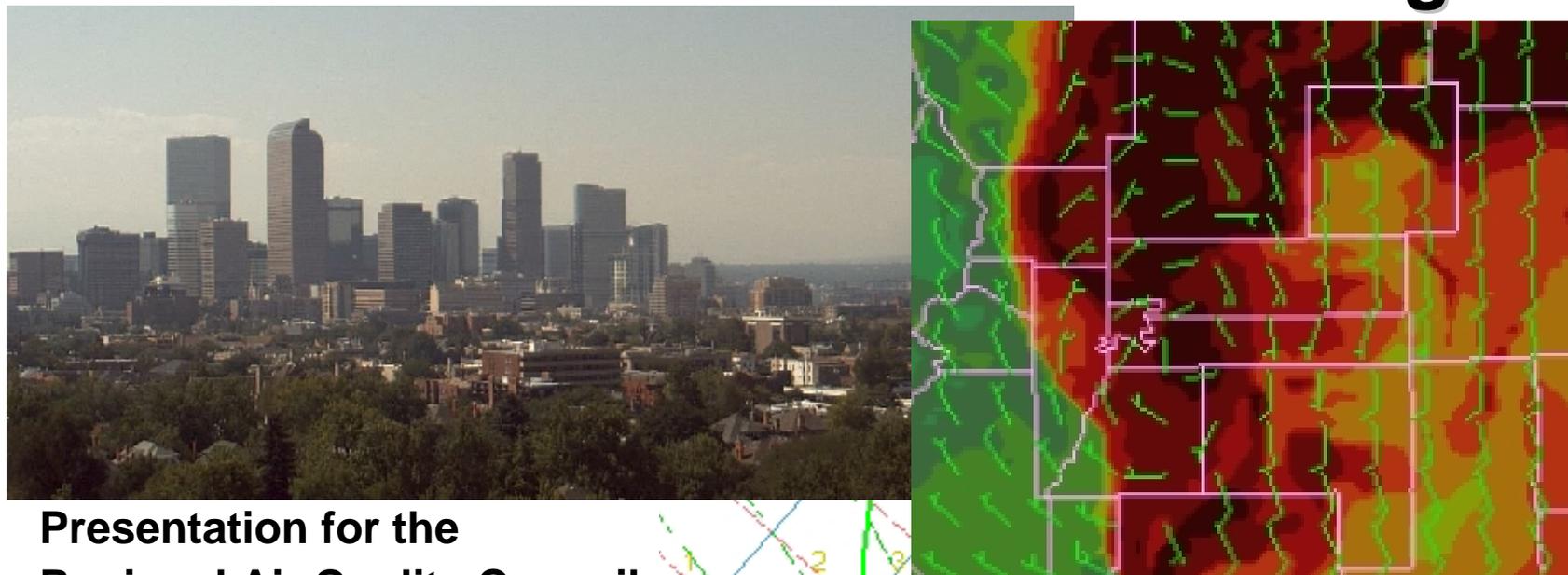
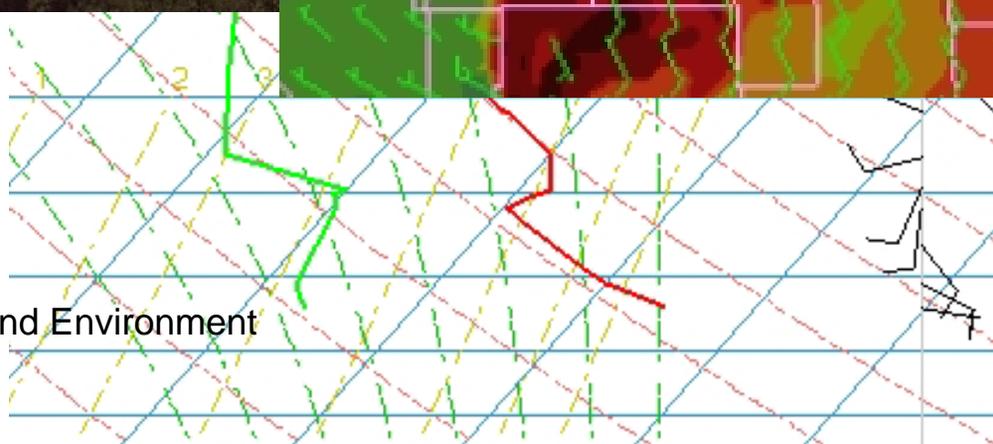


# Weight of Evidence Approach to Support the Denver 8-hr Ozone SIP Modeling



**Presentation for the  
Regional Air Quality Council  
September 8, 2008**

Prepared by  
Colorado Department of Public Health and Environment  
Regional Air Quality Council



08/29/2008 KDNR

Lat = 39.75 , Lon = -104.87

# What is a Weight of Evidence Analysis?

- It is a required set of supplemental analyses for areas whose modeled attainment results are near the National Ambient Air Quality Standard (NAAQS)
- It combines and weighs the various supplemental analyses with the results of the modeled attainment test
- It draws a conclusion and states whether or not the SIP package will likely yield attainment by the relevant future year.

# When is a WOE Analysis Required?

- EPA's 8-hour ozone modeling guidance recommends a WOE analysis to support the modeled attainment determination if the maximum modeled 8-hour ozone future design value is between 0.082 ppm and 0.087 ppm at more than one monitor.
- The 2010 base year modeling has four sites (Rocky Flats North, Fort Collins West, Chatfield, and NREL) with a modeled design value between 0.082 - 0.087 ppm.

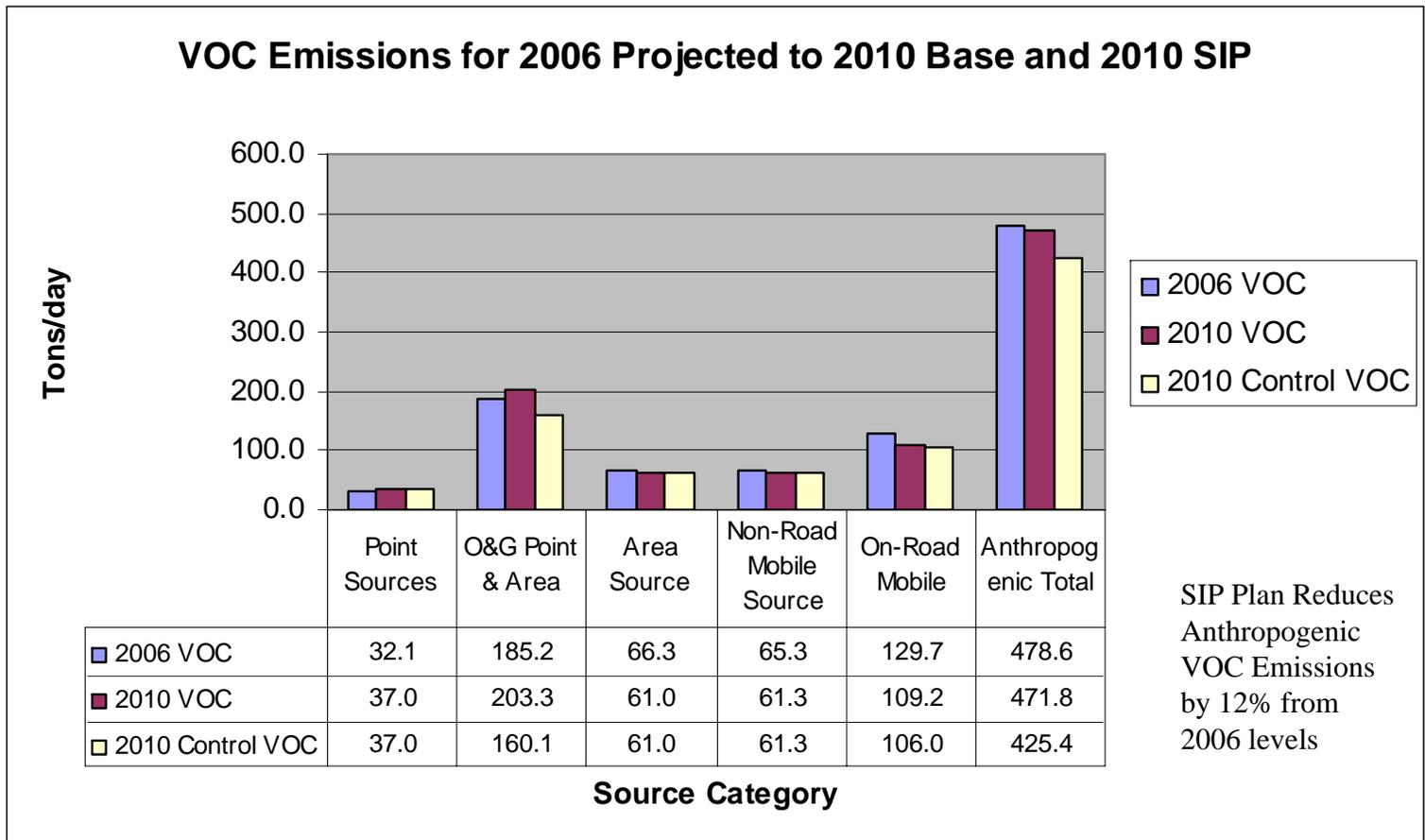
# Elements: Denver's WOE Analysis

1. Emissions trends
2. Ozone time series analysis and trends
3. Ozone conceptual model for the north front range
4. Alternative modeling metrics to assess changes in ozone
5. Alternative attainment test methodologies
6. Efficacy of SIP, State-only and voluntary control strategies

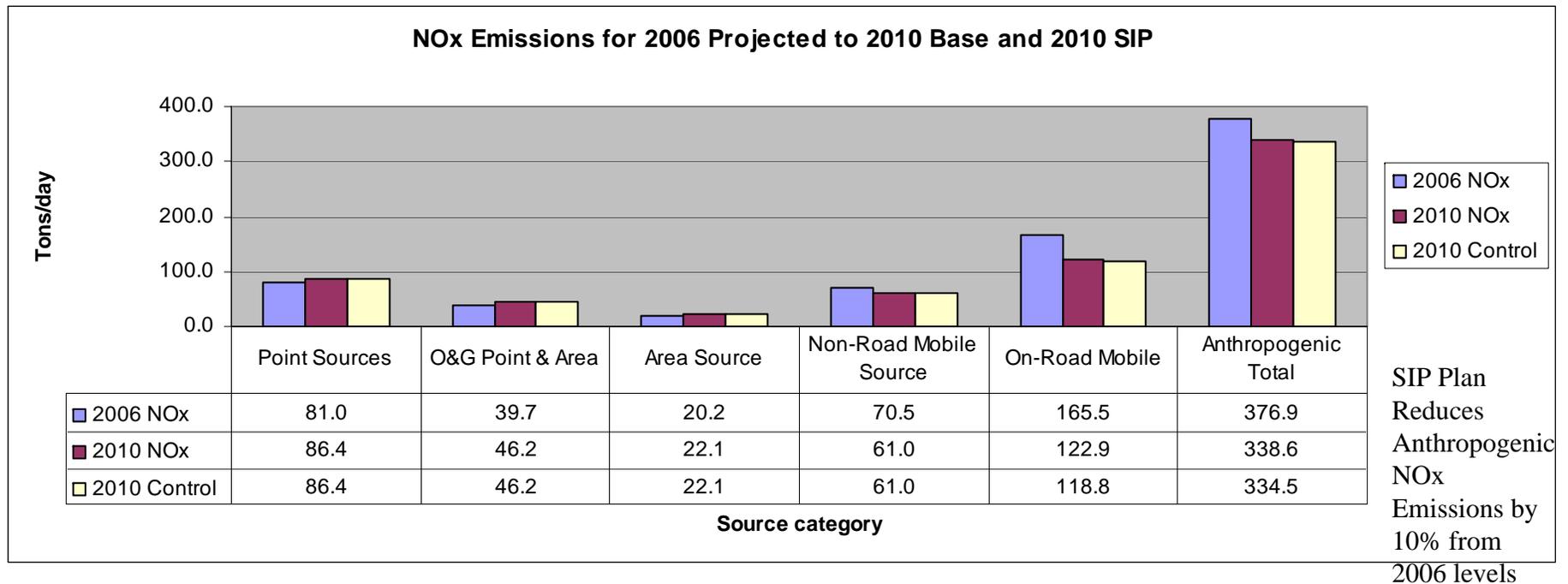
# 1. Emission Trends

- For most source categories, the emission estimates used in the modeling show downward trends from 2006 to 2010.
- Does this make sense?
- Yes, despite growth in VMT, population, and housing, emissions are declining for mobile, non-road, and area sources due to:
  - Mobile source fleet turnover
  - Federal tail pipe regulations
  - Tier 2 & 3 non-road mobile regulations
  - Reformulation of paints and consumer product
- Nevertheless, some categories like Oil & Gas show growth since 2002, despite aggressive emissions control programs

# Projected VOC Emission Trends



# Projected NOx Emission Trends



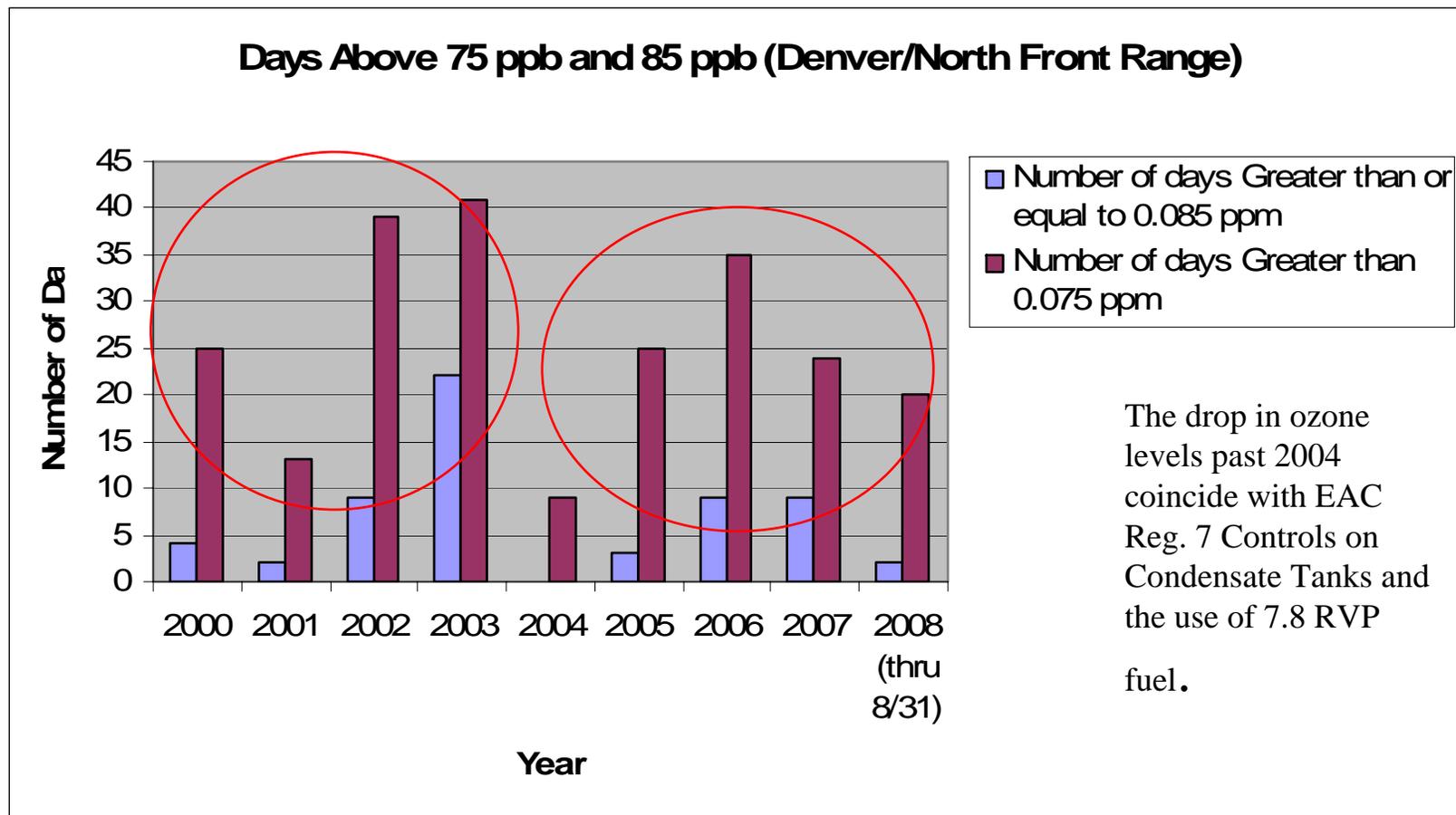
# Emission Trends - Conclusion

- Trends in emissions correlate well with surrogate indicators such as mobile source fleet turnover.
- If emission trends are directionally correct, then Relative Response Factors (RRFs) are likely to be directionally correct.
- How are the emission trends expected to affect ozone?
  - Reductions in VOC emissions are expected to reduce ozone
  - Reductions in NO<sub>x</sub> emissions are expected to both increase and decrease ozone, but the most of the reductions are expected in areas where ozone reductions are needed the most.

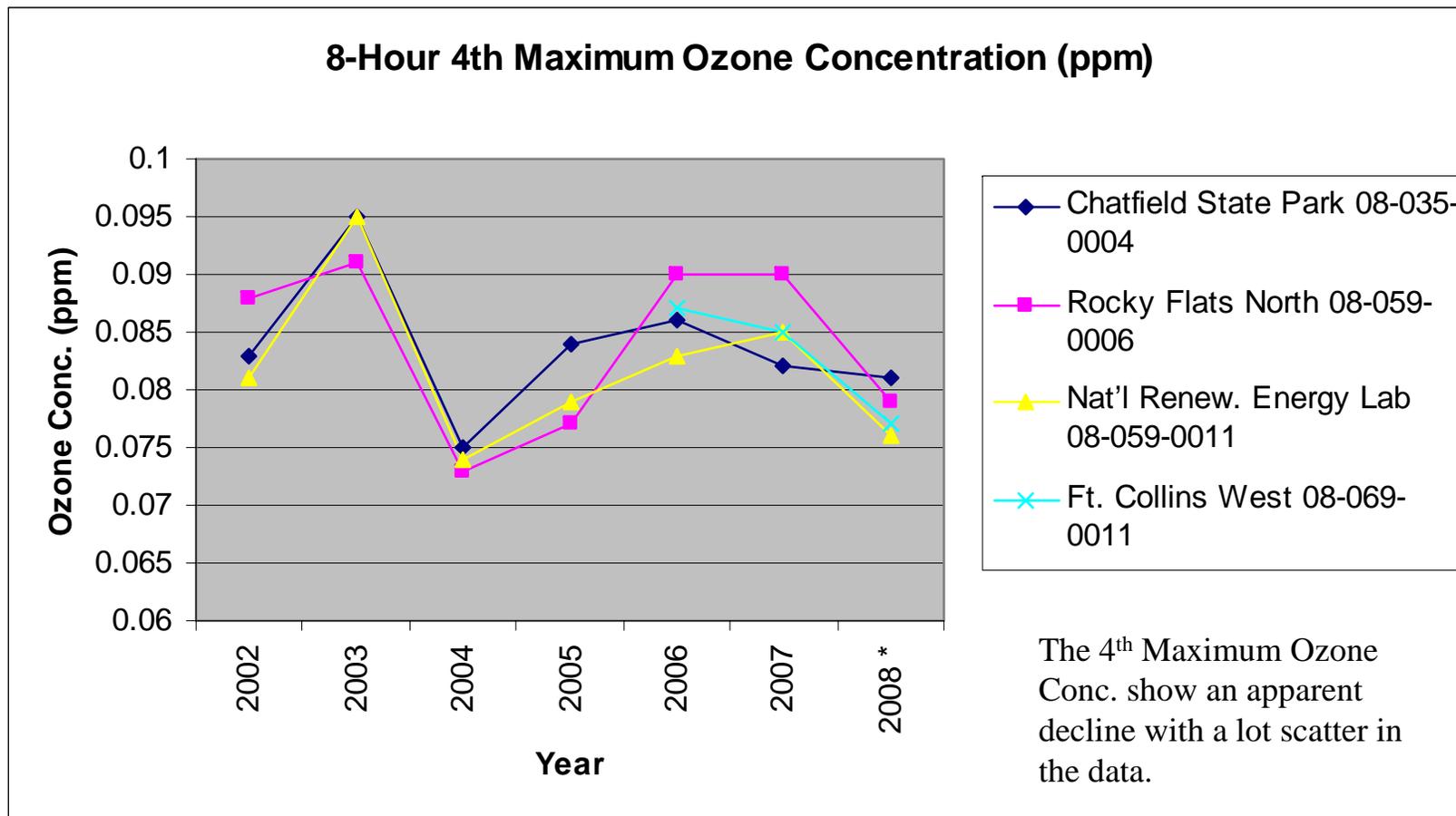
## 2. Ozone Trends

- The following graphs show various ways of looking at ozone data.
- Despite apparent “trends” in maximum and 4<sup>th</sup> maximum ozone values over time, the trends are seldom statistically significant.
- If trends are flat or not statistically significant, it can be suggested that ozone levels are not getting worse.

# Monitoring Days Exceeding 0.085 ppm and 0.075 ppm



# Monitoring Time Series - 4<sup>th</sup> Maximum Ozone Concentration at Key Monitors



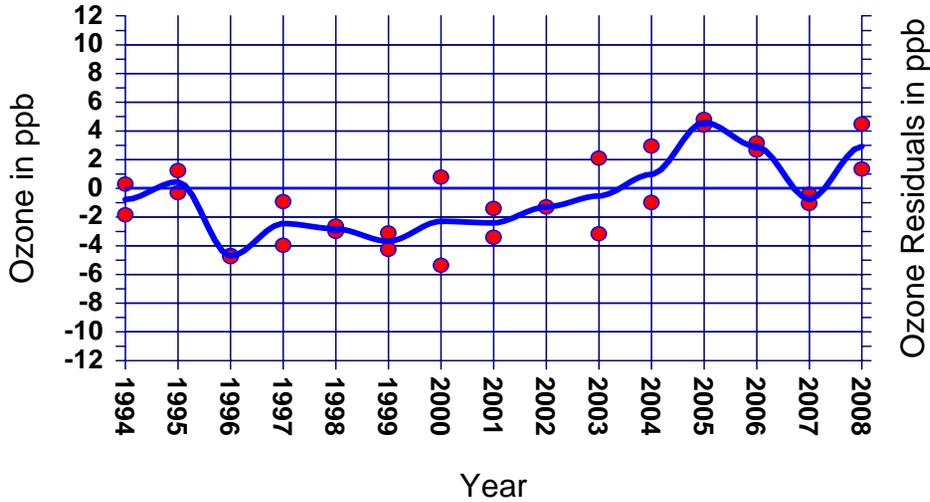
### 3. Ozone Conceptual Model for the North Front Range

- A conceptual model describes the local meteorological conditions and associated large-scale weather patterns experienced during periods of high ozone.
- Key meteorological ingredients for high ozone at the surface
  - light winds.
  - A deep layer of thermally-driven upslope flow during the day
  - Cloud-free skies
  - Warm temperatures are key ingredients for high ozone at the surface
  - Local vertical re-circulation to around 18,000 Feet (~500 mb height)

# Weather and Ozone Trends

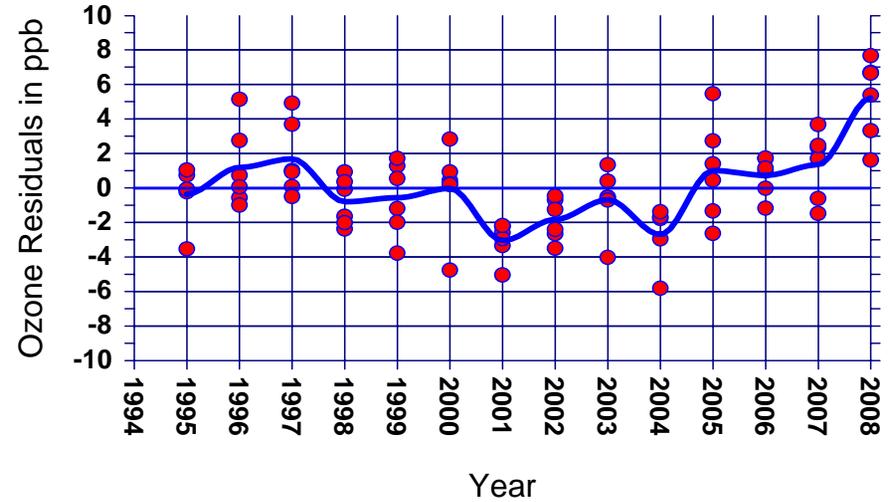
- July monthly mean daily maximum 8-hour ozone is more strongly correlated with upper level high pressure strength than any of a host of other logical choices for significant predictors of ozone, including temperatures, winds aloft, cloud cover, solar radiation, and number of days with temperatures above 90 degrees.
- July monthly mean daily maximum 8-hour ozone correlates with upper level high pressure strength with R-squared values as high as 0.84.
- July is the pivotal month for our ozone season, and high pressure strength in July has a pivotal effect on annual 4<sup>th</sup> max ozone. R-squared values for 4<sup>th</sup> max concentrations and 500 mb heights are as high as 0.77.
- The strong linear relationships between ozone and 500 mb heights at most sites can be used to remove the effects of weather from the ozone record.

Trend in FTC/GRE July Mean Daily Max 8-hr Ozone, Effect of Mean 500 mb Heights Removed



(Residuals are differences between actual and weather predicted ozone.)

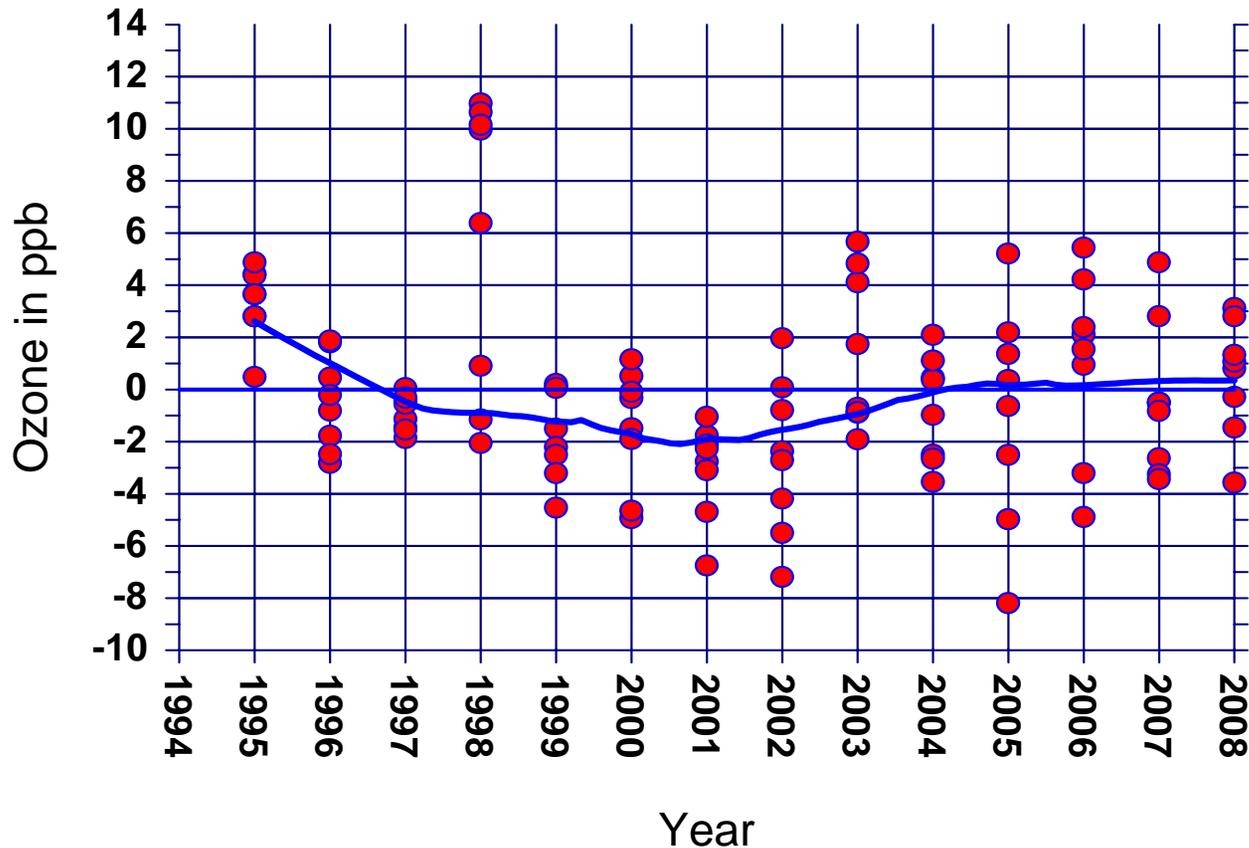
Trend in DEN Metro July Mean Daily Max 8-hr Ozone, Effect of Mean 500 mb Heights Removed



(Residuals are differences between actual and weather predicted ozone.)

Weather-corrected ozone trends show the possible impacts of oil and gas controls in Ft. Collins and Greeley and a regional increase in ozone of 4 ppb in 2008. The cause(s) of this increase are not yet known, but might be the result of significant changes in summer VMT across the West.

## Trend in Front Range 4th Max Ozone Effect of Mean 500 mb Heights Removed



The weather-corrected 4<sup>th</sup> max time series shows a period of decline followed by a rise and ending in a level line from 2004 through 2008. This is consistent with the idea that ozone is difficult to control but increases have ceased since 2004. In addition, the possible increase in regional background in 2008 seen in earlier plots does not appear to have had an impact on these worst-case concentrations.

# Conceptual Model and Ozone Trends – Conclusions

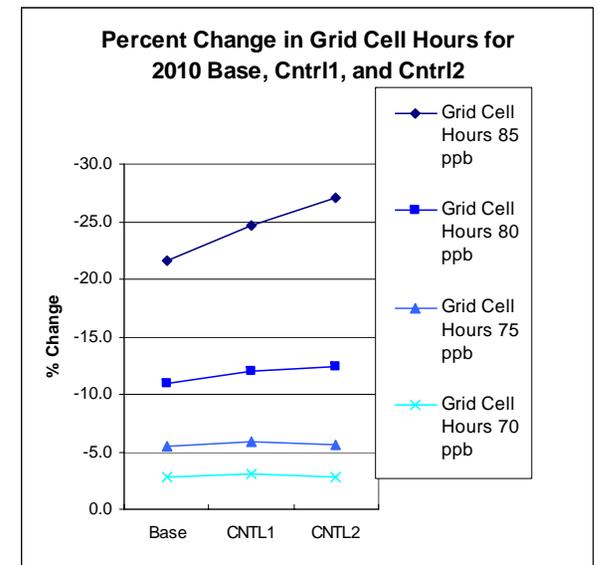
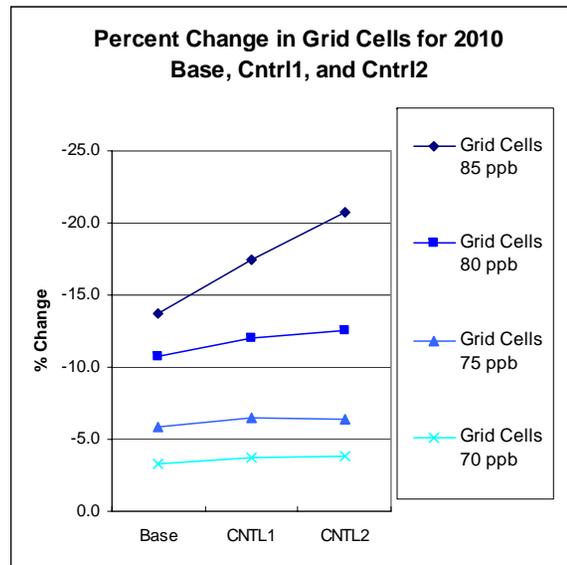
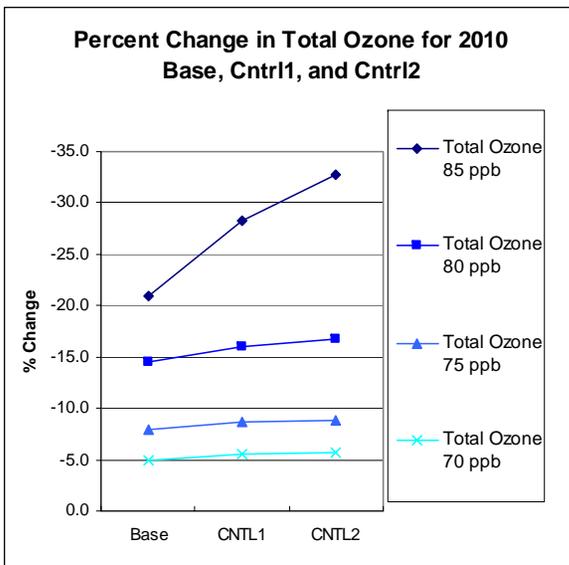
- Weather-corrected 4<sup>th</sup> maximum time series suggest that ozone levels are flat from 2004 through 2008.
- While Non-weather-corrected 4<sup>th</sup> maximum time series suggest ozone levels are flat or slightly decreasing, the trends are not statistically significant at the key monitors like Rocky Flats North, so confidence in any trend is low.
- The absence of apparent upward trends is good news.
- However, the lack of statistically significant trends suggest that the area will remain at or near the level of the standard unless there are additional emission reductions.

## 4. Alternative Modeled Metrics to Assess the Changes in Ozone Levels in the NAA

- EPA guidance recommends that at least 3 additional model outputs be examined in the weight of evidence (WOE) determination to provide assurance that passing or nearly passing the recommended attainment and screening tests indicates attainment
- These test measure how much estimated elevated 8-hour ozone concentrations are reduced from the current year base case conditions to the future-year control strategy.
- The three metrics used for this SIP are:
  - Number of Grid-Hours:
  - Number of Grid-Cells:
  - Change in Total Ozone:

# Alternative Model Metrics

Threshold	% Change								
	Total Ozone			Grid Cells			Grid Cell Hours		
	Base	CNTL1	CNTL2	Base	CNTL1	CNTL2	Base	CNTL1	CNTL2
85 ppb	-20.9	-28.2	-32.7	-13.7	-17.4	-20.7	-21.6	-24.7	-27.1
80 ppb	-14.4	-16.0	-16.8	-10.7	-12.0	-12.5	-10.9	-12.0	-12.4
75 ppb	-8.0	-8.7	-8.9	-5.8	-6.5	-6.4	-5.4	-5.8	-5.6
70 ppb	-5.0	-5.6	-5.7	-3.3	-3.7	-3.8	-2.8	-3.1	-2.8



# 5. Alternative Attainment Test Methodologies

- Supplementary analysis suggested for use for the attainment test:
  - EPA's recommended average for base Design Value (DVB) of the three Design Values over a five-year (2004-2008) timeframe
    - Currently using a single 2005-2007 design value which is a more stringent case
  - Use of Different Thresholds for Selecting Days for the RRF Calculation
    - This analysis is not complete. It is expected that the RRFs calculated with days greater than or equal to 80 ppb will yield increases in reduction of ozone concentration in the 2010 Base and Control Case.

# EPA's Preferred DVF Methodology

2010 Base Case Design Values for Each Monitoring Site for  
Modeled Days greater than 0.075 ppm

Site Name	Current (2004-08*) Base Case Design Value (ppm)	Relative Response Factors	Calculated 2010 Base Case Design Value (ppm)	Truncated 2010 Base Case Design Value (ppm)
Welby	0.0707	1.0042	0.0710	0.071
Arvada	0.0777	1.0026	0.0779	0.077
NREL	0.0808	1.0039	0.0811	0.081
Rocky Flats North	0.0840	0.9994	0.0839	<b>0.083</b>
S. Boulder Creek	0.0791	0.9976	0.0789	0.078
Fort Collins	0.0728	0.9878	0.0719	0.071
Fort Collins West**	0.083	0.9874	0.0820	<b>0.082</b>
Carriage	0.0728	1.0022	0.0730	0.073
Welch	0.0740	1.0004	0.0740	0.074
CAMP	0.0560	1.0017	0.0561	0.056
Weld County Tower	0.0769	0.9964	0.0766	0.076
Highland	0.0760	0.9916	0.0754	0.075
Chatfield Res.	0.0829	0.9934	0.0824	<b>0.082</b>
Rocky Mtn. N.P.	0.0759	0.9903	0.0752	0.075

\* thru August 31, 2008, 2008 data is not Quality Assured at this time;

\*\* FCW only has three years of data and is presented as a true Design Value to three places

## 6. Efficacy of SIP, State-only and Voluntary control measures

- Emissions reductions from 2006 base case thru 2010 base and control case reduce VOC and NO<sub>x</sub> emissions 11% and demonstrate through photochemical grid modeling attainment of the standard with the 2010 base case and additional ozone reduction with the proposed 2010 control case.
- Proposed State-only controls will reduce 50-60 tpd of VOC and 20-21 tpd of NO<sub>x</sub> and demonstrate through modeling additional reduction in ozone concentration.

# Efficacy of SIP, State-only and Voluntary control measures (cont.)

- Voluntary measures not accounted for in the emissions inventories include:
  - Ozone Alert Program
  - RAQC “Let’s Take Care of Our Summer Air”
  - Lawn mower exchange in DMA/NFR
  - Faulty Gas Cap replacement (employer and fleet)
  - Stop at the Click program with gasoline retailers
  - Salvage of high emitting gas vehicles
  - Pollution Prevention programs by local business and industry

# Efficacy of SIP, State-only and Voluntary control measures (cont.)

- Employer based travel reduction programs implemented by DRCOG, TMO, RTD, local governments and local business
- RAQC diesel retrofit program with local school districts, governmental and private fleets
- Car Care Fairs
- Greenprint Denver promoting energy efficiency, sustainable development, increased use of alternative fuels, and low emissions vehicles, recycling, and increased tree planting
- Household chemical recycling events sponsored by local governments and health departments in DMA/NFR

# Weight of Evidence - Conclusions

- The final WOE will combine and weigh the various supplemental analyses with the results of the attainment test resulting in an aggregated, qualitative and quantitative conclusion as to whether the proposed set of control strategies will result in the Denver Front Range reaching attainment by 2010.
- *The full WOE analysis anticipated is currently incomplete though a large portion of the basic WOE analyses has been presented. The WOE analysis will continue to be refined through the AQCC Public Hearing process.*

# Is Attainment Likely by 2010?

- Weather-corrected and non-weather-corrected 4<sup>th</sup> maximum time series suggest that ozone levels are flat at key monitors.
- A review of other metrics supports the conclusion that the area will attain the 0.08 ppm ozone standard by 2010.
- The overall reduction in emissions expected between 2006 and 2010 provides further evidence for attainment.
- At this time, the photochemical modeling is considered to be the best predictor of future ozone levels.
- The overall weight of evidence suggests that the area will attain the standard in 2010, but there will not be much of a cushion.