Draft Final Report

2010 OZONE ATTAINMENT DEMONSTRATION MODELING FOR THE DENVER 8-HOUR OZONE STATE IMPLEMENTATION PLAN CONTROL STRATEGY

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September 22, 2008

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EXECUTIVE SUMMARY

Based on 2005-2007 air quality monitoring data the Denver Metropolitan Area (DMA) violated the 0.08 parts per million (ppm) 8-hour ozone National Ambient Air Quality Standard (NAAQS). Thus, in November 2007 the DMA reverted to an 8-hour ozone nonattainment area. This requires the DMA to develop an 8-hour ozone State Implementation Plan (SIP) that demonstrates the area will achieve the 1997 8-hour ozone NAAQS (0.08 ppm) by 2010. The Denver Regional Air Quality Council (RAQC), in consultation with the Colorado Department of Health and Environment (CDPHE) Air Pollution Control Division (APCD), contracted with ENVIRON International Corporation, and their subcontractor Alpine Geophysics, LLC, to develop the photochemical modeling databases necessary to demonstrate that the DMA will achieve the 0.08 ppm 8-hour ozone NAAQS by 2010.

OVERVIEW OF APPROACH

The Comprehensive Air-quality Model with extensions (CAMx; www.camx.com) was set up for a June-July 2006 episode on a 36/12/4 km grid with the 4 km domain focused on Colorado. Meteorological inputs were prepared using the MM5 meteorological model whose results and evaluation are discussed by McNally and co-workers (2008a). An initial emissions inventory was prepared using the SMOKE emissions modeling system and a preliminary 2006 base case was performed. A preliminary model performance evaluation was conducted and diagnostic sensitivity tests performed to identify an optimal model configuration for simulating ozone formation in the DMA (Morris et al., 2008b). A revised final CAMx 2006 base case simulation was performed and a comprehensive model performance evaluation was conducted (Morris et al., 2008c). Although there were some model performance issues on some of the modeling days during the June-July 2006 episode, a vast majority of the modeling days achieved EPA's model performance goals and looking at many model performance displays and metrics we concluded that the model was simulating the observed ozone sufficiently well for use in making ozone projections. Furthermore, on most days the model reproduced the observed VOC/NOx ratios in Denver quite well suggesting that the model is simulating the same chemical regimes as observed as well.

2010 BASE CASE OZONE PROJECTIONS

The procedures given in EPA's 8-hour ozone modeling guidance were used to project current year 8-hour ozone Design Values (DVC) to obtain projected future year 2010 8-hour ozone Design Values (DVF) at each of the DMA monitoring sites (EPA, 2007). These procedures use the 2006 and 2010 base case modeling results in a relative fashion whereby modeled relative response factors (RRFs) are used to scale the current year 8-hour ozone Design Value (DVC) to obtain the projected future year 8-hour ozone Design Value (DVF):

$$DVF = DVC \times RRF$$

The 2010 ozone projections were made using EPA's Modeled Attainment Test Software (MATS) tool (http://www.epa.gov/scram001/modelingapps_mats.htm).

For the Denver 2010 ozone projections, with one exception, the DVCs were based on the 8-hour ozone Design Values from the 2005-2007 period (i.e., the three year average of the fourth highest daily maximum 8-hour ozone concentration at each monitor). The exception to this was for the Fort Collins West (FTCW) monitor that started monitoring in 2006 so a two year average of the fourth highest daily maximum 8-hour ozone concentrations was used from 2006-2007 for the FTCW DVC.

Table ES-1 summarizes the projected 8-hour ozone Design Values (DVF) at the DMA monitoring sites for the 2010 base case simulation using the CAMx 2006 and 2010 base case modeling results and EPA recommended default ozone projection procedures (EPA, 2007). The maximum projected 8-hour ozone Design Value is 84 ppb and occurs at both the Rocky Flats North (RFNO) and Fort Collins West (FCTW) monitoring sites (see column 5 in Table ES-1). As this value is 84 ppb or lower, then the 2010 base case modeling results pass the model attainment demonstration test. EPA's guidance for making 8-hour ozone projections recommends truncating the final projected DVF for comparisons with the 85 ppb NAAQS. In column 6 of Table ES-1 the DVFs are presented to the nearest tenth of a ppb before truncation, in which case we see that the projected 2010 base case DVFs at RFNO and FTCW are both 84.9 ppb. Also shown in Table ES-1 are the RRFs and the cut-off thresholds used in selecting days and number of days used in calculating the RRF. The EPA desire to use at least 10 modeling days and a cutoff threshold of 70 ppb or higher is satisfied using the Denver June-July 2006 modeling period at all monitoring sites. Modeling days are selected based on whether the 2006 base case model estimated maximum daily maximum 8-hour ozone concentration near a monitor (i.e., within 7 x 7 array of 4 km grid cells centered on the monitor) are above the cut-off threshold. In order to achieve at least 10 model days for developing the RRFs, the cut-off thresholds of 74 ppb to 78 ppb were used depending on the monitor (the key RFNO and FTCW monitors using a 78 and 76 ppb cut-off thresholds, respectively).

Table ES-1. Current-year (DVC) and projected future-year (DVF) 8-hour ozone Design Values using the CAMx 2006 and 2010 base case modeling results.

			2005-07	2010 Base Case				
Site ID	Monitor Name	County	DVC	DVF	DVF	RRF	Cutoff	#days
80013001	Welby	Adams	70.0	70	70.2	1.0042	77.0	11
80050002	Highland	Arapahoe	78.0	77	77.3	0.9916	78.0	14
80130011	S. Boulder Creek	Boulder	81.0	80	80.8	0.9976	78.0	10
80310002	Denver - CAMP	Denver	56.0	56	56.0	1.0017	78.0	10
80310014	Carriage	Denver	74.0	74	74.1	1.0022	78.0	10
80350004	Chatfield State Park	Douglas	84.0	83	83.4	0.9934	78.0	11
80410013	USAF Academy	El Paso	73.0	72	72.0	0.9873	75.0	10
80410016	Manitou Springs	El Paso	74.0	73	73.7	0.9966	74.0	10
80590002	Arvada	Jefferson	79.0	79	79.2	1.0026	78.0	10
80590005	Welch	Jefferson	75.0	75	75.0	1.0004	78.0	10
80590006	Rocky Flats North	Jefferson	85.0	84	84.9	0.9994	78.0	10
80590011	NREL	Jefferson	82.0	82	82.3	1.0039	78.0	11
80690011	Fort Collins - West	Larimer	86.0	84	84.9	0.9874	76.0	10
80691004	Fort Collins	Larimer	74.0	73	73.0	0.9878	76.0	12
81230009	Greeley - Weld Tower	Weld	78.0	77	77.7	0.9964	75.0	10
GTH161	Gunnison	Gunnison	68.0	67	67.8	0.9984	74.0	10
ROM206	Larimer	Larimer	76.0	75	75.2	0.9903	77.0	10
ROM406	Larimer	Larimer	76.0	75	75.2	0.9903	77.0	10

2010 CONTROL PLAN EMISSION SCENARIOS

2010 ozone projections were made for two 2010 emission control plans: (1) 2010 Control 1 that consists of the federally-enforceable control measures that are proposed for the Denver 8-hour ozone State Implement plan (SIP); and (2) Control 2 that includes the federally-enforceable measures of Control 1 plus additional control measures that are adopted as state-only enforceable. The 2010 ozone projections for the two control plans were made using the same procedures as for the 2010 base case. Table ES-2 summarizes the control measures for the two 2010 control plans.

Table ES-2. Summary of control measures in the 2010 Control 1 and Control 2 emission scenarios.

Strategies Under Development for 2008 Proposed Ozone Action Plan ***(All strategies apply to the entire Denver/North Front Range nonattainment area (NAA) unless otherwise noted)***			
Control 1 Recommended Measures for Federally-Enforceable State Implementation Plan (SIP)	*Potential Emission Reduction*	**Control 2** Recommend Measures Adopted and Enforced as State-only Measures	*Potential Emission Reduction*
➢ More stringent Reg. 11 I/M cutpoints (Denver area) – adopted, effective May 1, 2008	*~ 1 tpd VOC,* *~3 tpd NOx,* *~13 tpd CO*	➢ Inspection/maintenance program in North Front Range (structure to be determined)	*~ 1 tpd VOC,* *~1 tpd NOx,* *~17 tpd CO*
➢ 7.8 RVP gasoline regulatory requirement in North Front Range (consistent with Denver area)	*~ 3 tpd VOC*	➢ Mandatory high-emitter pilot program (Denver area) – began January 1, 2008	*unknown at this time*
		➢ Tighten up collector plate requirements for older vehicles (statewide)	*< 1 tpd VOC* *~ 7 tpd CO*
➢ Increase condensate tank control (95%) ▪ for all new/modified tanks >2 tpy (2009) ▪ for all existing tanks >10 tpy (2010)	*VOC* *~ 6-9 tpd* *~19-30 tpd*	➢ Increase condensate tank control (95%) ▪ for all existing tanks >5 tpy (2011) ▪ for all existing tanks >2 tpy (2012)	*VOC* *~ 30-35 tpd* *~9-12 tpd*
➢ Pneumatic valves controls - require low/no bleed valves on all new and existing valves by 2009	*~ 23 tpd VOC*	➢ Statewide Oil & Gas regulations -- Controls on existing reciprocating internal combustion engines	*unknown at this time*
➢ Expand Reg. 7 (VOC control requirements) to entire NAA	*unknown at this time*		
➢ Remove current exemptions in Reg. 3 for selected small sources required to file air pollution emission notices and obtain permits	*unknown at this time*		
➢ Require Reasonably Available Control Technology (RACT) for minor sources in NAA (Reg. 3)	*unknown at this time*		
TOTAL EMISSION REDUCTIONS — VOC NOx CO	*~52-66 tpd* *~ 3 tpd* *~13 tpd*	VOC NOx CO	*~41-49 tpd* *NA* *>24 tpd*

2010 CONTROL PLAN OZONE PROJECTIONS

Table ES-3 displays the projected 8-hour ozone DVFs for the 2010 base case and the two 2010 control plans. The maximum projected 8-hour ozone Design Values for the 2010 Base, Control 1 and Control 2 emissions scenarios are 84 ppb at the Rocky Flats North (RFNO) and Fort Collins West (FTCW) monitoring sites. Thus, the 2010 Base Case and two control scenarios pass the modeled attainment demonstration test. However, since there are four monitoring sites with projected 2010 DVFs of 82 ppb or higher (84 ppb at RFNO and FTCW, 83 ppb at Chatfield and 82 ppb at NREL), an additional weight of evidence (WOE) analysis is required.

When reporting the DVFs to the nearest tenth of a ppb we see that the projected 2010 DVF for the Base Case is 84.9 ppb at both the RFNO and FTCW monitoring sites. The implementation of the federally enforceable SIP control measures in the 2010 Control 1 emissions scenario reduces the DVFs at the RFNO and FTCW by, respectively, 0.1 and 0.2 ppb (to 84.8 and 84.7 ppb, respectively). The addition of the state-enforceable control measures in the 2010 Control 2 scenario reduces the DVFs at RFNO and FRTCW by an additional 0.1 and 0.2 ppb, respectively (to 84.7 and 84.5 ppb, respectively). These results are consistent with the 2010 sensitivity modeling that found ozone to be more responsive to emission controls at the FTCW than RFNO monitoring sites (McNally et al., 2008b).

Table ES-3. Projected 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and 2010 Control 1 (Cntl1) and Control 2 (Cntl2) control strategies.

			DVF (EPA Recommended)			DVF (to nearest 0.1 ppb)		
Name	**County**	**DVC**	**Base**	**Cntl1**	**Cntl2**	**Base**	**Cntl1**	**Cntl2**
Welby	Adams	70.0	70	70	70	70.2	70.2	70.2
Highland	Arapahoe	78.0	77	77	77	77.3	77.2	77.1
S. Boulder Creek	Boulder	81.0	80	80	80	80.8	80.7	80.6
Denver - CAMP	Denver	56.0	56	56	55	56.0	56.0	55.9
Carriage	Denver	74.0	74	74	74	74.1	74.1	74.0
Chatfield State Park	Douglas	84.0	83	83	83	83.4	83.3	83.3
USAF Academy	El Paso	73.0	72	71	71	72.0	71.9	71.9
Manitou Springs	El Paso	74.0	73	73	73	73.7	73.7	73.7
Arvada	Jefferson	79.0	79	79	79	79.2	79.1	79.1
Welch	Jefferson	75.0	75	75	74	75.0	75.0	74.9
Rocky Flats North	Jefferson	85.0	84	84	84	84.9	84.8	84.7
NREL	Jefferson	82.0	82	82	82	82.3	82.2	82.1
Fort Collins - West	Larimer	86.0	84	84	84	84.9	84.7	84.5
Fort Collins	Larimer	74.0	73	72	72	73.0	72.9	72.7
Greeley-WeldTower	Weld	78.0	77	77	77	77.7	77.4	77.0
Gunnison	Gunnison	68.0	67	67	67	67.8	67.8	67.9
Larimer	Larimer	76.0	75	75	75	75.2	75.1	75.1
Larimer	Larimer	76.0	75	75	75	75.2	75.1	75.1

2010 UNMONITORED AREA ANALYSIS

EPA's 8-hour ozone projection procedure also includes an unmonitored area analysis (EPA, 2007) that has been codified in MATS. The unmonitored area analysis uses the future-year 8-hour ozone Design Value projection procedure applied to each grid cell in the modeling domain. In this procedure, the current-year Design Values (DVC) are interpolated to each grid cell in the modeling domain. This interpolation scheme uses the modeled concentration gradients. RRFs are then obtained for each grid cell in the modeling domain using essentially the same approach as used for the monitored ozone projections, only using the modeling data within each grid cell rather than near a grid cell as done for the projections at the monitor.

Figure ES-1 displays the interpolated current year 8-hour ozone Design Values (DVC) and projected 8-hour ozone Design Values (DVFs) for the 2010 Base Case using the MATS unmonitored area analysis. Interpolated current year ozone DVCs in excess of 80 ppb are estimated to the south, west and northwest of Denver stretching to Fort Collins and then west of Fort Collins. In fact, the MATS interpolation procedure estimates 12 grid cells of current-year DVCs in excess of the 85 ppb NAAQS occur west of the Fort Collins (Figure ES-1, left). The projected DVFs for the 2010 base case (Figure ES-1, right) have greatly reduced the spatial extent of the DVFs in excess of 80 ppb and the 12 cells with DVCs exceeding the 85 ppb NAAQS have been reduced by half to 6 grid cells in the 2010 base case emissions scenario.

Figure ES-2 displays the unmonitored area analysis projected DVFs for the 2010 Control 1 (left) and 2010 Control 2 (right) emission scenarios. There are slight reductions in the 2010 DVFs over the 2010 Base Case, which can be seen more clearly in the difference plots seen in Figure ES-3. The 6 remaining grid cells with projected DVFs that are 85 ppb or higher in the 2010 Base case are reduced to 4 and 3 grid cells in the, respectively, 2010 Control 1 and Control 2 emission scenarios.

EPA guidance stresses that the unmonitored area test has more uncertainties than the projections at the monitors and it should be treated separately from the monitor based attainment demonstration test (EPA, 2007). EPA further notes that while it is expected that additional emission controls will likely be needed to eliminate predicted exceedances of the ozone NAAQS in the monitor based attainment test, the same requirements may not be appropriate in unmonitored areas. In any event, EPA recommends that areas of predicted violations in the unmonitored area test be scrutinized and understood to determine whether they are likely to really exist in the ambient air, or whether they may be caused by an error or uncertainties in the modeling system. At a minimum, it may be appropriate to deploy additional ozone monitors to such areas. In the case of the Denver ozone modeling, higher ozone concentrations are estimated west of Fort Collins than at the locations of the two monitors in Fort Collins on some days and this does not appear to be due to an error in the modeling system. Whether it may be due to uncertainties in the modeling system can not be determined. However, it does not seem implausible that higher ozone values could exist west of the Fort Collins West monitoring site.

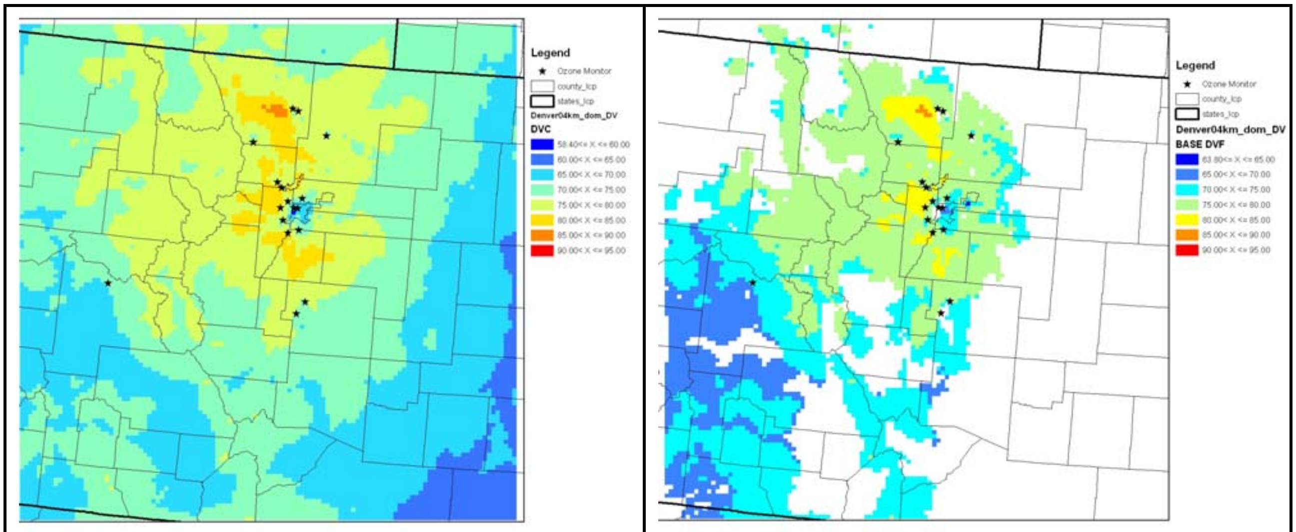

Figure ES-1. Interpolated current year 8-hour ozone Design Values (DVC; left) and projected 2010 Base Case 8-hour ozone Design Values (DVF; right).

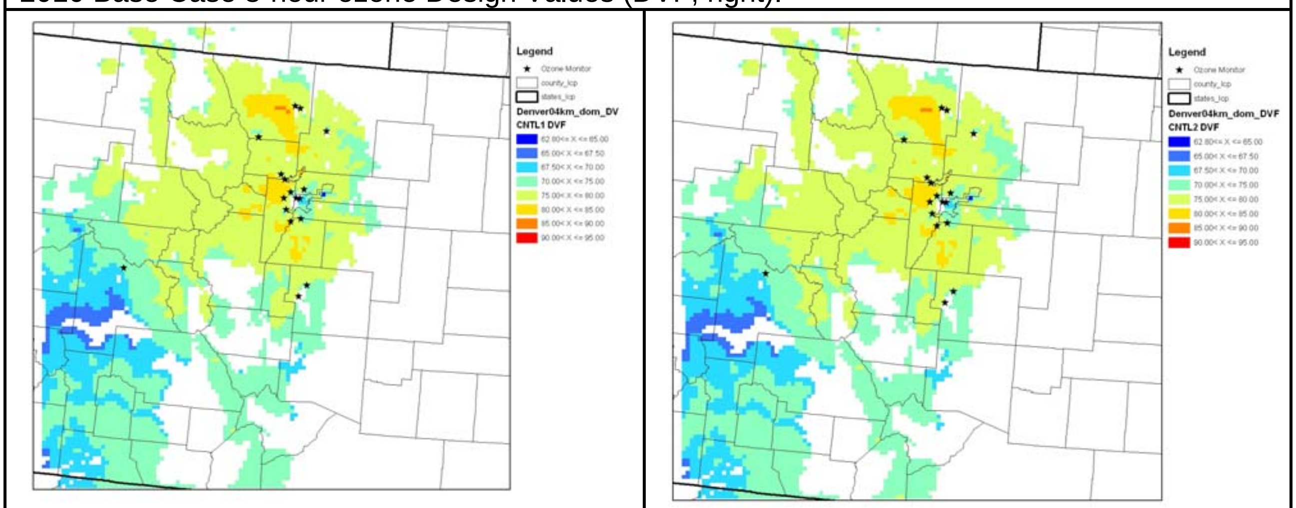

Figure ES-2. Projected 2010 8-hour ozone Design Values (DVF) for the 2010 Control 1 (left) and Control 2 (right) emission scenarios.

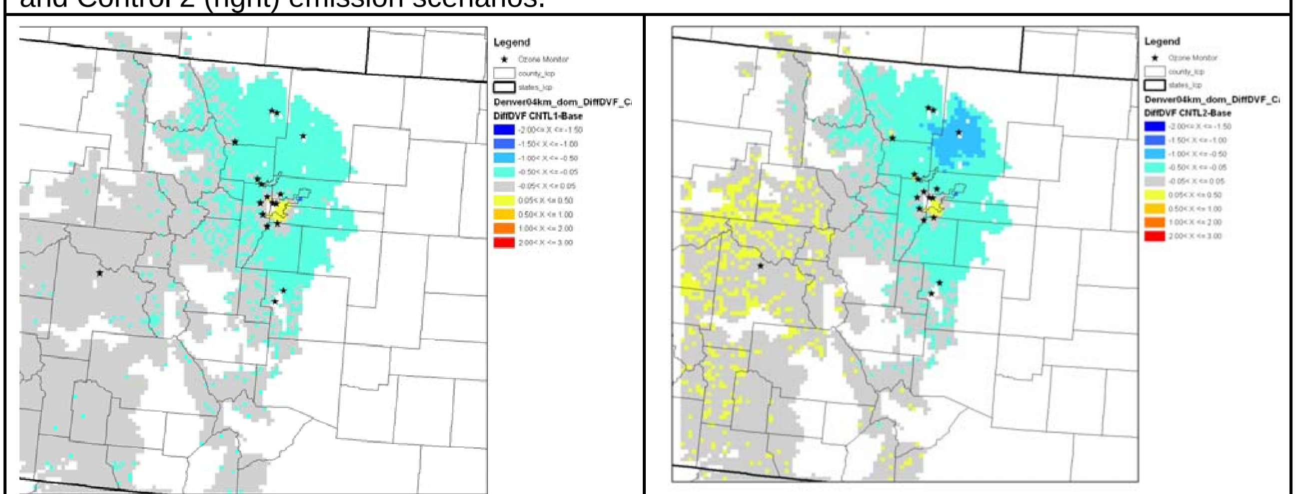

Figure ES-3. Differences in projected 2010 8-hour ozone Design Values (DVF) between the 2010 Control 1 (left) and 2010 Control 2 (right) and the 2010 Base Case.

ALTERNATIVE 2010 OZONE PROJECTION RESULTS

Several alternative 2010 ozone projection procedures were analyzed for the 2010 Base Case, Control 1 and Control 2 emission scenarios to estimate the uncertainties in the projection procedures and provide confidence that passing the modeled attainment demonstration test does indicate attainment will likely be achieved in 2010 under either the 2010 Base Case, Control 1 or Control 2 emission scenarios. These alternative ozone projection procedures differ in the days used and how modeled ozone near the monitor is selected to construct the RRFs. Six additional ozone projection procedures were analyzed, in addition to the EPA guidance default approach discussed previously:

> Minimum 5 Days to Develop RRF using 85-70 ppb Sliding Threshold (5dth): In the EPA default approach, days are selected for use RRFs based on whether the maximum daily maximum 8-hour ozone concentration near the monitor (with 7 x 7 array of grid cells) in the 2006 Base Case is greater than a threshold, with the threshold determined when at least 10 days are obtained for the RRF. In this alternative projection approach, we require a minimum of 5 modeled days to construct the RRFs.
>
> Use of 80 ppb Cutoff Threshold and Minimum of 1 Day (1dth80): The second alternative ozone projection approach uses an 80 ppb cutoff threshold and RRFs are allowed to be calculated with as few as one modeling day.
>
> Use of 75 ppb (1dth75) and 70 ppb (1dth70) Cutoff Thresholds: In those two alternative projection approaches the cutoff threshold is reduced to 75 and 70 ppb.
>
> Use of 5 x 5 and 3 x 3 Array of Grid Cells: Select the maximum daily maximum 8-hour ozone concentration from a 5 x 5 or 3 x 3 array of grid cells centered on the monitor, instead of using a 7 x 7 array as used in the EPA default procedure

Table ES-4 lists the projected 2010 DVFs at the key RFNO and FTCW monitoring sites for the EPA guidance default and the six alternative ozone projection procedures discussed above. Also shown in Table ES-4 are the ozone cutoff thresholds and number of days used in calculating the RRFs for each alternative 2010 ozone project methods and the RFNO and FTCW monitoring sites. It should be noted that there is really no one “correct” method for projecting future year ozone concentrations that has been proven the most reliable. Methods based on just a few number of days have been shown to be less robust than ones based on more days. And it is logical that methods based on modeled concentrations closer to the observed 8-hour ozone Design Values would be more representative of the conditions that produced those Design Values than methods based on days much higher or lower than the Design Values.

2010 Base Case: For the 2010 Base Case, the projected 2010 DVF using the EPA guidance default approach was 84.9 ppb at both the RFNO and FTCW monitoring sites. Some of the six alternative projection approaches result in increases, whereas others in decreases in the projected 2010 DVFs at these two sites relative to the EPA guidance default approach. The projected DVFs at RFNO for the 2010 Base Case range from 84.5 to 85.2 with an average value of 84.9 ppb. A similar range for the FTCW monitor is 84.6 to 85.2 ppb with an average of 84.9 ppb. At the RFNO monitoring site, 3 of the 7 projection methods pass the modeled attainment demonstration test (43%), while at the FTCW 5 of the 7 methods pass the test (71%).

2010 Control 1 Case: A majority of the 2010 ozone projection procedures pass the modeled attainment demonstration test at both the RFNO (4 out of 7, 57%) and FTCW (6 out of 7, 86%) monitoring sites. 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. And at the FTCW monitoring site the projected DVFs range from 84.4 to 85.0 ppb with an average of 84.7 ppb.

2010 Control 2 Case: The 2010 projected DVFs at RFNO for 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.

An examination of the different 2010 ozone projection methods across monitoring sites shows no method is tending toward estimating higher or lower DVFs than the EPA default method across all monitoring sites. This is clearly shown in Table ES-4 for the RFNO and FTCW monitoring sites where, in most cases, a method in which the projected DVF at RFNO is greater than the EPA default method is below the EPA default method at FTCW and vice versa.

In conclusion, the alternative ozone projection approaches support the findings using the EPA default approach that the 2010 Base Case will likely achieve attainment in the Denver region of the 0.08 ppm 8-hour ozone NAAQS. The ozone projection methods indicate 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 emission scenarios.

Table ES-4. Projected 2010 8-hour ozone Design Values (DVFs) at the Rocky Flats North (RFNO) and Fort Collins West (FTCW) monitoring sites using the EPA guidance default approach, the six alternative projection approaches and the 2010 Base, Control 1 and Control 2 modeling results.

Alternative 2010 Ozone Projection Procedures									
Name	**DVC**	**EPA**	**5dth**	**1dth80**	**1dth75**	**1dth70**	**5x5**	**3x3**	**Avg**
2010 Base Case (Base) DVFs (ppb)									
Rocky Flats North	85.0	84.9	85.2	85.1	84.9	85.0	85.0	84.5	84.9
Fort Collins - West	86.0	84.9	84.6	84.6	84.9	85.1	84.8	85.2	84.9
2010 Control Strategy No. 1 (Cntl1) DVFs (ppb)									
Rocky Flats North	85.0	84.8	85.1	85.0	84.8	85.0	84.9	84.3	84.8
Fort Collins - West	86.0	84.7	84.4	84.4	84.7	84.9	84.6	85.0	84.7
2010 Control Strategy No. 2 (Cntl2) DVFs (ppb)									
Rocky Flats North	85.0	84.7	85.1	84.9	84.8	84.9	84.8	84.3	84.8
Fort Collins - West	86.0	84.5	84.3	84.3	84.5	84.7	84.5	84.8	84.5
Cut-Off Concentration (ppb)									
Rocky Flats North		78	81	80	75	70	76	75	
Fort Collins - West		76	81	80	75	70	75	73	
Number of Days Used									
Rocky Flats North		10	6	7	19	27	11	10	
Fort Collins - West		10	5	5	13	22	10	10	

ADDITIONAL MODELING METRICS

EPA's 8-hour ozone modeling guidance recommends calculating additional modeling metrics from the current year base case to future year control scenario to assure that they indicate the modeled ozone concentrations are going down. These additional modeling metrics examine the ozone differences between the current year base case and future year emission scenarios in the modeling domain to assure that ozone is going down, on average, across the entire nonattainment area (NAA) rather than just limited to a few key monitoring sites.

The changes in daily maximum 8-hour ozone concentrations between the 2006 Base Case and 2010 emission scenarios was calculated across grid cells in the Denver NAA and across all days in the June-July 2006 modeling episode. The changes 8-hour ozone concentrations are calculated for values above four separate threshold concentrations: 85, 80, 75 and 70 ppb. These modeling metrics consist of the following:

> Total Ozone: 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.
>
> Grid Cells: Number of grid cell-days with modeled daily maximum 8-hour ozone concentrations greater than the threshold for all grid cells in the NAA and days from the June-July 2006 episode.
>
> Grid Cell-Hours: 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.

Figure ES-4 displays the percent change in the Total Ozone and Grid Cells between the 2006 Base Case and the 2010 emission scenarios (the change in Grid-Cell Hours is similar). There are small reductions between 2006 and 2010 in the Total Ozone (~-5%) and Grid Cell (~-3%) modeling metrics greater than the 70 ppb threshold. However, the emission reductions between 2006 and 2010 are having their intended effect in being more effective at reducing the elevated 8-hour ozone concentrations. For example, 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. These reductions are even greater for the 2010 Control 1 case (-28% and -17%) and even greater still for the 2010 Control 2 scenario.

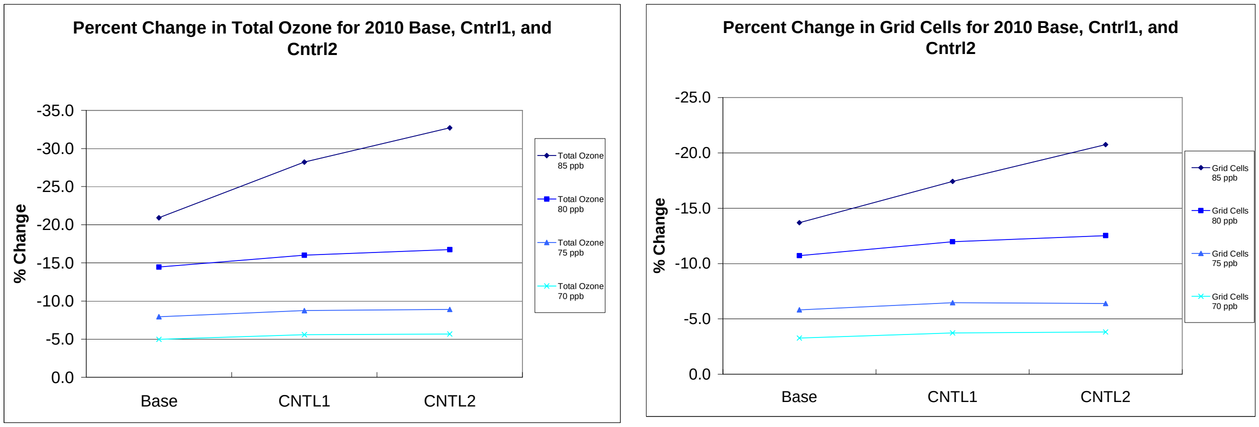

Figure ES-4. Percent change in Total Ozone (left) and Grid Cells (right) greater than 85, 80, 75 and 70 ppb between the 2006 Base Case and the 2010 Base Case (Base), Control 1 (CNTL1) and Control 2 (CNTL2) emission scenarios.

2010 CONTROL PLAN MODELING CONCLUSIONS

The 2010 ozone modeling indicates that the Denver region would achieve attainment of the 1997 8-hour ozone NAAQS (0.08 ppm) by 2010 under any of the three 2010 emission scenarios studied. All three 2010 emission scenarios pass the modeled attainment demonstration test. Examining the unmonitored area test, the alternative ozone projection procedures and additional modeling metrics we conclude that the two 2010 control strategies provide more certainty that ozone attainment will be achieved in 2010 than the 2010 base case.

There are numerous uncertainties in the modeling analysis. By definition, models are simplistic approximations of complex phenomena. The modeling analysis used to asses whether various emission reduction measures will bring the Denver area into attainment of the 8-hour ozone NAAQS contain many elements that are uncertain (e.g., emissions inputs and projections, meteorological inputs, ozone transport, etc.). There are a lot of year-to-year meteorological variations in the Denver area that greatly affect the ozone formation potential of the region. For example, the most ozone formation conducive year for the DMA in recent record was 2003 that was followed by the year with the least ozone formation conducive conditions in 2004. If the ozone formation conditions in the next few years are much more severe than seen in the June-July 2006 modeling period, then that could jeopardize achieving attainment in 2010. However, for 2008 it appears the opposite is true providing further confidence that the DMA will achieve attainment of the 8-hour ozone NAAQS in 2010.

1.0 INTRODUCTION

1.1 BACKGROUND

Ozone air quality in the Denver Metropolitan Area (DMA) has been near the 8-hour ozone National Ambient Air Quality Standard (NAAQS) of 0.08 ppm (exceedance defined by values of 85 ppb or higher) for several years. In December 2002, the Denver Regional Air Quality Council (RAQC) and Colorado Department of Health and Environment (CDPHE) Air Pollution Control Division (APCD) and others entered into an 8-hour ozone Early Action Compact (EAC) with the U.S. Environmental Protection Agency (EPA). EPA's EAC allows an area to submit an enforceable 8-hour ozone State Implementation Plan (SIP) by March 2004 that demonstrates attainment of the 8-hour ozone NAAQS by 2007. In return, EPA will defer the classification of an area as nonattainment until 2007. Based on 2005-2007 measured air quality, the DMA violated the 0.08 ppm 8-hour ozone NAAQS (i.e., 1997 8-hour ozone NAAQS), so in November 2007 the DMA reverted to an 8-hour ozone nonattainment area and is required to prepare an 8-hour ozone State Implementation Plan (SIP) that demonstrates attainment by 2010. The contracting team of ENVIRON International Corporation, and their subcontractor Alpine Geophysics, LLC, were selected by the RAQC and CDPHE to perform the 2010 8-hour ozone attainment demonstration modeling for the new SIP.

On March 12, 2008, EPA promulgated a new primary ozone NAAQS that has the same form as the 1997 ozone NAAQS, but lowers the threshold from 0.08 ppm (85 ppb) to 0.075 ppm (76 ppb). Of the ~14 ozone monitors in the greater DMA, half have 2005-2007 8-hour ozone DVs that are 0.075 ppm or higher. The current Denver 8-hour ozone SIP modeling effort addresses the 0.08 ppm 8-hour ozone NAAQS, the new 0.075 ppm 8-hour ozone NAAQS will be addressed in future SIP actions.

1.2 APPROACH

The fifth generation Mesocale Model (MM5) meteorological model (Anthes and Warner, 1978; Dudhia, 1993), the Sparse Matrix Operating Kernel Emissions (SMOKE) modeling system (Coats, 1996) and the Comprehensive Air-quality Model with extensions (CAMx) photochemical grid model (ENVIRON, 2008) are being used to model ozone in the Denver area for a June-July 2006 modeling period for the purposes of demonstrating attainment of the 8-hour ozone standard by 2010. The 8-hour ozone modeling activities being performed by the ENVIRON/Alpine Modeling Team consists of the following activities:

- Development of a Denver 8-hour ozone SIP attainment demonstration Modeling Protocol (Morris et al., 2007; http://www.ozoneaware.org/documents/DraftFinalProtocolDenver8-HourOzoneNov282007.pdf);
- MM5 meteorological modeling and model performance evaluation (McNally et al., 2008a);
- Development of a preliminary 36/12/4 km photochemical modeling database for the June-July 2006 episode, the DMA, and initial model performance evaluation, sensitivity test modeling and identification of optimal model configuration for simulating ozone in the DMA (Morris et al., 2008b);

- Final base case modeling and model performance evaluation for the June-July 2006 DMA episode (Morris et al., 2008c);
- 2010 base case modeling, emission sensitivity tests and ozone source apportionment modeling (McNally et al., 2008b); and
- 2010 control strategy modeling (this document).

This document presents the results of the 2010 control strategy modeling. These results include the ozone projections for the SIP control plan (Control 1) federally-enforceable control measures, as well as the SIP control plan plus additional state-only measures (Control 2). In Chapter 2 we present the 2010 ozone projections for the 2010 Base, Control 1 and Control 2 Cases using the default projection procedures in EPA's 8-hour ozone modeling guidance (EPA, 2007) and compare against the model ozone attainment demonstration test. In Chapter 3 we look at additional air quality metrics and alternative 2010 ozone projection approaches that are used to corroborate the modeled ozone attainment demonstration and is one component of the Weight of Evidence (WOE) ozone attainment demonstration.

Figure 1-1a displays the MM5 (red) and CAMx (blue) 36/12/4 km modeling domains used in the Denver 8-hour ozone modeling study. The CAMx model was first applied to the 36 km continental U.S. domain using boundary conditions (BCs) from a global climate air quality model (Figure 1-1a). The CAMx 2006 and 2010 base case modeling results from the 36 km continental U.S. domain simulation are then processed to generate BCs for the CAMx 12/4 km domain (Figure 1-1b). The CAMx simulations for the 12/4 km domains were run using two-way interactive grid nesting (i.e., pollutants can flow back and forth between the 12 km and 4 km domains to account for recirculation).

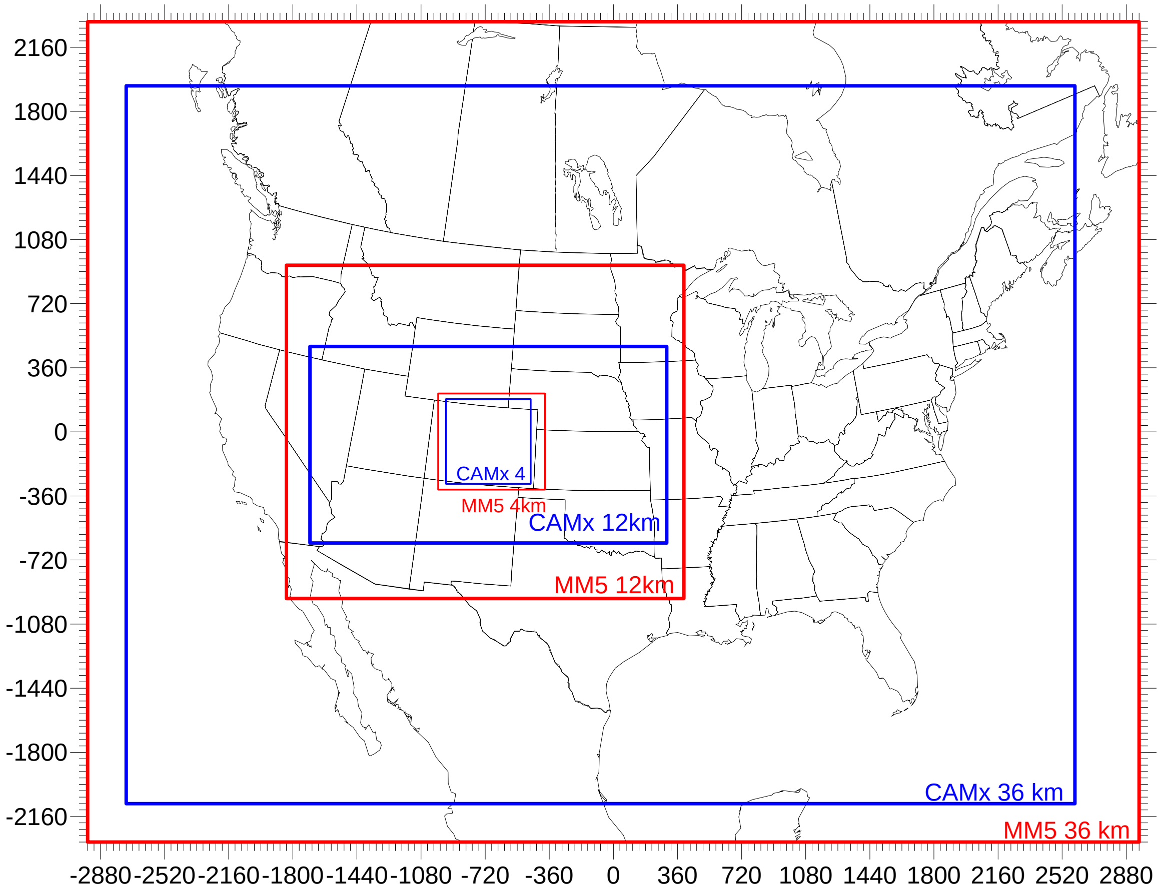

Figure 1-1a. Nested 36/12/4 km modeling domains for the Denver 8-hour ozone modeling study. Blue line domains are for CAMx/SMOKE domains that are nested in the MM5 red line domains.

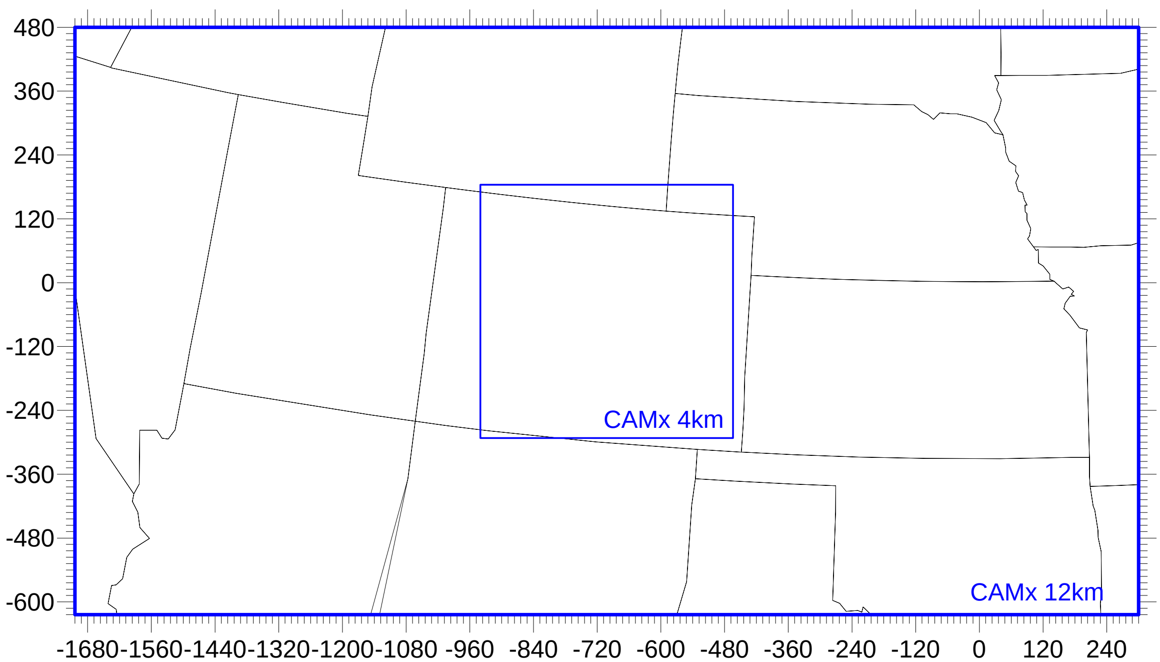

Figure 1-1b. Nested 12/4 km modeling domains for the Denver CAMx air quality and SMOKE emissions modeling.

1.3 2010 EMISSIONS MODELING APPROACH

The 2010 base case and control strategy emissions were prepared using the same procedures as used to prepare the final 2006 base case emissions scenario (Morris et al., 2008b) and are described by McNally and co-workers (McNally et al., 2008b). The CDPHE/APCD provided 2010 emissions for all anthropogenic emission sources in Colorado except oil and gas (O&G) emissions in the Denver-Julesburg Basin for which 2010 emissions from the WRAP Phase III O&G emissions development project were utilized (Bar-Ilan et al., 2008b). Outside of Colorado, the 2010 anthropogenic emissions were based on the WRAP 2002 and 2018 emissions inventories projected to 2010. CAMx-ready emissions were generated using the Sparse Matrix Operator Kernel Emissions (SMOKE) emissions modeling system (Coats, 1996) for all anthropogenic emissions categories except on-road mobile sources in the DMA, which used the Consolidated Community Emissions Processing Tool (ConCEPT) modeling system (Loomis et al., 2005) and biogenic emissions. The same biogenic emissions were used for the 2010 base case as were used for the final 2006 base case biogenic emissions were based on the Model of Emissions of Gases and Aerosols from Nature (MEGAN) biogenic emissions model (Guenther and Wiedinmyer, 2004). Emissions from fires were also kept constant between the 2006 base case and 2010 base case emission scenarios.

The 2010 emissions for the two control strategies were either provided by the CDPHE or, for the case of on-road mobile sources, modeled using the CONCEPT MV and SMOKE-MOBILE6 on-road mobile source emissions modeling system. Section 2 contains the results of the 2010 emissions modeling.

2.0 2010 OZONE PROJECTIONS

2.1 INTRODUCTION

This section presents the 2010 ozone Design Value projections for the 2010 base case and the two 2010 emission control plans. These two 2010 control plans correspond to: (1) 2010 Control 1 that consists of the federally-enforceable control measures that are proposed for the Denver 8-hour ozone State Implement plan (SIP); and (2) Control 2 that includes the federally-enforceable measures of Control 1 plus additional control measures that are adopted as state-only enforceable. The 8-hour ozone projections are made using the CAMx modeling results for the 2006 base case (Morris et al., 2008b,c) and the 2010 Base, Control 1 and Control 2 Cases. These ozone projections are made using EPA's Modeled Attainment Test Software (MATS) tool (http://www.epa.gov/scram001/modelingapps_mats.htm). The MATS ozone projection procedures and 8-hour ozone projections for the 2010 Base Case and 2010 sensitivity simulations are described in detail by McNally and co-workers (2008b). Below we provide a brief overview of the ozone projection procedures, whose results for the 2010 Base, Control 1 and Control 2 emissions are presented later in this Chapter.

2.2 OZONE PROJECTION PROCEDURES

The Denver 2010 8-hour ozone projections were made following default procedures in EPA's latest modeling guidance (EPA, 2007), with one exception described below. These procedures use the model in a relative sense to scale the observed current year 8-hour ozone Design Value (DVC) to obtain a future year 8-hour ozone Design Value (DVF). The model derived scaling factors are referred to as relative response factors (RRF) and are defined as the ratio of daily maximum 8-hour ozone concentrations *near a monitor* averaged over *several days* of modeling results for the 2010 emissions scenario to the 2006 base case:

$$RRF = [\Sigma \text{ 2010 scenario}] / [\Sigma \text{ 2006 base}]$$
$$DVF = DVC \times RRF$$

The basic steps in performing the 2010 8-hour ozone projections can be summarized as follows:

1. Develop an observed current year 8-hour ozone Design Value (DVC) as the starting point for the ozone projections. EPA guidance recommends using a three year average of three years of Design Values centered on the modeling year, which for the Denver June-July 2006 episode modeling would mean Design Values from the five year period of 2006-2008. As the 2008 ozone season is not yet completed, use of this approach for the DVCs is not possible. So instead we used the 8-hour ozone Design Values from the 2005-2007 period that resulted in Denver being classified as nonattainment for the DVCs.
2. Select the maximum modeled 8-hour ozone concentrations *near a monitor* for *several days* from the 2006 base and 2010 emission scenarios and take the ratio of their averages to construct the monitor-specific RRFs:
    a. By *near a monitor* EPA guidance suggests using an array of 7 x 7 grid cells centered on the monitoring location for the Denver modeling that uses a 4 km grid resolution.

   b. By *several days* EPA recommends RRFs based on at least 10 modeled days and recommends selecting days in which the 2006 base case maximum daily maximum 8-hour ozone concentrations near a monitor are greater than an ozone threshold (cut off). Initially, an ozone threshold of 85 ppb is used. If less than 10 days are obtained the threshold is reduced by 1 ppb until at least 10 days are obtained for the RRF. When the 70 ppb threshold floor is reached and there are at least 5 days then the RRF is used.
3. The RRF is applied to the DVC to obtain the projected DVF for the 2010 emission scenarios. The projected DVF is truncated to the nearest ppb.
4. If the DVFs at all monitoring sites are less than or equal to 84 ppb, then the modeled attainment demonstration test is passed. If a DVF at any monitor is 85 ppb or higher, the modeled attainment test is not passed.
5. If there are any DVFs between 82 ppb and 87 ppb then a Weight of Evidence (WOE) analysis is required to corroborate the modeled attainment demonstration.
6. An unmonitored area analysis is also performed that interpolates the DVCs across the modeling domain and performs the ozone projections in each grid cell using the procedures given above, except using the modeling results within each grid cell rather than near the grid cell.
   a. EPA believes that the unmonitored area analysis is more uncertain than the monitor based ozone projections, whereas additional emissions reductions are likely required to eliminate any projected monitored ozone exceedances, the same is not true in the unmonitored area test.
   b. EPA recommends that the reasons behind any unmonitored area test exceedances be understood and explained.

2.3 2010 CONTROL PLAN CONTROL MEASURES AND EMISSIONS

The same emissions modeling procedures used for the 2006 and 2010 base cases were used for the 2010 control plan emission scenarios (Morris et al, 2008a,b; McNally et al., 2008b). The on-road mobile source control measures were modeled using either the CONCEPT MV (area covered by the Denver link-based network) or SMOKE-MOBILE6. The other control measures were included in emissions files provided by the CDPHE/APCD. Table 2-1 summarizes the control measures in the 2010 Control 1 federally-enforceable SIP control strategy and the 2010 Control 2 that includes the Control 1 control measures as well as additional control measures to be adopted by the state of Colorado.

2.3.1 Measures Proposed for the Federally-Enforceable SIP

The following measures are proposed for inclusion in the Ozone State Implementation Plan (SIP) and were modeled as the 2010 Control 1 emissions scenario. In addition to being adopted and enforced by the State of Colorado, these measures will also be federally-enforceable upon approval of the SIP revision by EPA.

1. **Adopt more stringent cut-points for inspection/maintenance program in 7-county Denver metro area**

   Lower cut-points will identify more high-emitting vehicles that will result in repairs to reduce emissions. The Air Quality Control Commission approved revisions to Regulation No. 11 implementing these cut-points in March 2008 and the changes took effect in May 2008. These revisions are expected to reduce mobile source VOC emissions by one ton per day (tpd), NOx emissions by three tpd, and carbon monoxide (CO) emissions by 13 tpd.

2. **Require 7.8 pounds per square inch (psi) RVP (Reid Vapor Pressure) gasoline in the entire nonattainment area**

   Gasoline with 7.8 RVP is already required in the former one-hour ozone nonattainment area (most of the 7-county Denver area) and will be required in portions of Larimer and Weld counties and eastern portions of Arapahoe and Adams counties under this action. This change requires EPA regulatory action, which hopefully can be implemented no later than May 2010, if not before. This action is expected to provide an additional SIP credit of three tpd VOC emission reduction.

3. **Increase control requirements for oil and gas condensate tanks to 95% for all new and modified tanks greater than two tons per year (tpy) by 2009 and all existing tanks greater than 10 tpy by 2010.**

   This will replace the current 75% system-wide control requirement in Regulation No. 7 and will be implemented as revisions to Regulation No. 7 adopted by the AQCC in December 2008. The requirements for new and modified tanks will take effect in February 2009 and the requirements for existing tanks greater than 10 tpy will take effect in May 2010. These controls are expected to reduce VOC emissions between 24 and 39 tpd. (The North Front Range Transportation and Air Quality Planning Council have endorsed an alternative approach suggested by industry that would increase the current system-wide control factor to 90% as a SIP measure. This alternative proposal is likely to be considered by the Air Quality Control Commission during its upcoming rulemaking pre-hearing process.)

4. **Require low-bleed control devices on all new and existing pneumatic valves in oil and gas operations by 2009**

   The AQCC will adopt revisions to Regulation No. 7 in December 2008 effective in May 2009 that require low-bleed controllers on valves. Exemptions will be granted for operations that require high-bleed controllers on valves for safety reasons. These controls are expected to reduce VOC emissions between 19 and 23 tpd.

5. **Expand current requirements in Regulation No. 7 for Volatile Organic Compound (VOC) controls to the entire nonattainment area**

Control requirements for VOC stationary sources currently pertain only to the former one-hour ozone attainment/maintenance area (most of the 7-county Denver area). These reasonably available control technology (RACT) requirements in Regulation No. 7 will now apply to specific new and existing listed source categories and all new and existing major (greater than 100 tons per year (tpy)) stationary sources of VOCs in portions of Larimer and Weld counties and eastern portions of Adams and Arapahoe counties. These revisions to Regulation No. 7 will be adopted by the AQCC in December 2008 and become effective in February 2009. The impact of these revisions is difficult to quantify since it is unknown how many sources will be affected and the control levels that will be required.

6. **Remove current exemptions contained in Regulation No. 3 for selected small sources required to file air pollution emission notices and obtain permits**

Regulation No. 3 currently contains exemptions for many small source categories. Many of these exemptions pertaining to VOC sources will be removed by the AQCC in revisions to Regulation No. 3 in December 2008 and become effective in February 2009. This change will result in the identification of more sources of VOCs and potentially additional control requirements. The impact of these revisions is difficult to quantify since it is unknown how many sources will be affected and the control levels that will be required.

7. **Require general application of permit requirements in Regulation No. 3 and reasonably available control technology (RACT) for all VOC stationary sources greater than two tons per year and NOx stationary sources greater than five tons per year in the entire nonattainment area.**

Revisions to Regulation No. 3 implementing these changes were adopted by the AQCC in February 2008. The impact of these revisions is difficult to quantify since it is unknown how many sources will be affected and the control levels that will be required.

2.3.2 Measures Proposed as State-Only Measures in State Regulation

The following measures will not be included in the federally-enforceable SIP at this time, but will be adopted and enforced exclusively under state authority. These measures will provide additional reductions of ozone-causing emissions, which will give the region an additional margin of safety to maintain compliance with the 1997 8-hour ozone NAAQS and will help the region make further progress towards meeting the new EPA standard.

1. **Implement a motor vehicle inspection/maintenance program in the North Front Range (Larimer and Weld counties)**

The North Front Range Transportation and Air Quality Planning Council have endorsed a proposal to extend the inspection/maintenance (I/M) program structure that currently exists in the Denver metropolitan area to portions of Larimer and Weld counties. The program includes IM240 testing, remote-sensing clean screen, gas cap checks, and advisory On-Board Diagnostics (OBDII) checks. Revisions to Regulation No. 11 implementing this change in the former basic I/M program area in Larimer and Weld counties will be proposed to the AQCC in September 2008 for adoption in December 2008. The program could become effective in 2010 or a date determined by the AQCC. Changes to the boundary of the North Front Range program area to include the entire urbanized portion of Larimer and Weld counties will likely be considered by the General Assembly during the 2009 session. Conservatively, this program is expected to reduce mobile source VOC emissions by at least one tpd, NOx emissions by at least one tpd, and CO emissions by at least 17 tpd.

The North Front Range Transportation and Air Quality Planning Council also endorse an evaluation of the I/M program structure by 2013 that includes consideration of expanded OBDII testing and high-emitter identification.

2. Continue implementing the high-emitter pilot program in the Denver metro area

A mandatory pilot program using remote sensing technology began January 1, 2008. The pilot program will continue through July 2009 after which the results from the program will be analyzed. This analysis may lead to implementation of a full-scale high-emitter program in the future. Since this pilot program is still underway, the emission reduction potential of this program has not yet been identified. However, it is a well-established fact that high-emitting vehicles contribute a disproportionate amount of pollution to our air.

3. Tighten up collector plate requirements in state law

Collector plate requirements in current state statute limit emission tests on vehicles more than 25 years old. The RAQC and CDPHE are working with stakeholders to develop legislation that will limit collector plates to true collector vehicles and close the emissions testing loophole for old, non-collector vehicles. The impact from these old, non-collector vehicles is difficult to quantify, but it is expected the VOC reduction could be around one tpd and the CO reduction could be around seven tpd.

4. Increase control requirements for oil and gas condensate tanks to 95% for all existing tanks greater than 2 tpy

Regulation No. 7 will be amended by the AQCC in December 2008 to increase the number of tanks controlled in the nonattainment area beyond the 10 tpy threshold included in the SIP. Control requirements for tanks greater than 5 tpy will take effect in May 2011 and tanks greater than 2 tpy will have to meet the requirements by May 2012. These provisions of Regulation No. 7 will be adopted and enforced as a state-only control measure and will not be included in the SIP. These controls are expected to reduce VOC emissions between 39 and 47 tpd. (The North Front Range Transportation and Air Quality Planning Council have endorsed an alternative approach suggested by industry that would increase the current system-wide control factor to 90% as a SIP measure. This alternative proposal is likely to be considered by the Air Quality Control Commission during its upcoming rulemaking pre-hearing process.)

5. Implement control requirements for reciprocating internal combustion engines (RICE) statewide

The control requirements will mirror requirements currently in place in the Denver/North Front Range nonattainment area. Revisions to Regulation No. 7 making these requirements apply statewide will be adopted by the AQCC in December 2008 and will become effective by May 1, 2010. The emission reduction impact from these statewide controls has not yet been quantified.

Table 2-1. Summary of control measures in the 2010 Control 1 and Control 2 emission scenarios.

Strategies Under Development for 2008 Proposed Ozone Action Plan ***(All strategies apply to the entire Denver/North Front Range nonattainment area (NAA) unless otherwise noted)***			
Control 1 Recommended Measures for Federally-Enforceable State Implementation Plan (SIP)	*Potential Emission Reduction*	**Control 2** Recommend Measures Adopted and Enforced as State-only Measures	*Potential Emission Reduction*
➢ More stringent Reg. 11 I/M cutpoints (Denver area) – adopted, effective May 1, 2008	*~ 1 tpd VOC, ~3 tpd NOx, ~13 tpd CO*	➢ Inspection/maintenance program in North Front Range (structure to be determined)	*~ 1 tpd VOC, ~1 tpd NOx, ~17 tpd CO*
➢ 7.8 RVP gasoline regulatory requirement in North Front Range (consistent with Denver area)	*~ 3 tpd VOC*	➢ Mandatory high-emitter pilot program (Denver area) – began January 1, 2008	*unknown at this time*
		➢ Tighten up collector plate requirements for older vehicles (statewide)	*< 1 tpd VOC ~ 7 tpd CO*
➢ Increase condensate tank control (95%) ▪ for all new/modified tanks >2 tpy (2009) ▪ for all existing tanks >10 tpy (2010)	*VOC ~ 6-9 tpd ~19-30 tpd*	➢ Increase condensate tank control (95%) ▪ for all existing tanks >5 tpy (2011) ▪ for all existing tanks >2 tpy (2012)	*VOC ~ 30-35 tpd ~9-12 tpd*
➢ Pneumatic valves controls - require low/no bleed valves on all new and existing valves by 2009	*~ 23 tpd VOC*	➢ Statewide Oil & Gas regulations -- Controls on existing reciprocating internal combustion engines	*unknown at this time*
➢ Expand Reg. 7 (VOC control requirements) to entire NAA	*unknown at this time*		
➢ Remove current exemptions in Reg. 3 for selected small sources required to file air pollution emission notices and obtain permits	*unknown at this time*		
➢ Require Reasonably Available Control Technology (RACT) for minor sources in NAA (Reg. 3)	*unknown at this time*		
TOTAL EMISSION REDUCTIONS — VOC NOx CO	*~52-66 tpd ~ 3 tpd ~13 tpd*	VOC NOx CO	*~41-49 tpd NA >24 tpd*

2.4 2010 EMISSION SUMMARY RESULTS

The emission inventories were developed using EPA-approved emissions modeling methods, including EPA's MOBILE6 model and local Vehicle Miles Travelled (VMT) data for on-road mobile source emissions, EPA's non-road model and local demographic information for area and off-road sources, and reported actual emissions for point sources from Continuous Emissions Monitors (CEMs). Estimates for future emissions are based on the above-mentioned tools and the EPA's Economic Growth and Analysis System (EGAS) model for estimating future point sources activity, VMT growth for on-road mobile sources, and 2010 demographic data for off-road and area sources.

Highway mobile source emissions within the DMA were based on the CONCEPT MV emissions model that uses link-based activity (VMT) data from the Denver Regional Council of Governments (DRCOG) and the MOBILE6 emissions model. The SMOKE-MOBILE6 emissions model was used to estimate on-road mobile source emissions in Larimer and Weld Counties not covered by the DRCOG transportation network using the VMT from the North Front Range Transportation and Air Quality Planning Council and CDOT.

Non-road source emissions are from the EPA NONROAD model. This model includes the impact of future controls on non-road engines, which is used in equipment such as lawn and garden equipment and construction equipment.

Oil and gas source emissions are from the WRAP Phase III oil and gas emissions inventory development study (Bar-Ilan, 2008a) and were projected to 2010 using the methodology in the WRAP Phase III projection methodology document (Bar-Ilan, 2008b). The WRAP Phase III oil and gas inventory was sponsored by the Independent Petroleum Association of Mountain States (IPAMS).

Non-oil and gas area source emissions (including heating, consumer solvent use, pesticides, etc) are from the 2002 EPA National Emissions Inventory (NEI), grown to 2006 and 2010 by population growth from data from the State Demographer. Consumer solvent emission reductions based on 75% of the per-person reductions listed in the EPA May 30, 2007 Emission Reduction Credit Memo were applied to the projected 2010 non-oil and gas area source inventory. An inventory completed in 2005 for Denver International Airport (DIA) was used for aircraft and airport non-road source emissions from DIA for both 2006 and 2010.

Non-oil and gas point source emissions were grown to 2010 by the EPA EGAS economic model, and by adding sources for which permits have been issued.

Emissions of VOC and nitrogen oxides (NOx) from biogenic sources have been generated by the Model of Emissions of Gases and Aerosols from Nature (MEGAN) Biogenic Emissions Model using land cover data base of biomass type and density and hourly meteorology data. The National Center of Atmospheric Research (NCAR) has produced a global data base of land use data, the MEGAN Driving Variable Database Version 1.2, for use with MEGAN. Surface temperatures are provided by the Mesoscale Meteorological Model (MM5) modeling.

Wildfire emissions were based on MODIS satellite data. Wildfire emissions can vary significantly on a day-to-day basis depending on conditions.

Summaries of the VOC and NOx base case inventories for the Denver nonattainment area and 2006 and 2010 are presented in Table 2-2. Emissions of NOx and VOCs are in tons per average episode day. Because of their large day-to-day variations and small influence in the Denver NAA for the June-July 2006 episode, emissions from wildfires are not included in Table 2-2.

Table 2-2. 2006 and 2010 Base Case emission inventories for the Denver 9-county nonattainment area (tons per average episode day).

Source Category	2006		2010	
	NOx	VOC	NOx	VOC
Point Sources				
Electric Generation Units (EGU)	55.6	0.7	58.5	1.6
External Combustion Boilers	9.5	0.4	10.0	0.5
Industrial Processes	12.5	10.2	14.0	11.0
Petroleum and Solvent Evaporation	0.3	19.0	0.3	22.0
Other	3.1	1.8	3.6	2.0
Point Sources Subtotal	**81.0**	**32.1**	**86.4**	**37.0**
Oil & Gas Point & Area Sources				
Condensate Tanks		126.5		129.6
Other O&G Point Sources	22.6	6.8	23.6	8.6
Pneumatic Devices (Area Source)		24.8		31.1
Unpermitted Fugitives (Area Source)		16.2		20.4
Other Area Sources	17.1	10.8	22.5	13.7
O&G Point & Area Sources Subtotal	**39.7**	**185.2**	**46.2**	**203.3**
Area Sources				
Personal Care Products		7.1		7.0
Household Products		21.4		17.9
Automotive Aftermarket Products		11.9		13.0
Architectural Coatings		20.1		16.8
Aircraft	7.4	1.3	8.2	1.5
Railroad	12.8	0.5	13.8	0.6
Other Coatings/Pesticides/Cooking/ Miscellaneous.		3.9		4.1
Area Source Subtotal	**20.2**	**66.3**	**22.1**	**61.0**
Non-Road Mobile Sources				
Agricultural Equipment	7.0	0.9	6.3	0.7
Airport Equipment	0.7	0.1	0.6	0.1
Commercial Equipment	5.3	6.2	5.1	7.0
Construction and Mining Equipment	35.7	5.5	31.2	4.5
Industrial Equipment	10.5	2.4	6.9	1.4
Lawn and Garden Equipment (Commercial)	9.4	35.9	8.9	28.1
Lawn and Garden Equipment (Residential)	1.2	7.5	1.2	11.8
Boats/Recreational Equipment/Miscellaneous	0.7	6.9	0.8	7.8
Non-Road Mobile Source Subtotal	**70.5**	**65.3**	**61.0**	**61.3**
On-Road Mobile Sources				
On-Road Mobile (including vehicle refueling)	165.5	129.7	122.9	109.2
On-Road Mobile Subtotal	**165.5**	**129.7**	**122.9**	**109.2**
Anthropogenic Total	**376.8**	**478.6**	**338.5**	**471.8**
Biogenic Total	**53.0**	**694.0**	**53.0**	**694.0**
Anthropogenic & Biogenic Total	**429.8**	**1172.6**	**391.5**	**1165.8**

2.5 OZONE PROJECTIONS FOR 2010 CONTROL PLANS

Table 2-3 displays the projected 8-hour ozone DVFs for the 2010 base case and the two 2010 control plans. Included in this table are the 2010 DVFs (Table 2-3a), the RRFs (Table 2-3b) and the cut-off threshold concentrations (Table 2-3c) and the number of modeling days (Table 2-3d) used in the construction of the RRFs. The first set of DVFs in Table 2-3a (columns 4-6) follow EPA's guidance approach (EPA, 2007) to truncate the final DVFs to the nearest ppb for comparisons with the NAAQS. Whereas the last set of three DVFs for the three 2010 emissions scenarios display the DVFs to the nearest tenth of a ppb. The maximum projected 8-hour ozone Design Values for the 2010 Base, Control 1 and Control 2 cases are 84 ppb at the Rocky Flats North (RFNO) and Fort Collins West (FTCW) monitoring sites. Thus, the 2010 Base Case and two control scenarios pass the modeled attainment demonstration test. However, since there are four monitoring sites with projected 2010 DVFs of 82 ppb or higher (84 ppb at RFNO and FTCW, 83 ppb at Chatfield and 82 ppb at NREL), then additional Weight of Evidence (WOE) analysis is required.

When reporting the DVFs to the nearest tenth of a ppb we see that the maximum projected DVF for the 2010 Base Case is 84.9 ppb at both the RFNO and FTCW monitoring sites. The implementation of the federally enforceable SIP control measures in the 2010 Control 1 emissions scenario reduces the DVFs at the RFNO and FTCW monitoring sites by, respectively, 0.1 and 0.2 ppb (to 84.8 and 84.7 ppb, respectively). The addition of the state-enforceable control measures in the 2010 Control 2 scenario reduces the DVFs at the RFNO and FTCW monitoring sites by another 0.1 and 0.2 ppb, respectively (to 84.7 and 84.5 ppb, respectively). These results are consistent with the 2010 sensitivity modeling that found ozone to be more responsive to emission controls at the FTCW than RFNO monitoring sites (McNally et al., 2008b).

Table 2-3a. Projected 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and 2010 Control 1 (Cntl1) and Control 2 (Cntl2) control strategies.

Name	County	DVC	DVF (EPA Recommended)			DVF (to nearest 0.1 ppb)		
			Base	Cntl1	Cntl2	Base	Cntl1	Cntl2
Welby	Adams	70.0	70	70	70	70.2	70.2	70.2
Highland	Arapahoe	78.0	77	77	77	77.3	77.2	77.1
S. Boulder Creek	Boulder	81.0	80	80	80	80.8	80.7	80.6
Denver - CAMP	Denver	56.0	56	56	55	56.0	56.0	55.9
Carriage	Denver	74.0	74	74	74	74.1	74.1	74.0
Chatfield State Park	Douglas	84.0	83	83	83	83.4	83.3	83.3
USAF Academy	El Paso	73.0	72	71	71	72.0	71.9	71.9
Manitou Springs	El Paso	74.0	73	73	73	73.7	73.7	73.7
Arvada	Jefferson	79.0	79	79	79	79.2	79.1	79.1
Welch	Jefferson	75.0	75	75	74	75.0	75.0	74.9
Rocky Flats North	Jefferson	85.0	84	84	84	84.9	84.8	84.7
NREL	Jefferson	82.0	82	82	82	82.3	82.2	82.1
Fort Collins - West	Larimer	86.0	84	84	84	84.9	84.7	84.5
Fort Collins	Larimer	74.0	73	72	72	73.0	72.9	72.7
Greeley-WeldTower	Weld	78.0	77	77	77	77.7	77.4	77.0
Gunnison	Gunnison	68.0	67	67	67	67.8	67.8	67.9
Larimer	Larimer	76.0	75	75	75	75.2	75.1	75.1
Larimer	Larimer	76.0	75	75	75	75.2	75.1	75.1

Table 2-3b. Relative Response Factors (RRFs) used to project 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and two 2010 control strategies.

Name	County	DVC	RRF		
			base	cntl1	cntl2
Welby	Adams	70.0	1.0042	1.0039	1.0031
Highland	Arapahoe	78.0	0.9916	0.9900	0.9896
S. Boulder Creek	Boulder	81.0	0.9976	0.9963	0.9956
Denver - CAMP	Denver	56.0	1.0017	1.0009	0.9999
Carriage	Denver	74.0	1.0022	1.0015	1.0005
Chatfield State Park	Douglas	84.0	0.9934	0.9921	0.9917
USAF Academy	El Paso	73.0	0.9873	0.9857	0.9856
Manitou Springs	El Paso	74.0	0.9966	0.9961	0.9962
Arvada	Jefferson	79.0	1.0026	1.0022	1.0013
Welch	Jefferson	75.0	1.0004	1.0002	0.9999
Rocky Flats North	Jefferson	85.0	0.9994	0.9981	0.9973
NREL	Jefferson	82.0	1.0039	1.0027	1.0020
Fort Collins - West	Larimer	86.0	0.9874	0.9852	0.9836
Fort Collins	Larimer	74.0	0.9878	0.9853	0.9832
Greeley-WeldTower	Weld	78.0	0.9964	0.9925	0.9883
Gunnison	Gunnison	68.0	0.9984	0.9984	0.9987
Larimer	Larimer	76.0	0.9903	0.9892	0.9890
Larimer	Larimer	76.0	0.9903	0.9892	0.9890

Table 2-3c. Ozone threshold Cutoff Concentration used to project 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and two 2010 control strategies.

Name	County	DVC	Cutoff Concentration		
			base	cntl1	cntl2
Welby	Adams	70.0	77.0	77.0	77.0
Highland	Arapahoe	78.0	78.0	78.0	78.0
S. Boulder Creek	Boulder	81.0	78.0	78.0	78.0
Denver - CAMP	Denver	56.0	78.0	78.0	78.0
Carriage	Denver	74.0	78.0	78.0	78.0
Chatfield State Park	Douglas	84.0	78.0	78.0	78.0
USAF Academy	El Paso	73.0	75.0	75.0	75.0
Manitou Springs	El Paso	74.0	74.0	74.0	74.0
Arvada	Jefferson	79.0	78.0	78.0	78.0
Welch	Jefferson	75.0	78.0	78.0	78.0
Rocky Flats North	Jefferson	85.0	78.0	78.0	78.0
NREL	Jefferson	82.0	78.0	78.0	78.0
Fort Collins - West	Larimer	86.0	76.0	76.0	76.0
Fort Collins	Larimer	74.0	76.0	76.0	76.0
Greeley-WeldTower	Weld	78.0	75.0	75.0	75.0
Gunnison	Gunnison	68.0	74.0	74.0	74.0
Larimer	Larimer	76.0	77.0	77.0	77.0
Larimer	Larimer	76.0	77.0	77.0	77.0

Table 2-3d. Number of days used to project 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and two 2010 control strategies.

Name	County	DVC	Number of Day		
			base	cntl1	cntl2
Welby	Adams	70.0	11	11	11
Highland	Arapahoe	78.0	14	14	14
S. Boulder Creek	Boulder	81.0	10	10	10
Denver - CAMP	Denver	56.0	10	10	10
Carriage	Denver	74.0	10	10	10
Chatfield State Park	Douglas	84.0	11	11	11
USAF Academy	El Paso	73.0	10	10	10
Manitou Springs	El Paso	74.0	10	10	10
Arvada	Jefferson	79.0	10	10	10
Welch	Jefferson	75.0	10	10	10
Rocky Flats North	Jefferson	85.0	10	10	10
NREL	Jefferson	82.0	11	11	11
Fort Collins - West	Larimer	86.0	10	10	10
Fort Collins	Larimer	74.0	12	12	12
Greeley-WeldTower	Weld	78.0	10	10	10
Gunnison	Gunnison	68.0	10	10	10
Larimer	Larimer	76.0	10	10	10
Larimer	Larimer	76.0	10	10	10

2.6 2010 CONTROL PLAN UNMONITORED AREA ANALYSIS

EPA's 8-hour ozone projection procedure also includes an unmonitored area analysis (EPA, 2007) that has been codified in MATS. The unmonitored area analysis uses the future-year 8-hour ozone Design Value projection procedure applied to each grid cell in the modeling domain. In this procedure, the current-year Design Values (DVC) are interpolated to each grid cell in the modeling domain. This interpolation scheme uses the modeled concentration gradients. RRFs are then obtained for each grid cell in the modeling domain using essentially the same approach as used for the monitored ozone projections, only using the modeled data within each grid cell rather than near a grid cell as done for the projections at the monitor.

Figure 2-1 displays the interpolated current year 8-hour ozone Design Values (DVC) and projected 8-hour ozone Design Values (DVFs) for the 2010 Base Case using the MATS unmonitored area analysis. Interpolated current year ozone DVCs in excess of 80 ppb are estimated to the south, west and northwest of Denver stretching to Fort Collins and then west of Fort Collins. In fact, the MATS interpolation procedure estimates 12 grid cells of current-year DVCs in excess of the 85 ppb NAAQS that occurs west of the Fort Collins (Figure 2-1, left). The projected DVFs for the 2010 base case (Figure 2-1, right) have greatly reduced the spatial extent of the DVFs in excess of 80 ppb and the 12 cells with DVCs exceeding the 85 ppb NAAQS have been reduced by half to 6 grid cells in the 2010 base case emissions scenario.

Figure 2-2 displays the unmonitored area analysis projected DVFs for the 2010 Control 1 (left) and 2010 Control 2 (right) emission scenarios. There are slight reductions in the 2010 DVFs over the 2010 Base Case, which can be seen more clearly in the difference plots seen in Figure 2-3. The 6 remaining grid cells with projected DVFs that are 85 ppb or higher in the 2010 Base case are reduced to 4 and 3 grid cells in the, respectively, 2010 Control 1 and Control 2 emission scenarios.

EPA guidance stresses that the unmonitored area test has more uncertainties than the projections at the monitors and it should be treated separately from the monitor based attainment demonstration test (EPA, 2007). EPA further notes that while it is expected that additional emission controls will likely be needed to eliminate predicted exceedances of the ozone NAAQS in the monitor based attainment test, the same requirements may not be appropriate in unmonitored areas. In any event, EPA recommends that areas of predicted violations in the unmonitored area test be scrutinized and understood to determine whether they are likely to really exist in the ambient air, or whether they may be caused by an error or uncertainties in the modeling system. At a minimum, it may be appropriate to deploy additional ozone monitors to such areas. In the case of the Denver ozone modeling, higher ozone concentrations are estimated west of Fort Collins than at the locations of the two monitors in Fort Collins on some days and this does not appear to be due to an error in the modeling system. Whether it may be due to uncertainties in the modeling system can not be determined. However, it does not seem implausible that higher ozone values could exist west of the Fort Collins West monitoring site.

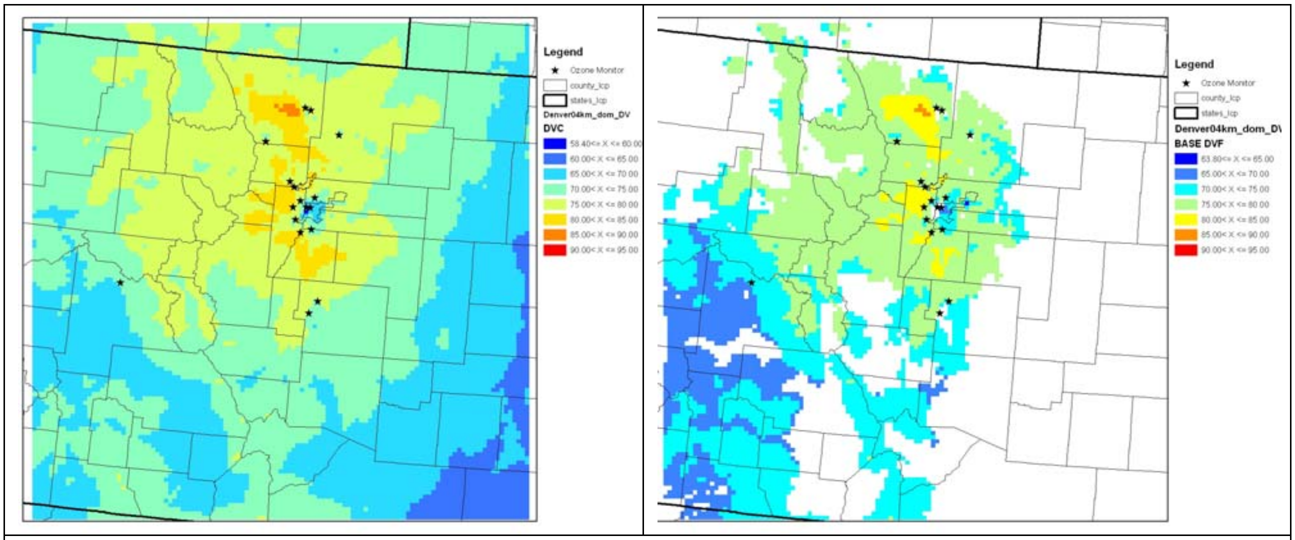

Figure 2-1. Interpolated current year 8-hour ozone Design Values (DVC; left) and projected 2010 Base Case 8-hour ozone Design Values (DVF; right).

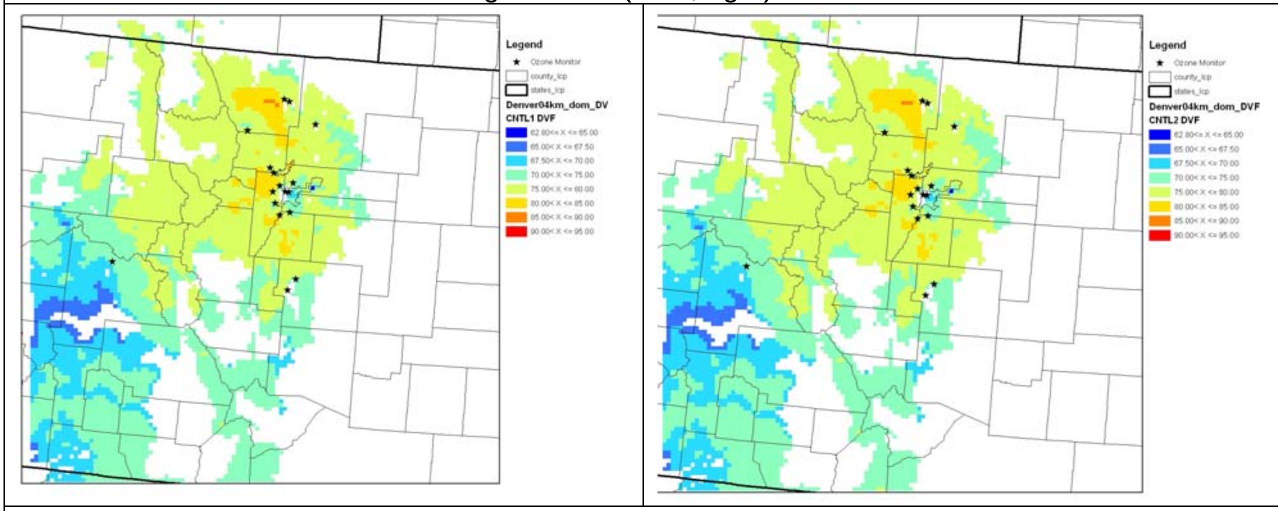

Figure 2-2. Projected 2010 8-hour ozone Design Values (DVF) for the 2010 Control 1 (left) and Control 2 (right) emission scenarios.

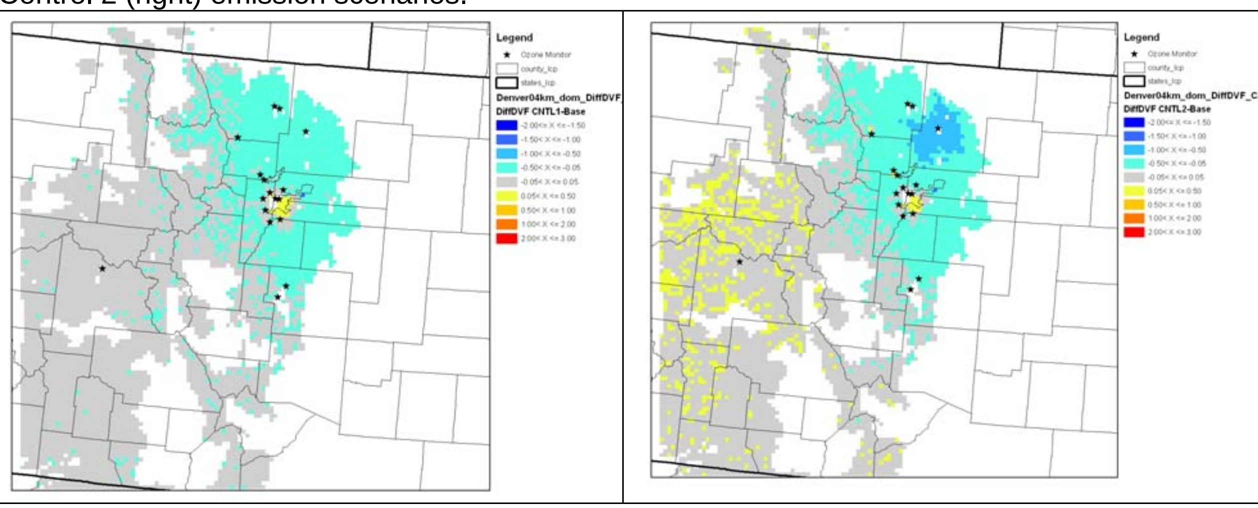

Figure 2-3. Differences in projected 2010 8-hour ozone Design Values (DVF) between the 2010 Control 1 (left) and 2010 Control 2 (right) and the 2010 Base Case.

3.0 ALTERNATIVE 2010 OZONE PROJECTIONS AND ADDITIONAL MODEL METRICS

3.1 INTRODUCTION

As noted in Chapter 2, the maximum projected 2010 8-hour ozone Design Value (DVF) at any monitor for the 2010 Base, Control 1 and Control 2 emission scenarios is 84 ppb at the Rocky Flats North (RFNO) and Fort Collins West (FTCW) monitoring sites, so passes the modeled attainment demonstration test. As these DVFs are 82 ppb or higher, then a Weight of Evidence (WOE) analysis is required to corroborate the modeled attainment demonstration test. The WOE analysis examines observed emissions and air quality data and their trends, assesses the conceptual model of ozone formation in the region, examines additional modeling metrics and performs additional analysis. All of the elements of the WOE analysis are examined together to determine whether the preponderance of evidence suggests that Denver area will in fact achieve attainment of the 0.08 ppm 8-hour ozone National Ambient Air Quality Standard (NAAQS) by 2010. Below we provide additional modeling metrics and alternative ozone projection procedures that are one component of a WOE analysis.

3.2 ALTERNATIVE 2010 OZONE PROJECTIONS PROCEDURES

Several alternative 2010 ozone projection procedures were analyzed for the 2010 Base Case, Control 1 and Control 2 scenarios to estimate the uncertainties in the projection procedures and provide confidence that passing the modeled attainment demonstration test does indicate attainment will likely be achieved in 2010. These alternative ozone projection procedures differ in the days used and how modeled ozone near the monitor is selected to construct the RRFs. Six additional ozone projection procedures were analyzed, in addition to the EPA guidance default approach discussed in Chapter 2:

> Minimum 5 Days to Develop RRF using 85-70 ppb Sliding Threshold (5dth): In the EPA default approach, modeling days are selected for use in constructing RRFs based on whether the maximum daily maximum 8-hour ozone concentration near the monitor (with 7 x 7 array of grid cells) in the 2006 Base Case is greater than a threshold, with the threshold determined when at least 10 days are obtained for the RRF. In this alternative projection approach, we require a minimum of 5 modeled days to construct the RRFs.
>
> Use of 80 ppb Cutoff Threshold and Minimum of 1 Day (1dth80): The second alternative ozone projection approach uses an 80 ppb cutoff threshold and RRFs are allowed to be calculated with as few as one modeling day.
>
> Use of 75 ppb (1dth75) and 70 ppb (1dth70) Cutoff Thresholds: These two alternative ozone projection approaches use cutoff thresholds of 75 and 70 ppb.
>
> Use of 5 x 5 and 3 x 3 Array of Grid Cells: Select the maximum daily maximum 8-hour ozone concentration from a 5 x 5 or 3 x 3 array of grid cells centered on the monitor, instead of using a 7 x 7 array as used in the EPA default procedure.

In regards to these last two alternative 2010 ozone projection methods, Figure 3-1 displays the sizes of the arrays of 7 x 7, 5 x 5 and 3 x 3 4 km grid cells around the monitors in the DMA. With the EPA default 7 x 7 array of grid cells around each monitor, there is a lot of overlap of the areas searched to obtain the maximum daily maximum 8-hour ozone concentrations near a monitor used in the RRFs. This can potentially result in selecting the same modeled concentrations from nearby grid cells to develop the RRFs for different monitors. Using the tighter 5 x 5 and 3 x 3 array of grid cells centered on each monitor (Figure 3-1b) reduces the overlap among nearby monitors and potentially retains the different characteristics of the monitoring sites, if such differences were captured by the model. For example, the CAMP, and other more urban Denver monitoring sites, are clearly affected by the high NOx concentrations that inhibit ozone formation. Use of the 7 x 7 array of grid cells results in selecting maximum modeled concentrations that are potentially outside of the influence of the downtown Denver high NOx concentrations for use in the RRFs thereby not capturing the NOx inhibition effect of these monitoring sites (Figure 3-1).

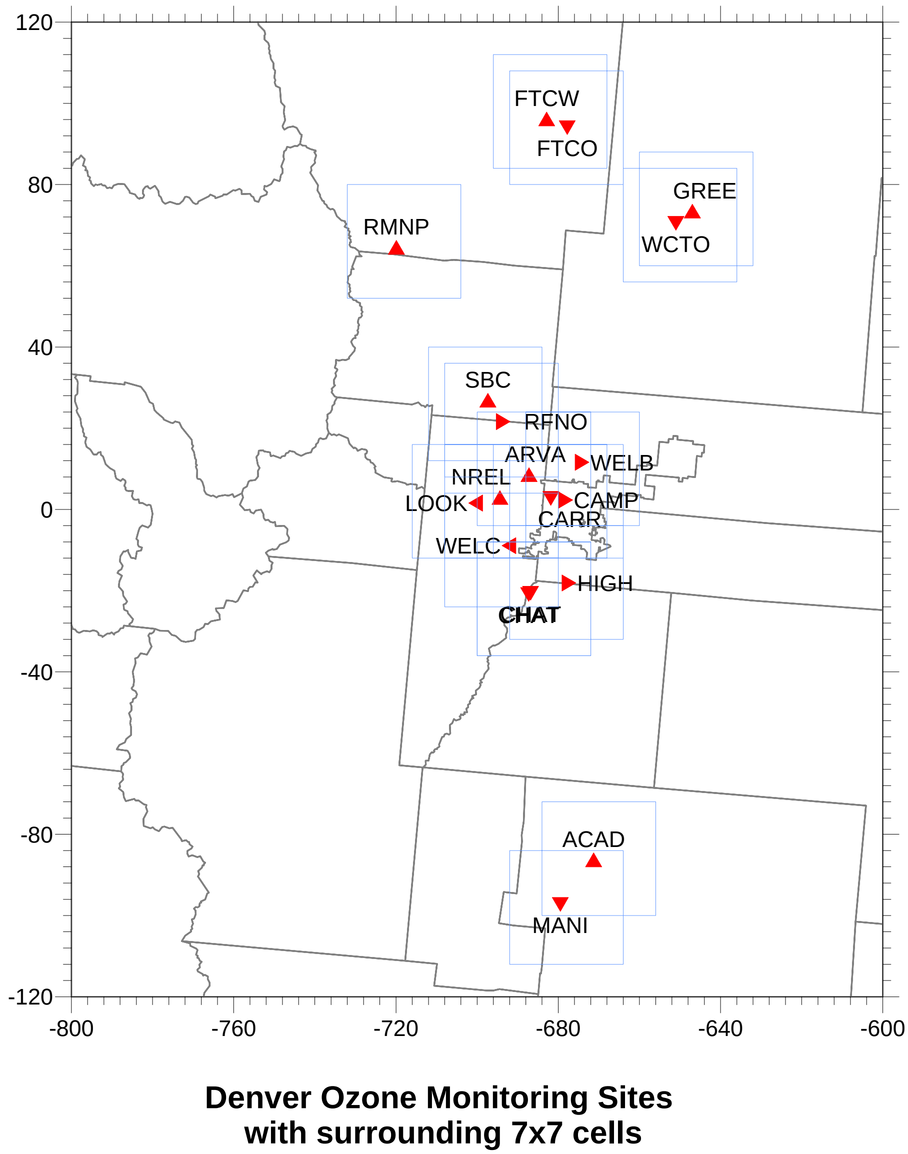

Figure 3-1a. Arrays of 7 x 7 4 km grid cells around monitors in the DMA.

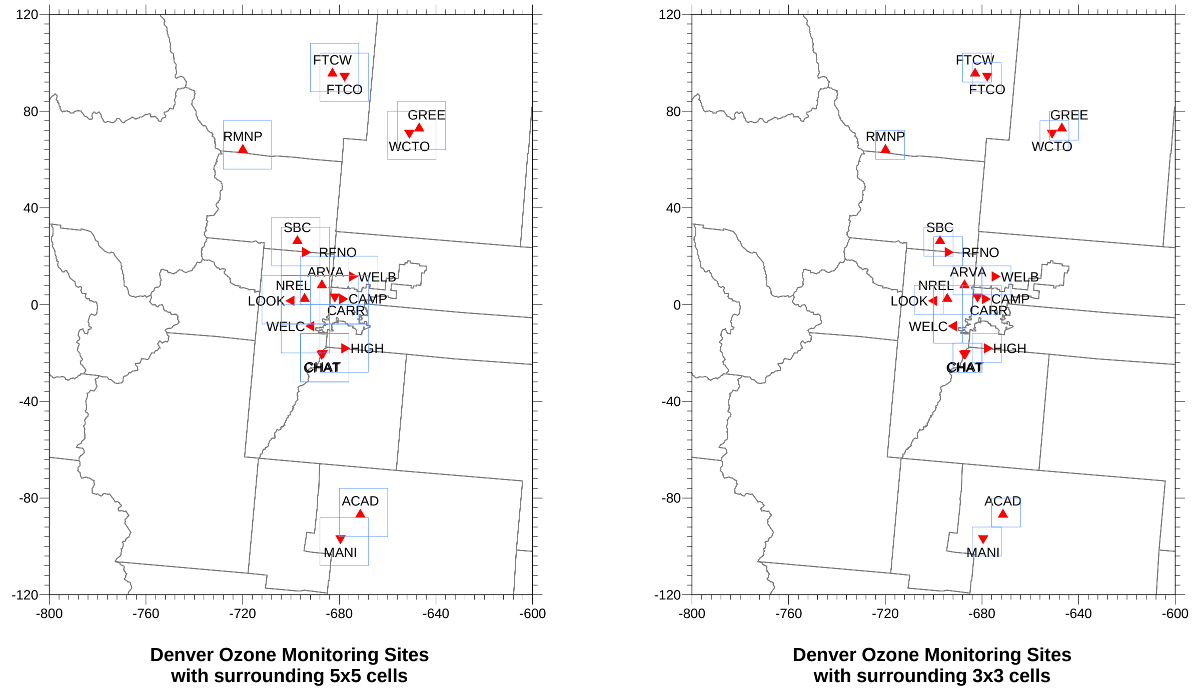

Figure 3-1b. Arrays of 5 x 5 (left) and 3 x 3 (right) 4 km grid cells around monitors in the DMA.

Table 3-1 lists the projected 2010 DVFs at the RFNO and FTCW monitoring sites for the EPA guidance default and the six alternative ozone projection procedures discussed above. Also shown in Table 3-1 are the ozone cutoff thresholds and number of days used in calculating the RRFs for each alternative 2010 ozone project method and the RFNO and FTCW monitoring sites. Results for all monitoring sites in the DMA are shown in Table 3-2. It should be noted that there is really no one "correct" method for projecting future year ozone concentrations that has been proven the most reliable. Methods based on just a few number of days have been shown to be less robust than ones based on more days. And it is logical that methods based on modeled concentrations closer to the observed 8-hour ozone Design Values would be more representative of the conditions that produced those Design Values than methods based on days with much higher or lower ozone concentrations than the Design Values.

<u>2010 Base Case</u>: For the 2010 Base Case, the projected 2010 DVF using the EPA guidance default approach was 84.9 ppb at both the RFNO and FTCW monitoring sites. Some of the six alternative projection approaches result in increases, whereas others in decreases relative to the EPA default approach in the projected 2010 DVFs at these two sites. The projected DVFs at RFNO for the 2010 Base Case range from 84.5 to 85.2 ppb with an average value of 84.9 ppb. A similar range for the FTCW monitor is 84.6 to 85.2 ppb with an average of 84.9 ppb. At the RFNO monitoring site 3 of the 7 projection methods pass the modeled attainment demonstration test (43%), while at the FTCW 5 of the 7 methods pass the test (71%).

<u>2010 Control 1 Case</u>: A majority of the 2010 ozone projection procedures pass the modeled attainment demonstration test at both the RFNO (4 out of 7, 57%) and FTCW (6 out of 7, 86%) monitoring sites. 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. And at the FTCW monitoring site the projected DVFs range from 84.4 to 85.0 ppb with an average of 84.7 ppb.

2010 Control 2 Case: The 2010 projected DVFs at RFNO for 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 the FTCW monitoring site where the 2010 projected DVFs range from 84.3 to 84.8 ppb with an average of 84.5 ppb.

An examination of the different 2010 ozone projection methods across monitoring sites shows no method is trending toward estimating higher or lower DVFs than the EPA default method across all monitoring sites. This is clearly shown in Table 3-1 for the RFNO and FTCW monitoring sites where, in most cases, a method in which the projected DVF at RFNO is greater than the EPA default method is below the EPA default method at FTCW and vice versa. The possible exception to this is at the downtown ozone monitors where as the array of grid cells becomes smaller, the projected DVF goes up. For example, at the CAMP monitor and the 2010 Control 1 case the projected DVF using the 7 x 7, 5 x 5 and 3 x 3 array of grid cells are, respectively, 56.0, 56.9 and 57.5 ppb (Table 3-2). This reflects the selection of modeling results closer to the urban core where the model is less responsive. It is encouraging that the EPA default 2010 ozone projection approach falls in between the alternative approaches and, in almost all cases, the average of the seven ozone projection approaches equals the EPA default method approach.

In conclusion, the alternative ozone projection approaches support the findings using the EPA default approach that the 2010 Base Case will likely achieve attainment in the Denver region of the 0.08 ppm 8-hour ozone NAAQS. The ozone projection methods indicate that there will be more certainty that the Denver region will achieve 8-hour ozone attainment in 2010 under the 2010 Control 1 emissions scenario.

Table 3-1. Projected 2010 8-hour ozone Design Values (DVFs) at the Rocky Flats North (RFNO) and Fort Collins West (FTCW) monitoring sites using the EPA guidance default approach and the six alternative projection approaches and the 2010 Base, Control 1 and Control 2 emission scenarios.

Alternative 2010 Ozone Projection Procedures									
Name	**DVC**	**EPA**	**5dth**	**1dth80**	**1dth75**	**1dth70**	**5x5**	**3x3**	**Avg**
2010 Base Case (Base) DVFs (ppb)									
Rocky Flats North	85.0	84.9	85.2	85.1	84.9	85.0	85.0	84.5	84.9
Fort Collins - West	86.0	84.9	84.6	84.6	84.9	85.1	84.8	85.2	84.9
2010 Control Strategy No. 1 (Cntl1) DVFs (ppb)									
Rocky Flats North	85.0	84.8	85.1	85.0	84.8	85.0	84.9	84.3	84.8
Fort Collins - West	86.0	84.7	84.4	84.4	84.7	84.9	84.6	85.0	84.7
2010 Control Strategy No. 2 (Cntl2) DVFs (ppb)									
Rocky Flats North	85.0	84.7	85.1	84.9	84.8	84.9	84.8	84.3	84.8
Fort Collins - West	86.0	84.5	84.3	84.3	84.5	84.7	84.5	84.8	84.5
Cut-Off Concentration (ppb)									
Rocky Flats North		78	81	80	75	70	76	75	
Fort Collins - West		76	81	80	75	70	75	73	
Number of Days Used									
Rocky Flats North		10	6	7	19	27	11	10	
Fort Collins - West		10	5	5	13	22	10	10	

Table 3-2a. Projected 2010 8-hour ozone Design Values (DVFs) at monitoring sites in the DMA using the EPA guidance default approach, the six alternative projection approaches and the 2010 Base Case modeling results.

2010 Base Case								
Name	DVC	**base**	**5dth**	**1dth80**	**1dth75**	**1dth70**	**5x5**	**3x3**
Welby	70.0	70.2	69.4	69.4	70.3	71.1	70.4	71.4
Highland	78.0	77.3	76.2	77.4	77.5	78.0	77.6	78.0
S. Boulder Creek	81.0	80.8	80.5	80.5	80.5	80.5	80.8	80.5
Denver - CAMP	56.0	56.0	55.8	55.8	56.2	56.7	56.8	57.3
Carriage	74.0	74.1	73.8	73.8	74.3	75.0	75.0	74.8
Chatfield State Park	84.0	83.4	83.0	83.3	83.6	84.0	83.2	82.9
USAF Academy	73.0	72.0	72.4	72.2	72.0	72.2	72.1	72.3
Manitou Springs	74.0	73.7	73.7	73.6	73.8	73.5	73.6	73.7
Arvada	79.0	79.2	78.9	78.9	79.4	79.7	79.5	79.4
Welch	75.0	75.0	75.0	75.0	74.8	74.9	74.5	74.6
Rocky Flats North	85.0	84.9	85.2	85.1	84.9	85.0	85.0	84.5
NREL	82.0	82.3	82.6	82.5	82.2	82.0	82.0	81.8
Fort Collins - West	86.0	84.9	84.6	84.6	84.9	85.1	84.8	85.2
Fort Collins	74.0	73.0	72.8	72.8	73.0	73.3	73.3	73.6
Greeley - Weld	78.0	77.7	78.0	77.5	77.7	77.7	77.7	77.8
Gunnison	68.0	67.8	67.9	68.0	67.9	67.8	67.8	67.8
Larimer	76.0	75.2	75.0	75.0	75.0	75.2	75.2	75.2
Larimer	76.0	75.2	75.0	75.0	75.0	75.2	75.2	75.2

Table 3-2b. Projected 2010 8-hour ozone Design Values (DVFs) at monitoring sites in the DMA using the EPA guidance default approach, the six alternative projection approaches and the 2010 Control 1 Case modeling results.

2010 Control Strategy No. 1 (Cntl1)								
Name	**DVC**	**EPA**	**5dth**	**1dth80**	**1dth75**	**1dth70**	**5x5**	**3x3**
Welby	70.0	70.2	69.2	69.2	70.3	71.2	70.3	71.4
Highland	78.0	77.2	76.0	77.2	77.4	78.0	77.5	77.9
S. Boulder Creek	81.0	80.7	80.4	80.4	80.4	80.4	80.7	80.3
Denver - CAMP	56.0	56.0	55.7	55.7	56.2	56.7	56.9	57.5
Carriage	74.0	74.1	73.7	73.7	74.3	75.1	75.1	75.0
Chatfield	84.0	83.3	82.8	83.1	83.6	83.9	83.1	82.8
USAF Academy	73.0	71.9	72.3	72.1	71.9	72.1	72.0	72.2
Manitou Springs	74.0	73.7	73.7	73.6	73.8	73.4	73.6	73.7
Arvada	79.0	79.1	78.9	78.9	79.4	79.7	79.4	79.3
Welch	75.0	75.0	75.0	75.0	74.7	74.8	74.5	74.5
Rocky Flats North	85.0	84.8	85.1	85.0	84.8	85.0	84.9	84.3
NREL	82.0	82.2	82.5	82.4	82.1	82.1	81.9	81.7
Fort Collins - West	86.0	84.7	84.4	84.4	84.7	84.9	84.6	85.0
Fort Collins	74.0	72.9	72.7	72.7	72.9	73.1	73.1	73.5
Greeley - Weld	78.0	77.4	77.7	77.1	77.4	77.4	77.4	77.5
Gunnison	68.0	67.8	67.9	68.0	67.9	67.8	67.8	67.8
Larimer	76.0	75.1	74.9	74.9	74.9	75.1	75.1	75.1
Larimer	76.0	75.1	74.9	74.9	74.9	75.1	75.1	75.1

Table 3-2c. Projected 2010 8-hour ozone Design Values (DVFs) at monitoring sites in the DMA using the EPA guidance default approach, the six alternative projection approaches and the 2010 Control 2 Case modeling results.

2010 Control Strategy No. 2 (Cntl2)								
Name	**DVC**	**EPA**	**5dth**	**dth80**	**1dth75**	**1dth70**	**5x5**	**3x3**
Welby	70.0	70.2	69.1	69.1	70.3	71.2	70.3	71.3
Highland	78.0	77.1	75.9	77.2	77.4	78.0	77.5	77.9
S. Boulder Creek	81.0	80.6	80.3	80.3	80.4	80.4	80.6	80.3
Denver - CAMP	56.0	55.9	55.7	55.7	56.2	56.7	56.9	57.5
Carriage	74.0	74.0	73.6	73.6	74.3	75.0	75.1	75.0
Chatfield State Park	84.0	83.3	82.7	83.1	83.5	83.9	83.0	82.8
USAF Academy	73.0	71.9	72.3	72.1	71.9	72.1	72.0	72.2
Manitou Springs	74.0	73.7	73.7	73.6	73.8	73.4	73.6	73.7
Arvada	79.0	79.1	78.8	78.8	79.3	79.7	79.3	79.2
Welch	75.0	74.9	74.9	74.9	74.7	74.8	74.4	74.5
Rocky Flats North	85.0	84.7	85.1	84.9	84.8	84.9	84.8	84.3
NREL	82.0	82.1	82.3	82.3	82.1	82.0	81.9	81.6
Fort Collins - West	86.0	84.5	84.3	84.3	84.5	84.7	84.5	84.8
Fort Collins	74.0	72.7	72.6	72.6	72.7	73.0	73.0	73.3
Greeley - Weld	78.0	77.0	77.4	76.7	77.0	77.1	77.1	77.2
Gunnison	68.0	67.9	67.9	68.0	67.9	67.9	67.9	67.8
Larimer	76.0	75.1	74.9	74.9	74.9	75.1	75.1	75.1
Larimer	76.0	75.1	74.9	74.9	74.9	75.1	75.1	75.1

Table 3-2d. Ozone cut-off threshold concentrations used in the 2010 8-hour ozone Design Value projections at monitoring sites in the DMA using the EPA guidance default and the six alternative projection approaches.

Cut-Off Concentration (ppb)							
Name	**EPA**	**5dth**	**1dth80**	**1dth75**	**1dth70**	**5x5**	**3x3**
Welby	77.0	80.0	80.0	75.0	70.0	76.0	74.0
Highland	78.0	83.0	80.0	75.0	70.0	78.0	76.0
S. Boulder Creek	78.0	80.0	80.0	75.0	70.0	76.0	75.0
Denver - CAMP	78.0	80.0	80.0	75.0	70.0	74.0	72.0
Carriage	78.0	80.0	80.0	75.0	70.0	76.0	73.0
Chatfield State Park	78.0	81.0	80.0	75.0	70.0	78.0	77.0
USAF Academy	75.0	78.0	80.0	75.0	70.0	75.0	73.0
Manitou Springs	74.0	78.0	80.0	75.0	70.0	73.0	72.0
Arvada	78.0	80.0	80.0	75.0	70.0	76.0	75.0
Welch	78.0	81.0	80.0	75.0	70.0	77.0	76.0
Rocky Flats North	78.0	81.0	80.0	75.0	70.0	76.0	75.0
NREL	78.0	81.0	80.0	75.0	70.0	77.0	75.0
Fort Collins - West	76.0	81.0	80.0	75.0	70.0	75.0	73.0
Fort Collins	76.0	80.0	80.0	75.0	70.0	75.0	73.0
Greeley - Weld	75.0	77.0	80.0	75.0	70.0	74.0	73.0
Gunnison	74.0	78.0	80.0	75.0	70.0	74.0	73.0
Larimer	77.0	80.0	80.0	75.0	70.0	77.0	76.0
Larimer	77.0	80.0	80.0	75.0	70.0	77.0	76.0

Table 3-2e. Number of modeling days used in the 2010 8-hour ozone Design Value projections at monitoring sites in the DMA using the EPA guidance default and the six alternative projection approaches.

Number of Days Used							
Name	**EPA**	**5dth**	**1dth80**	**1dth75**	**1dth70**	**5x5**	**3x3**
Welby	11	6	6	13	29	10	10
Highland	14	5	9	17	37	10	11
S. Boulder Creek	10	6	6	18	28	12	11
Denver - CAMP	10	7	7	14	31	12	10
Carriage	10	6	6	15	32	10	12
Chatfield State Park	11	5	6	18	33	11	10
USAF Academy	10	6	3	10	30	10	10
Manitou Springs	10	5	3	9	25	12	12
Arvada	10	7	7	16	25	12	11
Welch	10	5	5	17	31	12	11
Rocky Flats North	10	6	7	19	27	11	10
NREL	11	5	6	16	30	13	10
Fort Collins - West	10	5	5	13	22	10	10
Fort Collins	12	5	5	14	24	10	10
Greeley - Weld	10	5	2	10	22	11	11
Gunnison	10	7	3	9	14	10	10
Larimer	10	5	5	13	21	10	10
Larimer	10	5	5	13	21	10	10

3.3 ADDITIONAL MODELING METRICS

EPA's 8-hour ozone modeling guidance recommends calculating additional modeling metrics from the current year base case to future year control scenarios to assure that they indicate the modeled ozone concentrations are going down. These additional modeling metrics examine the ozone differences between the current year base case and future year emission scenarios in the modeling domain to assure that ozone is going down, on average, across the entire nonattainment area (NAA) rather than just limited to a few key monitoring sites.

The changes in daily maximum 8-hour ozone concentrations between the 2006 Base Case and 2010 emission scenarios were calculated across grid cells in the Denver NAA and across all days in the June-July 2006 modeling episode. The changes 8-hour ozone concentrations are calculated for values above four separate threshold concentrations: 85, 80, 75 and 70 ppb. These modeling metrics consist of the following:

Total Ozone: 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.

Grid Cells: Number of grid cell-days with modeled daily maximum 8-hour ozone concentrations greater than the threshold for all grid cells in the Denver NAA and days from the June-July 2006 episode.

Grid Cell-Hours: Number of grid cell-hours with modeled running 8-hour ozone concentrations greater than the threshold for all grid cells in the Denver NAA and hours during the June-July 2006 episode.

Figure 3-2 displays the percent change in the Total Ozone, Grid Cells and Grid Cell-Hours between the 2006 Base Case and the 2010 emission scenarios. Using the 70 ppb threshold, there are small reductions between 2006 and 2010 in the Total Ozone (~-5%) and Grid Cell (~-3%) modeling metrics. However, the emission reductions between 2006 and 2010 are having their intended effect in reducing the elevated 8-hour ozone concentrations. For example, the changes in Total Ozone, Grid Cells and Grid Cell-Hours greater than the 85 ppb threshold modeling metrics between the 2006 and 2010 Base Cases are -21%, -14% and -22%, respectively. These reductions are even greater for the 2010 Control 1 case (-28%, -17% and -25%) and even greater still for the 2010 Control 2 scenario.

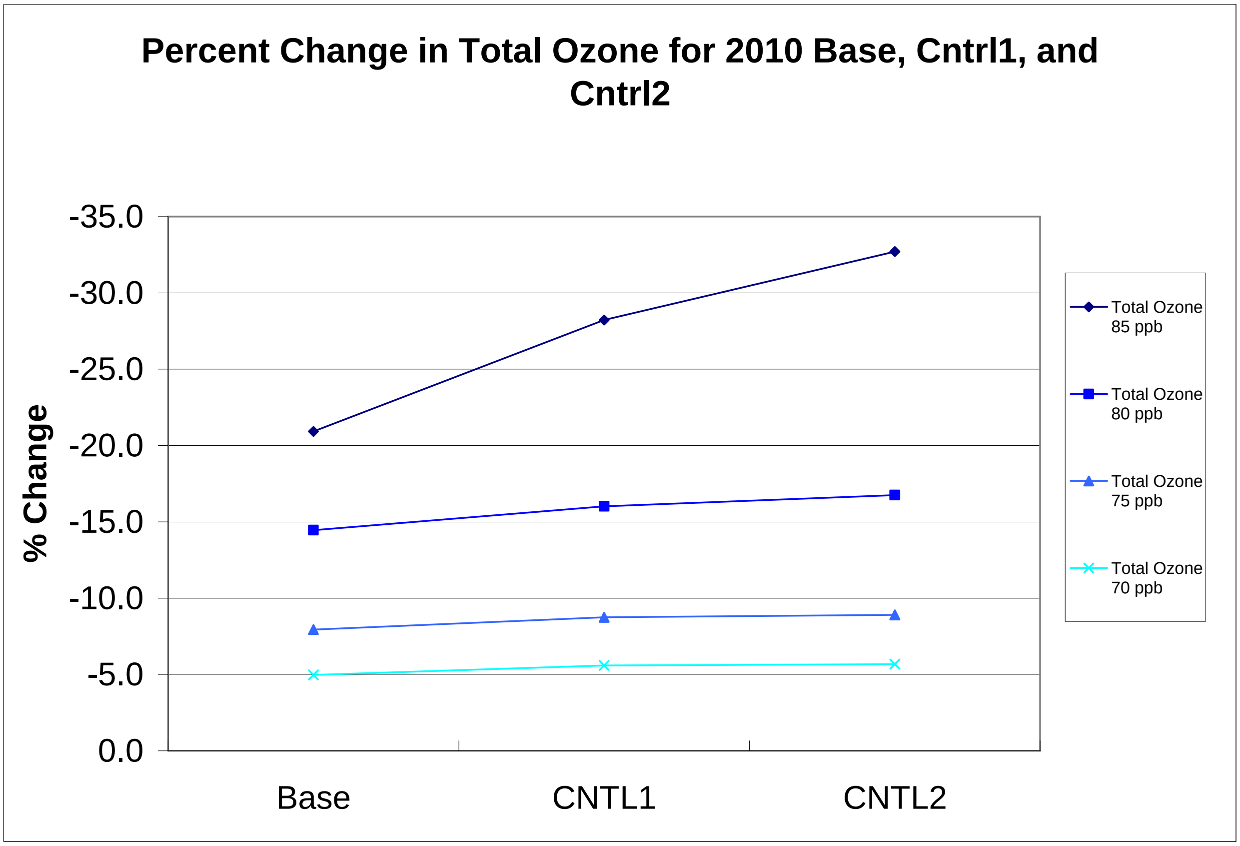

Figure 3-2a. Percent change in Total Ozone greater than 85, 80, 75 and 70 ppb between the 2006 Base Case and the 2010 Base Case (Base), Control 1 (CNTL1) and Control 2 (CNTL2) emission scenarios.

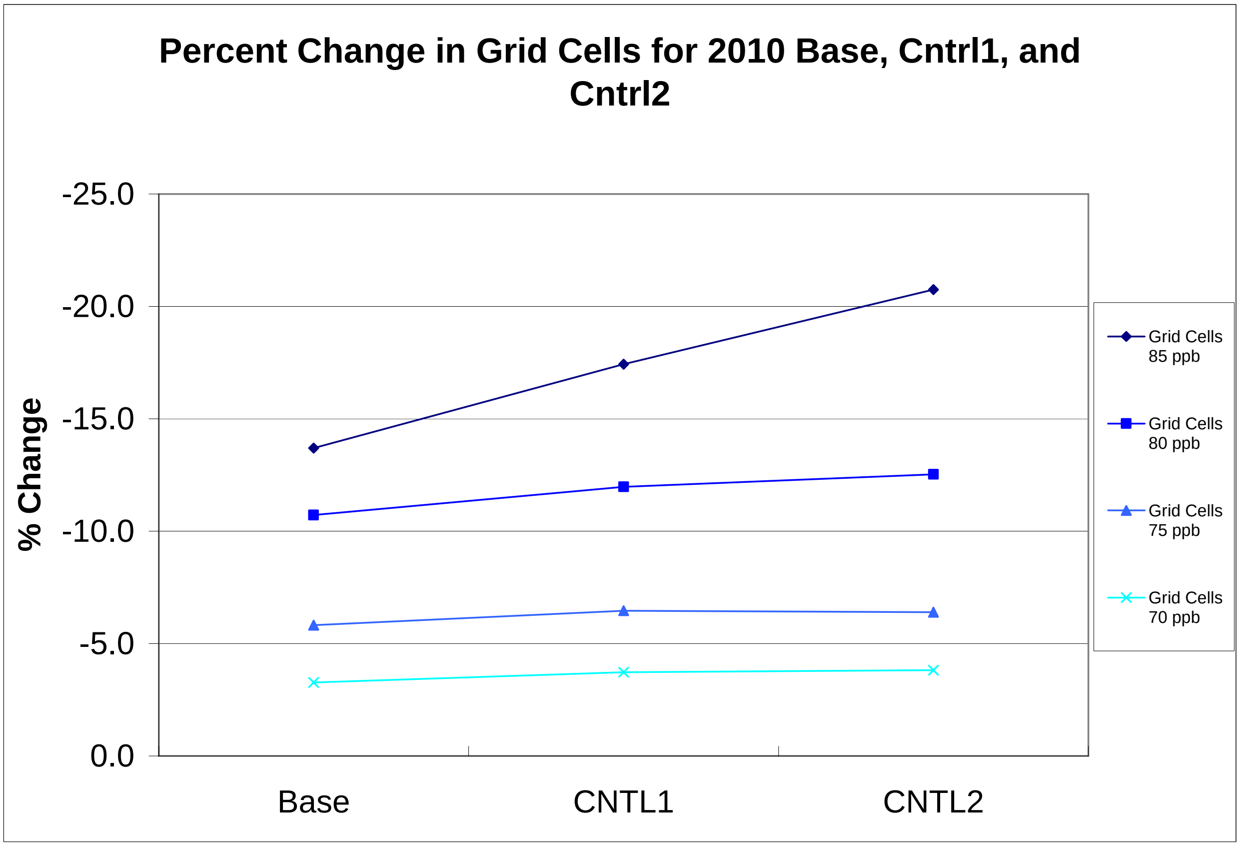

Figure 3-2b. Percent change in Grid Cells greater than 85, 80, 75 and 70 ppb between the 2006 Base Case and the 2010 Base Case (Base), Control 1 (CNTL1) and Control 2 (CNTL2) emission scenarios.

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