Memo

August 9, 2008

To: Cynthia Peterson
Andy Spielman
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Ken Lloyd
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From: Doug Lawson

Re: Technical Comments on August 5, 2008 Draft of Denver Metro Area & North Front Range Ozone Action Plan and 8-Hour Ozone Attainment Plan

I have quickly read through the documents referenced above, and will make the following points in this memo:

1) Front Range ozone trends have slightly increased over the past several years, despite numerous regulatory attempts to reduce ozone precursors.
2) The emission inventory used to perform air quality simulation modeling greatly underestimates on-road mobile source VOC emissions; hence, modeling results and source apportionments for ozone formation are incorrect. Other serious questions remain regarding the accuracy and credibility of the inventories used by the contractors.
3) Using Weight Of Evidence Analysis, we have learned that control measures to reduce NOx emissions will not reduce ground-level ozone readings at the monitors along the Front Range, and will likely increase ambient ozone. Particulate nitrate levels will not decrease to any measurable extent as a result of NOx control measures proposed in the Ozone Action Plan or the 8-Hour Ozone Attainment Plan.
4) Ambient air quality data and program evaluations from other states can be used to evaluate proposed ozone reduction strategies:
    a. Ozone trend data from the South Coast (Los Angeles) Air Basin
    b. NOx emission inventories and ozone trends from Dallas/Ft. Worth and East Texas
5) Reformulating gasoline composition will not produce observable reductions in ambient ozone levels.

Because the above points are strongly supported in reports from the National Academy of Sciences and numerous publications in the scientific literature over the past 20 years, we have sufficient additional information to design an ozone reduction program that is both “effective and cost-efficient” (page ii of Ozone Action Plan).

1) **Front Range ozone trends have slightly increased over the past several years, despite numerous regulatory attempts to reduce ozone precursors.** The figure on the following page displays data shown in Table 2 of the 8-Hour Ozone Attainment Plan (page II-4).

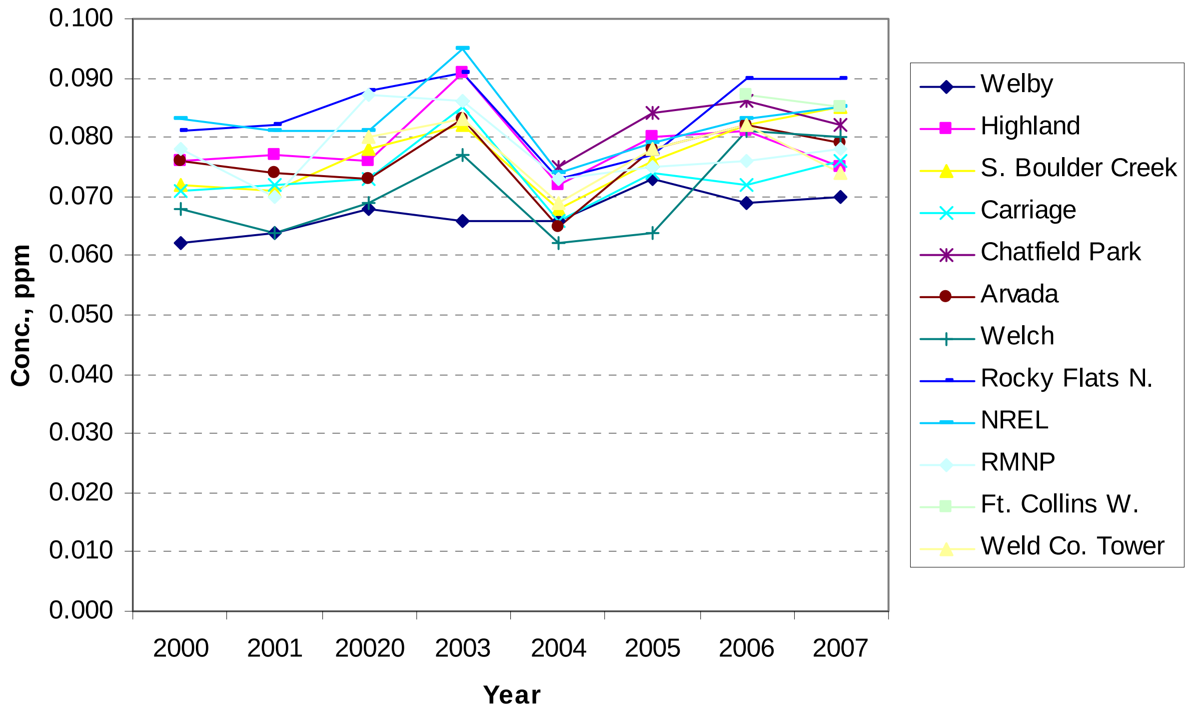

Figure 1. 4th maximum 8-hour ozone values along the Front Range, 2000-2007 (source: Table 2 of the 8-Hour Ozone Attainment Plan (page II-4).

Despite at least $0.5 billion spent by Colorado's citizens on ozone precursor reduction programs since 1995, the 4th maximum 8-hour ozone levels have not dropped, and in fact, appear to have increased since at least 2000. The most important question to ask is "Why haven't ozone levels dropped over the past several years, given all the mobile source and stationary source regulations that have been recommended by the APCD and the RAQC?"

2) The emission inventory used to perform air quality simulation modeling greatly underestimates on-road mobile source VOC emissions; hence, modeling results and source apportionments for ozone formation are incorrect.

While I was a member of the AQCC, I asked the contractors who are performing the air quality simulation modeling as part of the Front Range SIP to perform two tasks: (1) compare ambient and modeled ambient ozone precursor concentrations; and to (2) compare ambient and modeled VOC speciation data. Completion of each of these tasks would lend credibility to the overall modeling effort and modeled ozone results. ENVIRON/Alpine Geophysics performed the first task, but I don't know whether they performed the second one. Figure 2 is taken from Chapter 4 of the draft final report dated May 13, 2008 to the RAQC. It depicts the comparisons between ambient concentrations of VOC and NOx at the CAMP monitoring site for the 6 a.m. to 9 a.m. time period on all of the modeling days in 2006. Excluding the anomalous data on June 16, the average ratio of observed VOC to modeled VOC at CAMP over the 15 days is 3. For NOx, the ratio is 1.25.

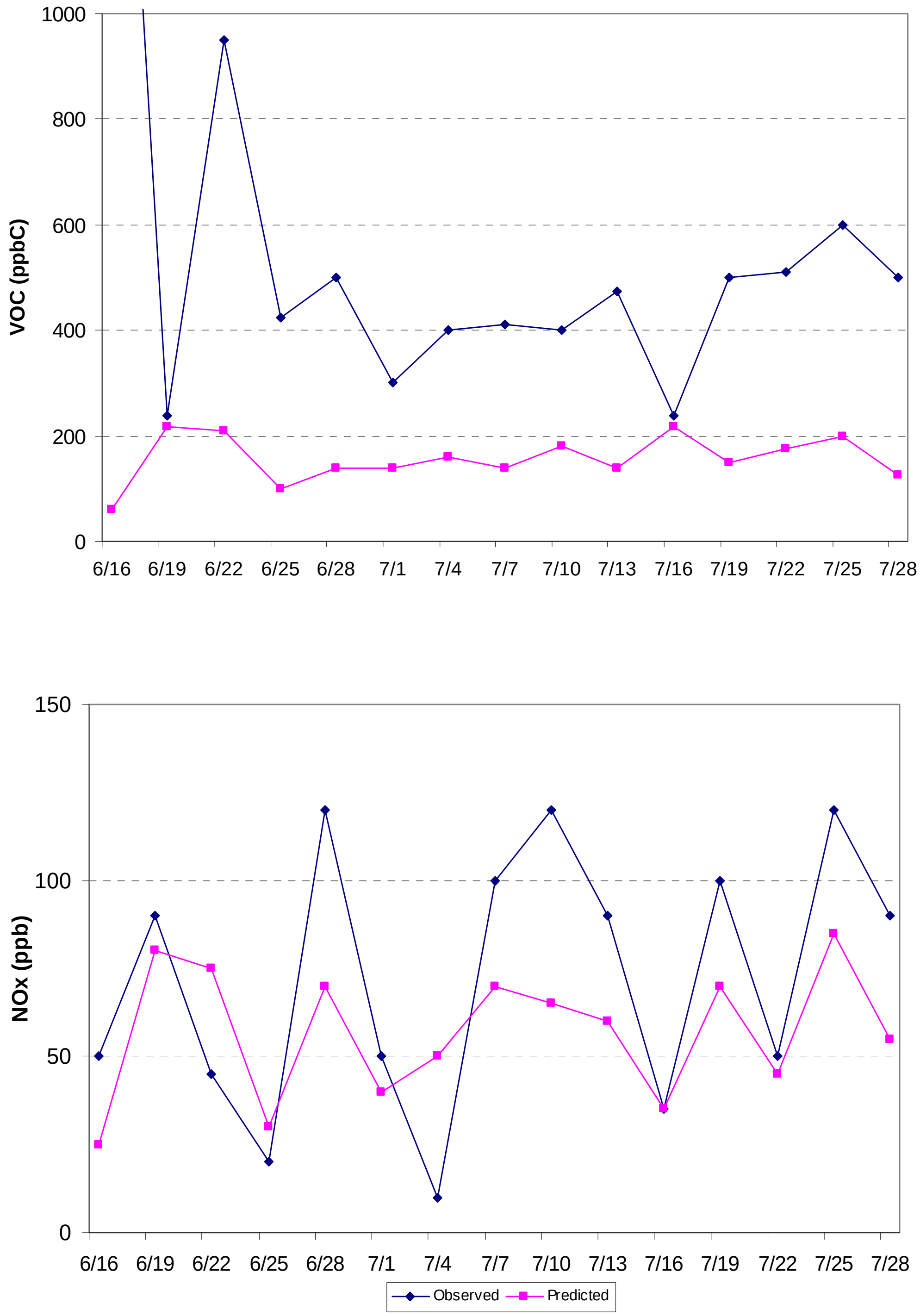

Figure 2. Comparison of predicted and observed 6-9am MDT VOC and NOx concentrations at the CAMP monitoring site during June-July 2006 for the preliminary CAMx Run1.1204 base case (Page 4-60).

Because the ambient and modeled NOx concentrations agree relatively well (within 25%), this means that the NOx inventory is predicting emissions well and/or that the meteorology at the CAMP site is modeled well during the 6 a.m – 9 a.m. time frame. This relative agreement between the ambient data and the inventory for NOx, however, poses a serious problem for VOC emissions. There is a factor of 3 difference between the ambient and modeled data. At this time period, the pollutant concentrations measured at the CAMP site are dominated entirely by fresh, on-road mobile emissions. From this Weight-Of-Evidence Analysis, we conclude that on-road VOC emissions are underestimated by the emissions inventory by a factor of 3. This large discrepancy is attributed to the EPA mobile emissions model MOBILE6.2. For more than 20 years, it has been demonstrated in a number of independent studies that the mobile emissions models have consistently underestimated on-road VOC emissions.

The current on-road VOC estimate along the Front Range is 135 tons/day; a better estimate for on-road emissions is at least 400 tons/day. Note that this difference is much larger than all the proposed VOC emission reduction regulations proposed for the 2008 Ozone Action Plan and the listed potential near-term strategies.

Because the current ozone model performance is "within EPA's accepted margin of accuracy" (page I-2 of 8-Hour Ozone Attainment Plan) for ozone model performance, this large underestimation of very reactive VOC emissions from the on-road fleet means that the model is getting the "right" answer for the wrong reason(s).

Other portions of the VOC inventory (page V-5) are highly questionable. For example, the lawn and garden equipment category contributes about 9% of the entire anthropogenic VOC inventory (or 32% of the total amount attributed to on-road VOC emissions!), this portion of the inventory is also in question. In our very detailed emission inventory work we recently performed in the Los Angeles Air Basin, where homeowners and commercial lawn and garden operations were surveyed extensively, we estimated that lawn and garden equipment produce only 1-2% of the total VOC emission in the Basin. These are very large differences and should be evaluated for their reliability/credibility.

Because the on-road mobile source VOC is so seriously underestimated, any effort to perform source apportionment for ozone will significantly underestimate the influence of mobile emissions on ambient ozone.

Bad inventories lead to bad policy.

Recommendation: Additional modeling runs: Increase on-road VOC in the entire modeling domain by a factor of 3, evaluate model performance and tune it as necessary to meet EPA criteria. Next, reduce on-road mobile VOC to the current estimate (135 tons/day) to evaluate how the model will respond to this large VOC emissions reduction. This control scenario would evaluate how well an in-use mobile emissions reduction program would reduce ambient ozone levels, provided that it can be demonstrated that the model is indeed accurate.

3) Using Weight Of Evidence Analysis, control measures to reduce NOx emissions will not reduce ground-level ozone readings at the monitors along the Front Range, and will likely increase ambient ozone.

We evaluated day-of-week differences in mean concentrations of ozone precursors [nitric oxide (NO), nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOC)] at monitoring sites in Colorado and other sites in 22 additional states from 1998-2003. We used Wednesdays to represent weekdays and Sundays to represent weekends; we also analyzed Saturdays. At a large majority of sites, NO, NO_x, and CO mean concentrations decreased at all individual hours from 6 a.m. through 3 p.m. on Sundays compared with corresponding Wednesday means. Nine-hour (6 a.m. through 3 p.m.) mean concentrations of NO, NO_x, CO, and VOC declined by 65, 49, 28, and 19 percent, respectively, from Wednesdays to Sundays (median site responses). Despite the large reductions in ambient NO_x and moderate reductions in ambient CO and VOC concentrations on weekends, ozone and PM nitrate did not exhibit large changes from weekdays to weekends. Weekend reductions of urban NO_x emissions generate little change in peak ozone and mean PM nitrate concentrations at most urban U.S. locations, including Colorado. The findings from this study suggest that timely attainment of ozone standards will require greater emphasis on reducing VOC emissions in major metropolitan areas. The results for Colorado, which will be published in the September or October 2008 issue of the *Journal of the Air & Waste Management Association*, are shown in the table below.

	Average Wednesday to Sunday Percent Change (relative to Wednesday), all days, 1998-2003 Colorado Monitoring Sites	
Species	6 a.m.	Noon
CO*	**-61**	**-17**
NO	**-74**	**-40**
Ozone	**+6 (peak 8-hr average value)**	

*CO is a surrogate for exhaust VOC emissions from on-road mobile sources.

The ambient data from the state’s monitoring sites show that NOx emission reductions of 50% or so on Sundays relative to Wednesdays, with a smaller decrease of VOCs (~15%) produce an increase in peak 8-hour ozone averages of 6% on all days for which sufficient data were available over a 6-year period. During this same period, weekend PM nitrate levels, which contribute to regional haze, were ~5% higher on weekends than on weekdays in Colorado, despite the very large NOx emission reductions on weekends.

Fortunately, we have extensive and reliable ambient air quality monitoring data that can be used to evaluate how large and reproducible ozone precursor emission reductions influence ambient ozone levels. In such analyses, we do not have to rely upon emission inventories or any modeling results.

Recommendation: Any air quality simulation modeling for SIP planning for the Front Range should be able to simulate the response of ambient ozone to weekend changes in ozone precursor emissions. Weekday/weekend modeling should be performed in the Denver area, to evaluate whether the "weekend ozone effect" can be accurately simulated by the model. Note: A few months ago, I spoke with the modeling supervisors at the California Air Resources Board and the South Coast Air Quality Management District, and they said they are unable to make their models reproduce the weekend ozone effect. This means much additional effort is needed before we will have confidence in the photochemical air quality simulation models to accurately and reliably simulate ambient ozone levels.

4) Ambient air quality data and program evaluations from other states can be used to evaluate proposed ozone reduction strategies.

Extensive monitoring data from California can be used to evaluate the effect of reformulated fuels on ozone air quality. For example, Figure 3 below displays the trends in ambient ozone levels in the South Coast Air Basin over the past 35 years.

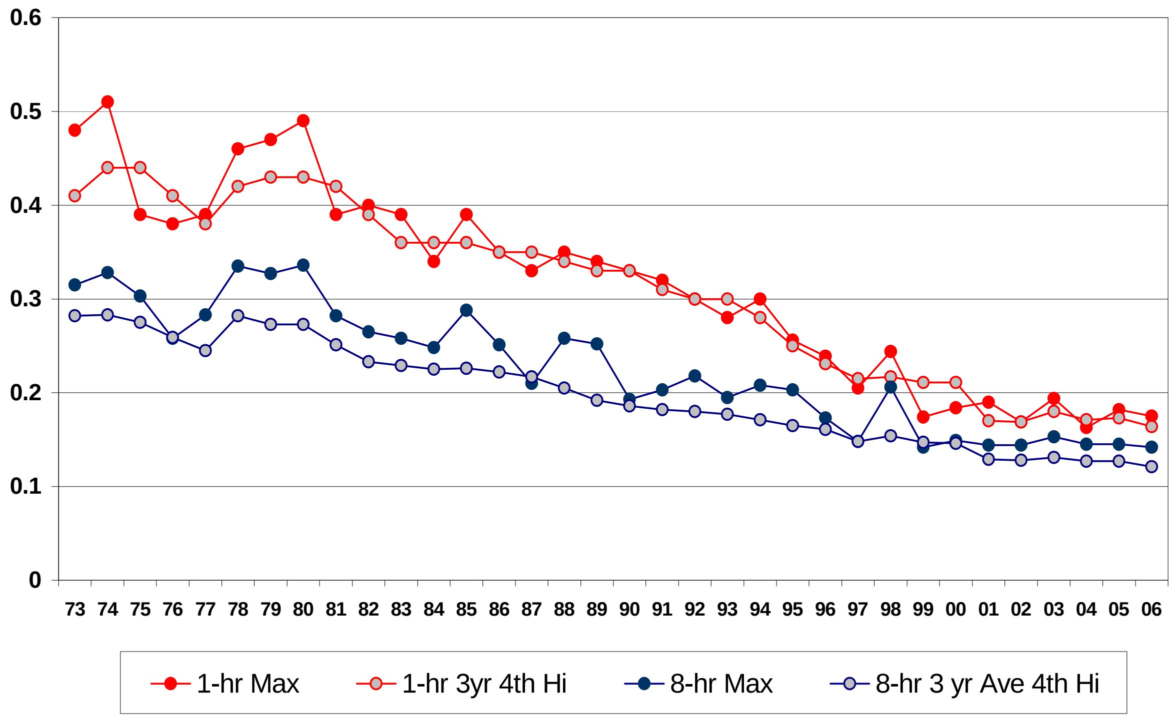

Figure 3. Ambient ozone trends in the South Coast Air Basin, 1973-2006.

State regulations in California mandated the use of California's Phase 2 gasoline by March 1, 1996 (shown as red arrow in graph). At its web site, the California Air Resources Board states that "Cleaner-burning gasoline reduces smog-forming emissions from motor vehicles by 15 percent" (http://www.arb.ca.gov/fuels/gasoline/cbgupdat.htm). However, close examination of the ambient ozone trends in the Los Angeles area show no observable reduction of ambient ozone levels during the 1996 ozone season, which should have been observable given the large predicted 15% reduction of ozone precursors, either as a step change or a greater reduction in ambient ozone levels during the 1996 and later ozone seasons. Note also that ozone levels quit dropping around 2001, when two large NOx control programs – RECLAIM and the Carl Moyer Program – began claiming credits for NOx reductions throughout the Los Angeles Basin.

Relationships between NOx emission inventories and ambient ozone levels are also available from the state of Texas. The following two figures present NOx emission inventory trends, as published by the Texas Commission on Environmental Quality SIP, for Dallas/Ft. Worth and the 110-county region of East Texas. These figures (3-15 and 3-17, taken from the SIP) show very large NOx emission reductions starting in the 1999-2000 time period and going through 2003.

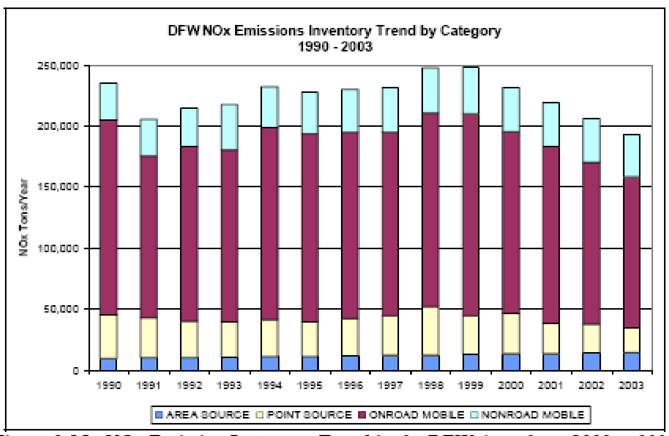

Figure 3-15: NOx Emission Inventory Trend in the DFW Area from 1990 to 2003

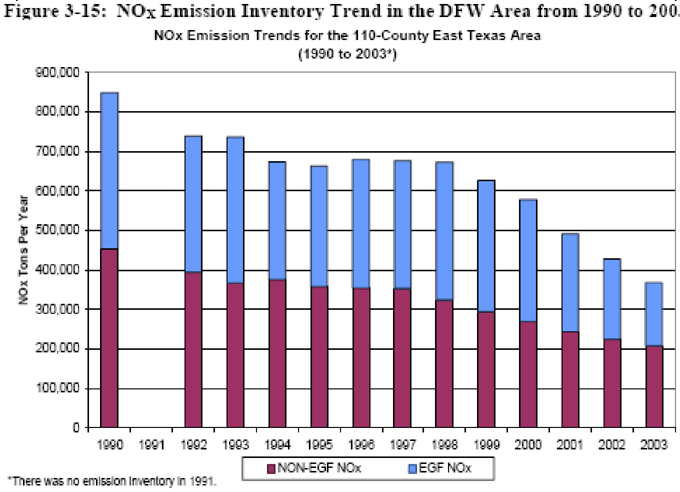

Figure 3-17: NOx Emission Inventory Trends for the 110-County East Texas Area from 1990 to 2003

However, when we examine the ambient ozone trends in the Dallas/Ft. Worth area during that same time (located between the two vertical red bars in Figure 3-1 below), we observe no changes in the 1-hr and 8-hr ozone design values between 1999 and 2003, showing that ~50% NOx emission reductions, as reported by the state of Texas, produced no measureable changes in measured ozone levels.

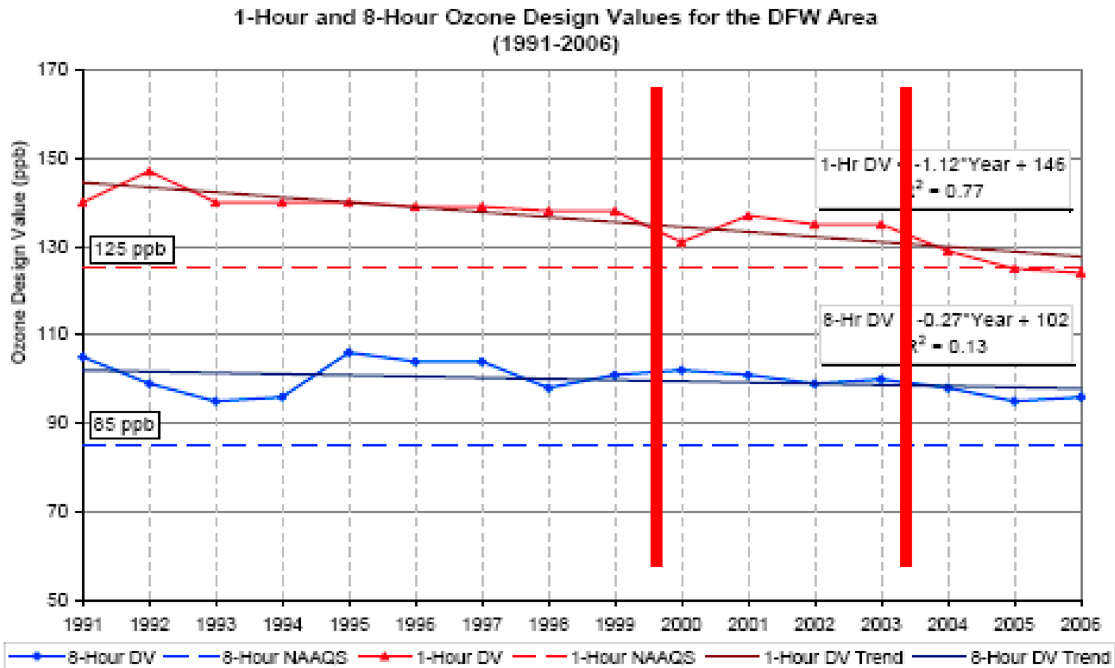

Figure 3-1: One-Hour and Eight-Hour Ozone Design Values in the DFW Area (1991-2006)

Fortunately, we have ambient ozone trend and emission inventory data from other locations that we can use here to help guide the RAQC and the Air Pollution Control Division in formulating "effective and cost-efficient" ozone reduction strategies.

5) Reformulating gasoline and composition of gasoline will not produce observable reductions in ambient ozone levels.

This point has been clearly demonstrated by ambient ozone trends in the South Coast Air Basin (figure 3 above). As we and others have stated in many public meetings, it's not the fuel that's the problem, it's the high-emitting car that's the real challenge in our meeting the ambient air quality standards. The automakers have been building clean cars since 1983, when they began using closed loop technology and fuel injection in new vehicles. Vehicles built since that time have been irrelevant to air quality, because they have been so clean relative to the number and absolute emissions rates from the high emitters. Simply adopting the California LEV standards will do very little, if anything, to reduce ambient ozone levels along the Front Range.

However, it has been demonstrated in industry/government studies that low- to mid-level blends of ethanol in gasoline have increased non-tailpipe (or permeation) VOC emissions, so this is now a new source of VOC emissions that previously were not present with the use of MTBE in gasoline. This issue of increased nontailpipe VOC emissions from low- to mid-level ethanol blends in gasoline has been well documented and is not an area of controversy. The challenge is how the regulatory agencies are addressing this new source of previously undocumented VOC emissions. Reducing the Reid Vapor Pressure in gasoline offers little air quality benefit, because refiners simply reduce or remove the lower molecular weight hydrocarbons in the fuel to reduce volatility. However, those compounds are not photochemically reactive, and they are replaced in the fuel by more photochemically reactive compounds, which aid in producing higher ambient ozone levels. This is an unintended consequence related to lowering RVP in gasoline. We have also presented these data to the RAQC and the Division on several occasions.

Fortunately, the solution to the Front Range ozone problem lies in a simple solution – quickly identifying, repairing and/or scrapping the high emitting vehicles. If they are repairable, then there needs to be an effective follow-up program to ensure that their emissions remain low.

Summary: The data and analyses contained in the five topic areas in this memo are well documented, all supported with a growing body of evidence in the scientific literature, beginning with real-world emissions studies and ambient data and inventory comparisons beginning 20 years ago. In a 1991 National Academy of Sciences Report titled “Rethinking the Ozone Problem in Urban and Regional Air Pollution,” the committee responsible for the report wrote: “The State Implementation Plan (SIP) process, outlined in the Clean Air Act for developing and implementing ozone reduction strategies, is fundamentally sound in principle but is seriously flawed in practice because of the lack of adequate verification programs.” The committee recommended “Reliable methods for monitoring progress in reducing emissions of VOCs and NOx must be established to verify directly regulatory compliance and the effectiveness associated with mandated emission controls” (Executive Summary, page 5). Unfortunately, EPA has not adopted the recommendations and finding of that report, and serious barriers remain for our effectively reducing ambient ozone (and other pollutant) levels to protect human health.

Colorado, however, can lead the way.