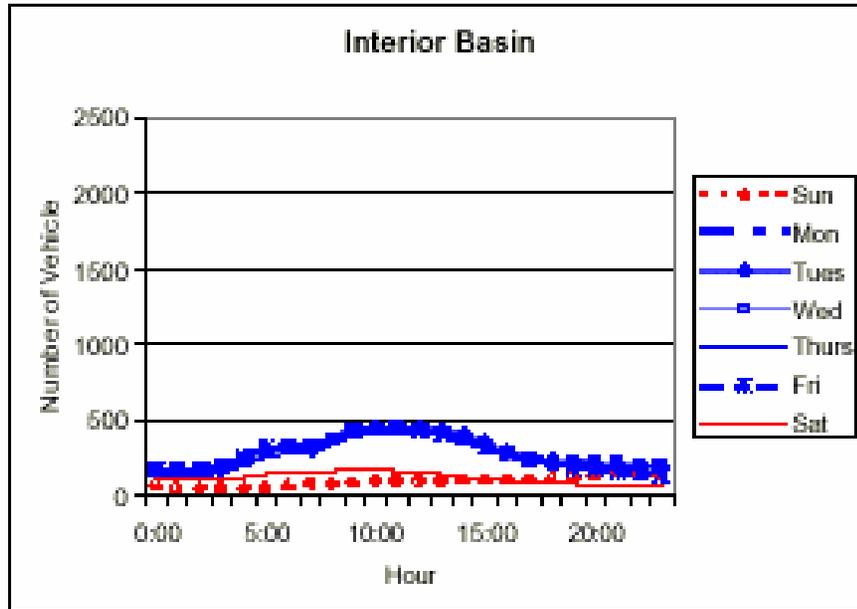
# Conclusions

- $\text{NO}_x$  reductions in Southern California (and other urban U.S. locations) increase ambient ozone levels.
- Ozone reductions in the SoCAB since 1987 are mostly due to VOC, and not  $\text{NO}_x$ , emission reductions.
- At current VOC levels, total  $\text{NO}_x$  emission reductions as large as 80-90% will be needed before the  $\text{NO}_x$  disbenefit can be overcome.
- Emission projections for 2010 suggest that ambient weekday ozone levels in the SoCAB may be as high as today's weekend ozone levels.
- If effective VOC controls can be put in place (repairing/eliminating high VOC-emitting vehicles), the amount of ozone in source regions would be reduced and the issue of ozone downwind of the source areas might be moot if the national ambient standards for ozone are met downwind.

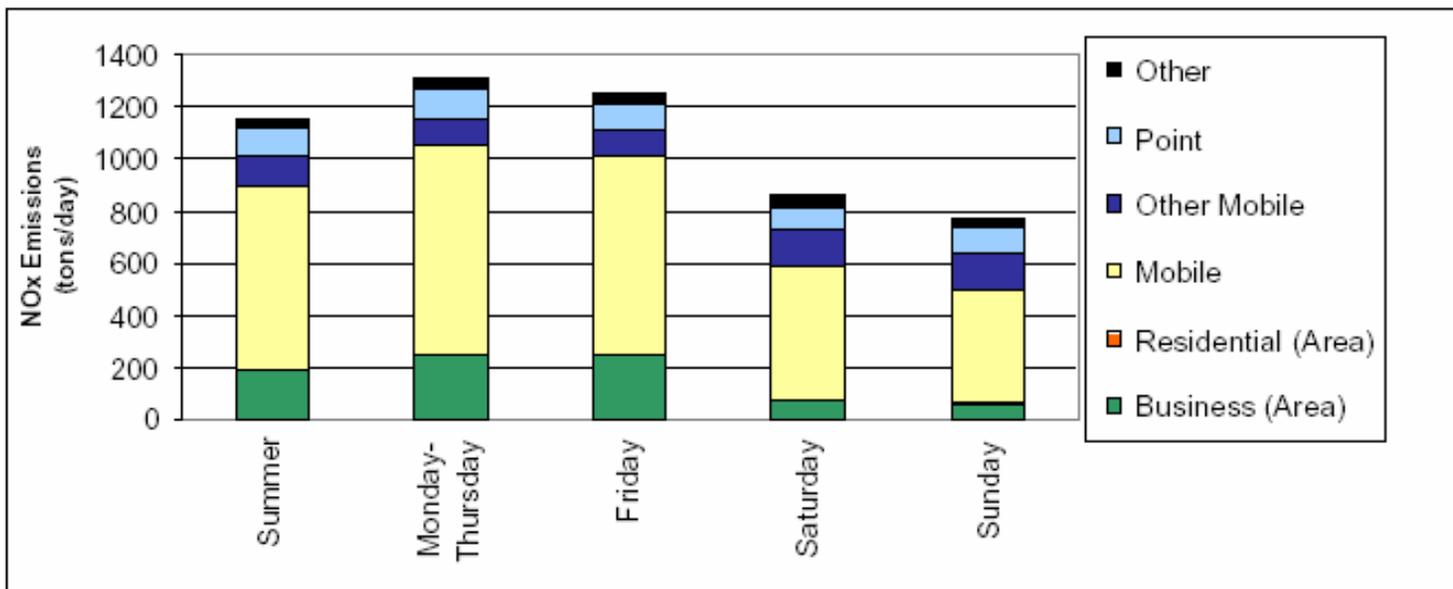
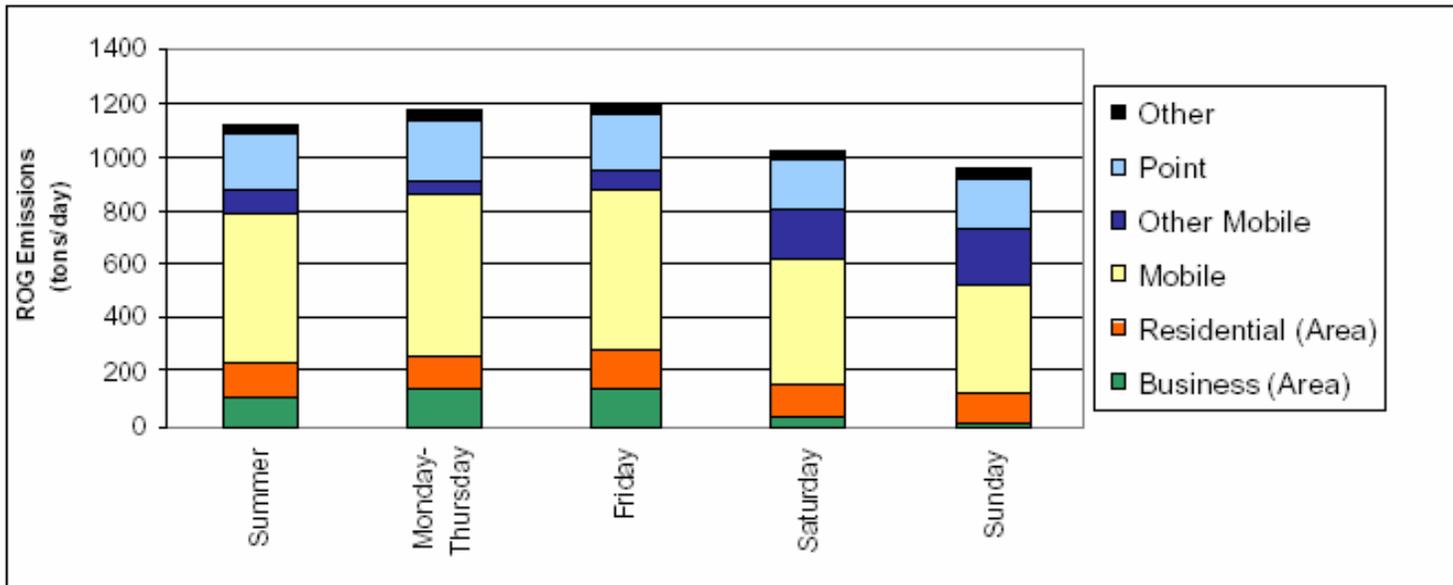
# Average LD Volumes at Freeway WIM Sites



# Average HD Volumes at Freeway WIM Sites



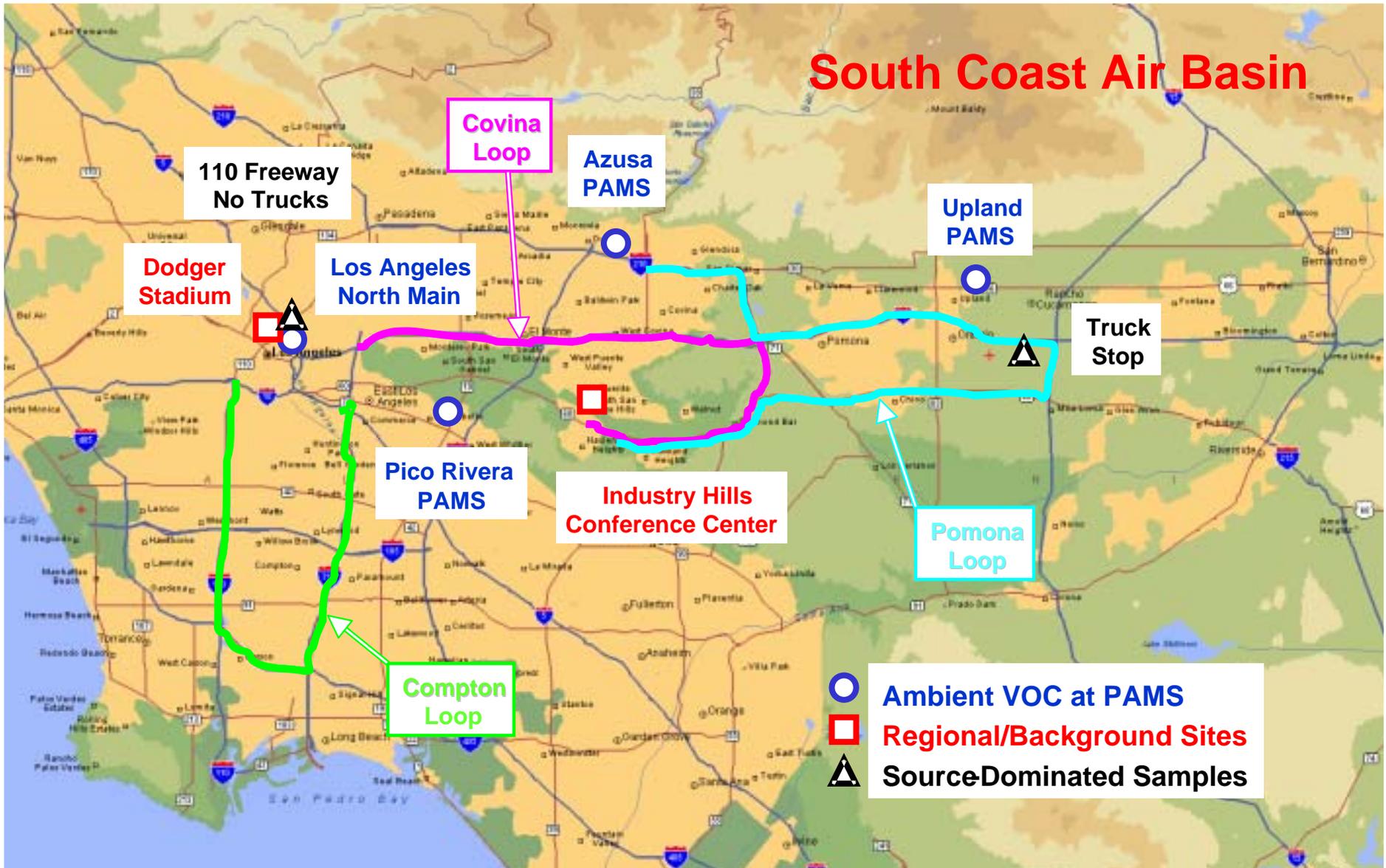
# Estimated Day-of-Week Emission Inventory After Applying Emission Activity Scaling Factors



# Ambient Measurements – Field Study

- Field study conducted Saturday, September 30 through Sunday, October 8, 2000
- Unique because this was an emissions-based study
- Ambient measurements made at routine AQMD and other fixed monitoring sites
- Mobile measurements made by sampling van at a variety of source locations and on various freeway loops

# Sampling Locations During Field Study, September 30-October 8, 2000



# Weekday/Weekend O<sub>3</sub> Study – Gasoline Source Profile Testing – 0647 hrs on Oct. 2, 2000

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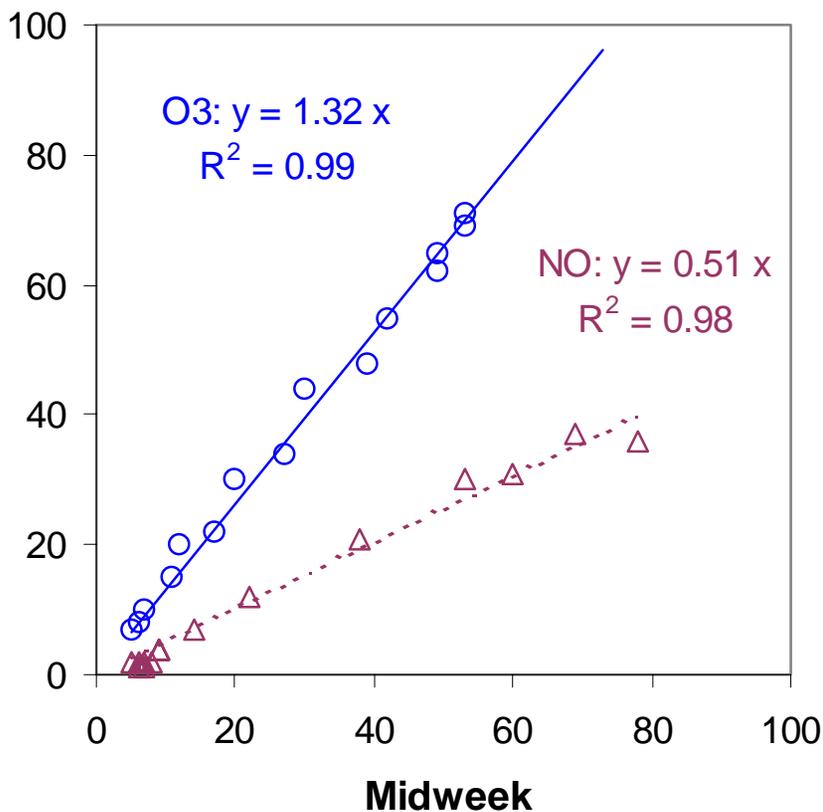
# Weekday/Weekend O<sub>3</sub> Study – Diesel Source Profile Testing – 0222 hrs on Oct. 3, 2000

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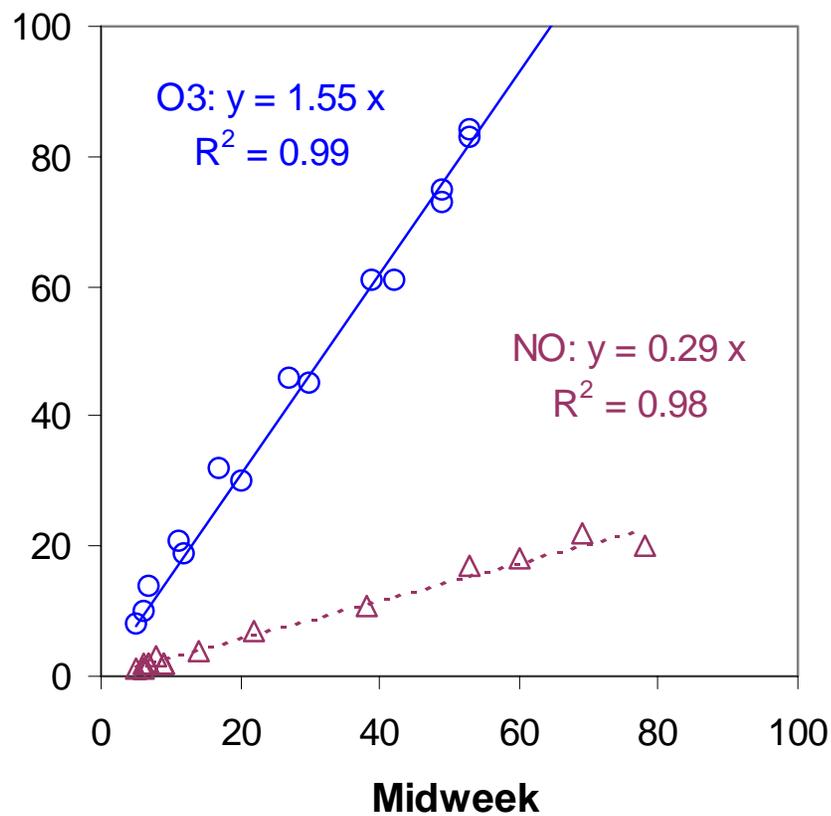


# Correlations of Saturday and Sunday Versus Midweek\* Hourly Daytime (0600 to 2000, PDT) O<sub>3</sub> and NO at Azusa, 1999-2000

## Saturday



## Sunday



\* Tuesday to Thursday

# Weekday Correlations of Hourly O<sub>3</sub> and NO

Location	Daylight (0600-2000)			
	Ozone		Nitric Oxide	
	Slope	R <sup>2</sup>	Slope	R <sup>2</sup>
<b><u>Friday/Midweek</u></b> <sup>1</sup>				
Los Angeles N. Main	<b>0.98</b>	1.00	<b>0.89</b>	0.99
Pico Rivera	<b>0.96</b>	1.00	<b>0.86</b>	0.98
Azusa	<b>0.98</b>	0.99	<b>0.94</b>	0.96
Upland	<b>1.02</b>	1.00	<b>1.03</b>	0.99
<b><u>Saturday/Midweek</u></b>				
Los Angeles N. Main	<b>1.29</b>	0.98	<b>0.61</b>	0.99
Pico Rivera	<b>1.27</b>	1.00	<b>0.69</b>	0.99
Azusa	<b>1.31</b>	0.99	<b>0.51</b>	0.98
Upland	<b>1.26</b>	0.99	<b>0.62</b>	0.99
<b><u>Sunday/Midweek</u></b>				
Los Angeles N. Main	<b>1.49</b>	0.96	<b>0.43</b>	0.97
Pico Rivera	<b>1.50</b>	0.98	<b>0.39</b>	0.99
Azusa	<b>1.55</b>	0.99	<b>0.29</b>	0.98
Upland	<b>1.44</b>	0.97	<b>0.29</b>	0.91
<b><u>Means</u></b>				
<b>Friday/Midweek</b>	<b>0.99</b>	1.00	<b>0.93</b>	0.98
<b>Saturday/Midweek</b>	<b>1.28</b>	0.99	<b>0.61</b>	0.99
<b>Sunday/Midweek</b>	<b>1.50</b>	0.98	<b>0.35</b>	0.96

<sup>1</sup> mean of Tuesday, Wednesday, and Thursday values