Denver Metropolitan Area and North Front Range 8-Hour Ozone State Implementation Plan

Weight of Evidence to Support the Modeled Attainment Demonstration

Executive Summary

DRAFT FINAL
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Preface

This Weight-of-Evidence report was completed in October 2008 prior to the Colorado Air Quality Control Commission's (AQCC) December 12, 2008 approval of the Ozone Action Plan, including revisions to the State Implementation Plan. After the hearing and as directed by the AQCC, the photochemical modeling was revised in the late December 2008 to early January 2009 timeframe to incorporate the final SIP control measures approved by the AQCC, which are based on a slight modification of the original Ozone Action Plan's Alternative Proposal #2.

The emission control scenarios (2010 base case, 2010 control 1, and 2010 control 2) referenced in this Weight-of Evidence document are summarized in Table ES-2 in the following September 2008 report:

> Morris R., T. Sakulyanontvittaya, E. Tai, D. McNally and C. Loomis. 2008. *2010 Ozone Attainment Demonstration Modeling for the Denver 8-Hour Ozone State Implementation Plan Control Strategy*. ENVIRON International Corporation, Novato, California. Prepared for Denver Regional Air Quality Council (RAQC), Denver, Colorado. September 22, 2008. (http://www.colorado.gov/airquality/documents/deno308/Denver_2010ControlStrat_Draft_Sep22_2008.pdf)

The final SIP control measures (referred to as the "Final 2010 Control Strategy") are summarized in the following January 2009 report:

> Morris R., E. Tai, T. Sakulyanontvittaya, D. McNally and C. Loomis. 2009. *Final 2010 Ozone Attainment Demonstration Modeling for the Denver 8-Hour Ozone State Implementation Plan*. ENVIRON International Corporation, Novato, California. Prepared for Denver Regional Air Quality Council (RAQC), Denver, Colorado. January 12, 2009. (http://www.colorado.gov/airquality/documents/deno308/2010_Denver_Final_Control_Jan12_2009.pdf)

Section 3.2 ('Alternative 2010 Ozone Projection Procedures') of the January 2009 report (Morris, et al, 2009) supplements section 4.3 ('Alternative 2010 Ozone Projections') of this Weight-of-Evidence document by including metrics for the "Final 2010 Control Strategy." Similarly, section 3.3 ('Additional Modeling Metrics') of the January 2009 report (Morris, et al, 2009) supplements section 4.1 ('Additional Modeling Metrics') of this Weight-of-Evidence document.

The final ozone modeling and analysis (Morris, et al, 2009) do not contain any results that alter the conclusions in this Weight-of-Evidence Report.

Executive Summary

The United States Environmental Protection Agency's (EPA) 8-hour ozone modeling guidance (EPA, 2007) recommends a weight of evidence analysis (WOE) (a set of supplemental analyses) to support the attainment determination if the maximum-modeled 8-hour ozone design value is between 0.082 ppm and 0.087 ppm at more than one monitor. Although all monitoring locations in the Denver/North Front Range SIP attainment demonstration indicate modeled attainment of the 8-hour ozone standard, four monitors (Rocky Flats North, Fort Collins West, Chatfield and National Renewable Energy Laboratory) have modeled concentrations that fall into the 0.082-0.087 ppm range. Therefore, a set of supplemental analyses are required to determine if these monitors are expected to demonstrate compliance with the ozone standard.

Overview of Supplemental Analysis and Weight of Evidence

Supplemental analyses used in a weight of evidence will help determine whether attainment is likely where modeled attainment test results indicate future air quality levels are near the National Ambient Air Quality Standards (NAAQS). A weight of evidence determination includes the modeled attainment and screening test results, plus results of additional model outputs plus other analyses of air quality, meteorological and emissions data. A weight of evidence analysis may be used either to increase or decrease emission reductions identified as sufficient to meet the NAAQS by a modeled attainment test.

The final WOE combines and weighs 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 Metro Area/North Front Range reaching attainment in 2010.

The supplemental analyses used in the weight of evidence for the Denver Ozone SIP include:

- Monitoring and emission inventory trend analysis
- Review of the conceptual model for ozone formation along the northern Front Range
- Additional modeling metrics
- Alternative attainment test methods
- Assessment of the efficacy of SIP, state-only, and voluntary control measures

Monitoring and Emission Inventory Trend Analysis

Trend analyses for ambient measurement of ozone and emission inventory trends are presented as one of the supplemental analysis for this weight of evidence. The trends analyses indicate several important points:

- The aggregate trend in weather-corrected 4th maximum time series suggests that ozone levels have been flat from 2004 through 2008, although individual concentrations have been highly variable. This suggests that without additional emission reductions the region will remain at or near the level of the standard.
- Trends in emissions correlate well with surrogate indicators such as fleet turnover.
- If the emissions trends are correct, then the Relative Response Factors (RRFs) are likely to be directionally correct.
- Meteorological variability is a key component for ozone formation and is reflected in the year-to-year variability of peak ozone levels. A key metric for upper level high pressure strength has remained steady or trended downward in recent years, suggesting a reasonable likelihood for moderate high pressure strength in the next few years, which would favor attainment.
- Analysis of the weekend-weekday effect for the Front Range shows a strong effect in Central Denver and weaker effects in outlying areas. This points to the possibility for NOx control disbenefits in central Denver due to the role of NOx

quenching here. The spatial pattern of the weekend effect is consistent with the localized NOx disbenefit identified in the photochemical modeling.

- Reductions in VOC emissions are expected to reduce ozone.
- Reductions in NOx emissions are expected to reduce ozone, possibly with greater efficiency than VOC reductions, at troublesome monitors outside of the urban core of metro Denver. Increases in ozone concentrations in the urban core of metro Denver due to NOx emissions reductions do not appear to be significant.

Conceptual Model

A review of the conceptual model for the Front-Range reveals the complexity of the meteorological, emission inventory, and photochemical modeling challenges that exist in the formation and subsequent control of ozone formation along the northern Front Range. Several diagnostic tests with subsequent changes to the science options and other input were made to the meteorological model to achieve the best performing meteorological model for the Front Range. Trajectory analyses indicate that the base case modeling of the June-July 2006 timeframe encompasses various local meteorological regimes under which elevated ozone levels have and are expected to occur. This assures that the modeled ozone impacts from various 2010 emissions scenarios have been examined under a range of meteorological regimes that are favorable for ozone formation.

Additional Modeling Metrics

Additional modeling metrics, such as the reduction in Total Ozone[1], the number of grid-cells with elevated ozone (Grid Cells[2]), and the number of hours of elevated ozone (Grid

[1] "Total Ozone" is defined as the difference between the modeled daily maximum 8-hour ozone concentrations and the threshold concentration, for modeled values above the threshold, summed across all grid cells in the Denver NAA and modeling days during June-July 2006.
[2] "Grid Cells" is the number of grid cell-days with modeled daily maximum 8-hour ozone concentrations greater than a given threshold (e.g., 85 ppb) for all grid cells in the NAA and days from the June-July 2006 episode.

Cell-Hours[3]), are used to demonstrate that the existing controls along with potential SIP and state-only emissions controls are effective in reducing ozone along the Front Range. Additional modeling metrics indicate that:

- The emission reductions between 2006 and 2010 are effective at reducing elevated 8-hour ozone concentrations.
- The changes in Total Ozone and Grid Cells greater than 85 ppb" modeling metrics between the 2006 and 2010 base cases are -21% and -14%, respectively. This suggests that changes in emissions between 2006 and 2010 base case emission scenarios reduce ozone levels.
- The changes in Total Ozone and Grid Cells are greater for the 2010 Control 1 case (-28% and -17%, respectively) and for the 2010 Control 2 case.
- Other modeled metrics indicate that there are reductions in Total Ozone, Grid Cells, and Grid Cell-Hours of 15% to 30% for thresholds of 85 ppb and 80 ppb from the 2006 base case through the 2010 base case, the 2010 Control 1 case, and the 2010 Control 2 case.

[3] "Grid Cell-Hours" is the number of grid cell-hours with modeled running 8-hour ozone concentrations greater than the threshold for all grid cells in the NAA and hours during the June-July 2006 episode.

Alternative Attainment Test Methods

EPA's modeling guidance for ozone offers several potential approaches for establishing base year design values. The guidance recommends the preferred methodology for establishing a base year design value as follows:

> "For the modeled attainment tests we recommend using the average of the three design value periods which include the baseline inventory year. Based on the attributes listed above (in the guidance), the average of the three design value periods best represents the baseline concentrations, while taking into account the variability of the meteorology and emissions (over a five year period)."

At the start of the work on the SIP in 2007 and throughout development of the proposed plan, the modeling analysis has used the 2005-2007 three-year design value as representative of the ozone situation facing the region at the time. In the SIP, modeled attainment of the 8-hour ozone standard was demonstrated at all of the monitored locations by 2010 as a result of the reductions in ozone precursors expected from existing programs and regulations. The use of the three-year design value from 2005-2007 is a conservative approach with higher base year and future year design values when compared to using the EPA preferred method.

Since the start of the Denver ozone SIP project, additional data from the 2008 ozone season (though currently not formally quality assured by the State or EPA) has become available. The additional data from 2008 provides the necessary data to estimate the average of the three Design Values in the 2004-2008 time period as prescribed in the the EPA recommended method. The importance of using 2008 monitoring data in the design value estimation is that year 2008 is the first year of the 2008-2010 ambient monitoring period used to demonstrate monitored attainment of the ozone standard.

Using the EPA preferred method of calculating the modeled base year design value using years 2004-2008, the current attainment tests show that the Denver region will attain the ozone standard by 2010. Table ES-1 presents the results of using EPA's

recommended methodology for estimating the base year design value with projected 2010-modeled concentrations.

Table ES-1: 2010 Control Case Design Values Utilizing EPA's Recommended DVB Calculation Methodology

Site Name	Current (2004-08*) Base Case Design Value (ppm)	Modeled Control Case Relative Reduction Factors	Calculated 2010 Control Case Design Value (ppm)	Truncated 2010 Control Case Design Value (ppm)
Welby	0.0707	1.0039	0.0709	0.071
Arvada	0.0777	1.0022	0.0779	0.077
NREL	0.0808	1.0027	0.0810	0.081
Rocky Flats North	0.0840	0.9981	0.0838	**0.083**
S. Boulder Creek	0.0791	0.9963	0.0788	0.078
Fort Collins	0.0728	0.9853	0.0717	0.071
Fort Collins West**	0.083	0.9852	0.0818	0.081
Carriage	0.0728	1.0015	0.0729	0.072
Welch	0.0740	1.0002	0.0740	0.074
CAMP	0.0560	1.0009	0.0560	0.056
Weld County Tower	0.0769	0.9925	0.0763	0.076
Highland	0.0760	0.9900	0.0752	0.075
Chatfield Res.	0.0829	0.9921	0.0822	**0.082**
Rocky Mtn. N.P.	0.0759	0.9892	0.0751	0.075

* Thru August 31, 2008. 2008 data have not been fully quality assured at this time;

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

Alternative 2010 Ozone Projections

Several alternative 2010 ozone projection procedures for the 2010 base case, Control 1 and Control 2 scenarios have been examined to estimate the uncertainties in the projection procedures and provide confidence that passing the modeled attainment demonstration indicates that attainment will likely be achieved in 2010 under the 2010 base case, Control 1 or Control 2 emission scenarios. Six additional ozone projection procedures were analyzed, in addition to the EPA guidance default procedure.

The six additional tests provide a range of future design values for the 2010 base case that is a more robust test than just using the EPA guidance default. In addition, the supplemental attainment tests provide a range of concentrations by which the likelihood of reaching attainment can be assessed. As presented in the technical support documentation, some of the six alternative projection approaches result in ozone concentration increases, whereas others in decreases in the projected 2010 design values (DVFs) at the two key sites, Rocky Flats North (RFNO) and Fort Collins West (FTCW), relative to the default EPA guidance approach. The future 2010 base year design value for the RFNO and the FTCW monitors using the alternative projection approach range from 84.6 ppb to 85.2 ppb with an average of 84.9 ppb. Using the default EPA guidance approach to show modeled attainment of the ozone standard also yielded a 2010 base year design value for RFNO and FTCW of 84.9 ppb, which is comparable to the six alternative projection methods.

When the proposed SIP control strategies are applied, the six alternative projection methods indicate that, at the RFNO monitoring site, the projected DVFs for the 2010 Control 1 scenario range from 84.3 to 85.1 ppb with an average of 84.8 ppb. At the FTCW monitoring site the projected DVFs range from 84.4 to 85.0 ppb with an average of 84.7 ppb. This indicates the SIP control strategies will provide a slightly better ‘cushion’ than reliance on only those strategies that are currently on the books.

The 2010 projected DVFs at RFNO using the 2010 Control 2 case are similar to the 2010 Control 1 case ranging from 84.3 to 85.1 ppb, with an average of 84.8 ppb. More benefits are seen at FTCW where the 2010 projected DVFs range from 84.3 to 84.8 ppb with an average of 84.5 ppb.

Assessment of the Efficacy of SIP, State-only, and Voluntary Control Measures

Along with the control measures contained in this SIP and proposed State-only measures contained in the Control 2 scenario, there have been and will continue to be a myriad of voluntary measures in the DMA/NFR that are not directly accounted for in the current and projected emissions inventories.

Conclusion

In conclusion, the collective supplemental analyses contained in this weight of evidence document support the current photochemical model attainment demonstration for the 0.08 ppm 8-hour ozone NAAQS using the EPA default approaches for the 2010 base case, 2010 Control 1, and the 2010 Control 2 scenarios. In addition, at this time, the photochemical modeling is considered to be the best predictor of future ozone levels. The collective supplemental analyses in this weight of evidence analysis support the findings using the EPA methods, as specified in the EPA modeling guidance, that the 2010 base case will likely achieve attainment of the 0.08 ppm 8-hour ozone NAAQS in the Denver Metro Area and North Front Range. As demonstrated using alternative attainment test methodologies, the same WOE indicators demonstrate that there will be more certainty that the Denver region will achieve 8-hour ozone attainment in 2010 under the 2010 Control 1, and Control 2 emissions scenario. The preponderance of evidence suggests that the region will attain the standard in 2010 under the base case, Control 1, and Control 2 scenarios, but the safety margin is small.