Draft Final Report

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

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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 applied to the June-July 2006 episode using 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 modeling 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., 2008a). A revised final CAMx 2006 base case simulation was performed and a comprehensive model performance evaluation was conducted (Morris et al., 2008b). 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 after the examination of many model performance displays and metrics we concluded that the model was simulating the observed ozone sufficiently well for use in making future year ozone projections (Morris et al., 2008b).

FINAL 2010 CONTROL STRATEGY

The Final 2010 Control Strategy was based on a slight modification of the CDPHE's Ozone Action Plan – Alternative Proposal #2 (CDPHE, 2008) presented at the Colorado Air Quality Control Commission (AQCC) hearing December 11-12, 2008 (AQCC, 2008). The Denver 8-hour ozone SIP modeling demonstrates that attainment of the 0.08 ppm ozone NAAQS will be achieved in 2010 under the 2010 Base Case emissions scenario. The Final 2010 Control Strategy contained two additional federally-enforceable control measures beyond the 2010 Base Case (CDPHE, 2008; AQCC, 2008) that provides more certainty that ozone attainment will be achieved in 2010:

- 85% control of VOC emissions on all condensate tanks with annual VOC emissions greater than 2 tons per year; and
- Revisions to condensate tank flaring controls that phases in the auto igniters on flares controlling tanks greater than or equal to 50 TPY by May 1, 2009 and on all remaining tanks greater than 2 TPY in the Denver NAA by May 1, 2010.

These control measures reduce VOC emissions from oil and gas (O&G) development sources that are primarily located in Weld County in the DMA. Across Colorado, the Final 2010 Control Strategy reduces anthropogenic VOC emissions by -3.6% from 2010 Base Case conditions.

2010 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 modeling results for the 2006 base case and 2010 emission scenarios in a relative fashion where modeled relative response factors (RRFs) are used to scale the current year observed 8-hour ozone Design Value (DVC) to obtain the projected future year 8-hour ozone Design Value (DVF):

DVF = DVC x 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 based on ozone observations from the 2006-2007 period.

Table ES-1 displays the projected future year 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and the Final 2010 Control Strategy emission scenarios. The first set of DVFs in Table ES-1 (columns 4 and 5) follow EPA's guidance approach (EPA, 2007) to truncate the final DVFs to the nearest ppb for comparison with the NAAQS. Whereas the last set of DVFs for the 2010 Base Case and Final 2010 Control Strategy (columns 6 and 7 in Table ES-1) display the DVFs to the nearest tenth of a ppb so that we can distinguish any differences in the ozone projections between the 2010 Base Case and Final 2010 Control Strategy. The maximum projected 8-hour ozone Design Value for the 2010 Base Case and Final 2010 Control Strategy is 84 ppb at the Rocky Flats North (RFNO) and Fort Collins West (FTCW) monitoring sites. As all projected 2010 8-hour ozone Design Values are below 85 ppb, the 2010 Base Case and Final 2010 Control Strategy both pass the modeled ozone 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 two additional control measures in the Final 2010 Control Strategy reduces the DVF at the FTCW monitoring site by 0.1 ppb (84.8 ppb) and has no effect at the RFNO monitoring site (84.9 ppb). Of the 18 sites listed in Table 2-3, the Final 2010 Control Strategy is projected to reduce the 2010 DVF by 0.1 ppb at four sites and by 0.2 ppb at one site,

with the remainder of the monitoring sites having identical 2010 DVFs for the 2010 Base Case and Final 2010 Control Strategy. The largest ozone reduction due to the control measures in the Final 2010 Control Strategy (0.2 ppb) occurs at the Weld County Tower monitoring site (Greely), which is not surprising given that it is the closest monitor to the O&G developments that occur primarily in Weld County which is where the largest VOC emission reductions occur in the Final 2010 Control Strategy control measures.

Table ES-1. Projected 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and Final 2010 Control Strategy.

Name	County	DVC (2005-2007)	2010 DVF (EPA Guidance)		2010 DVF (nearest 0.1 ppb)	
			Base Case	Final Strategy	Base Case	Final Strategy
Welby	Adams	70.0	70	70	70.2	70.2
Highland	Arapahoe	78.0	77	77	77.3	77.3
S. Boulder Creek	Boulder	81.0	80	80	80.8	80.7
Denver - CAMP	Denver	56.0	56	56	56.0	56.0
Carriage	Denver	74.0	74	74	74.1	74.1
Chatfield State Park	Douglas	84.0	83	83	83.4	83.4
USAF Academy	El Paso	73.0	72	72	72.0	72.0
Manitou Springs	El Paso	74.0	73	73	73.7	73.7
Arvada	Jefferson	79.0	79	79	79.2	79.1
Welch	Jefferson	75.0	75	75	75.0	75.0
Rocky Flats North	Jefferson	85.0	84	84	84.9	84.9
NREL	Jefferson	82.0	82	82	82.3	82.2
Fort Collins - West	Larimer	86.0*	84	84	84.9	84.8
Fort Collins	Larimer	74.0	73	73	73.0	73.0
Greeley-WeldTower	Weld	78.0	77	77	77.7	77.5
Gunnison	Gunnison	68.0	67	67	67.8	67.8
Larimer	Larimer	76.0	75	75	75.2	75.2
Larimer	Larimer	76.0	75	75	75.2	75.2

* Fort Collins West DVC based on two-years of measured data. With the 2008 zone season data now available the 2006-2008 8-hour ozone Design Value at Fort Collins is now 82 ppb.

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.

Figure ES-1 displays the interpolated current year 8-hour ozone Design Values (DVC; left) and projected 8-hour ozone Design Values (DVFs) for the 2010 Base Case (right) 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 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 Final 2010 Control Strategy (left) and the differences in the 2010 DVFs between the 2010 Base Case and Final 2010 Control Strategy (right). There are slight reductions in the 2010 DVFs in the Final 2010 Control Strategy over the 2010 Base Case, which can be seen more clearly in the difference plot seen in Figure ES-2 (right). The 6 remaining grid cells with projected DVFs that are 85 ppb or higher in the 2010 Base case are reduced to 5 grid cells in the Final 2010 Control Strategy.

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. 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.

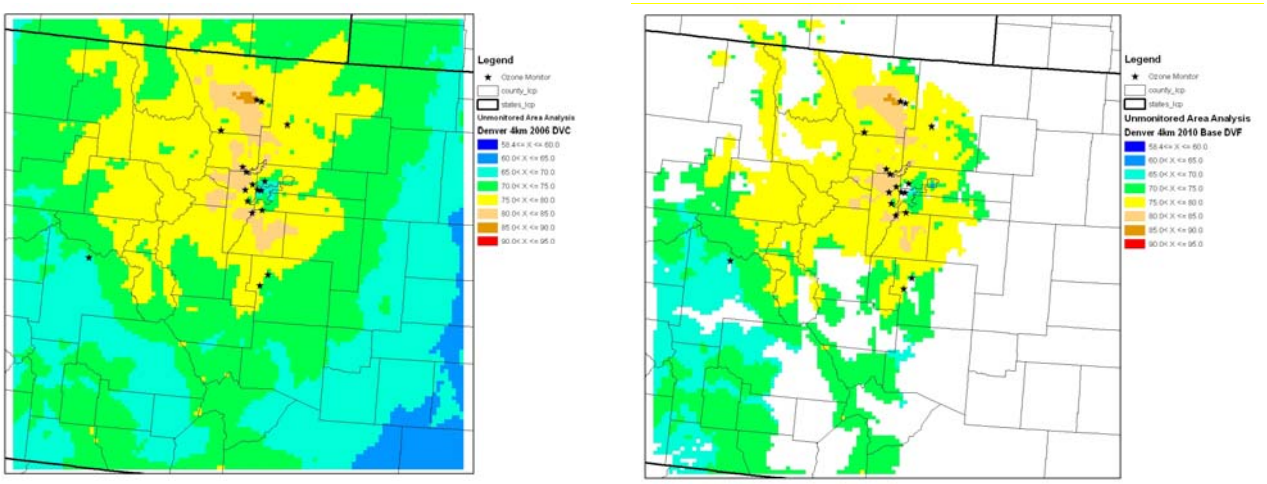


Figure ES-1. Interpolated current year 8-hour ozone Design Values (DVC; left) and projected 2010 Base Case 8-hour ozone Design Values (DVF; right).

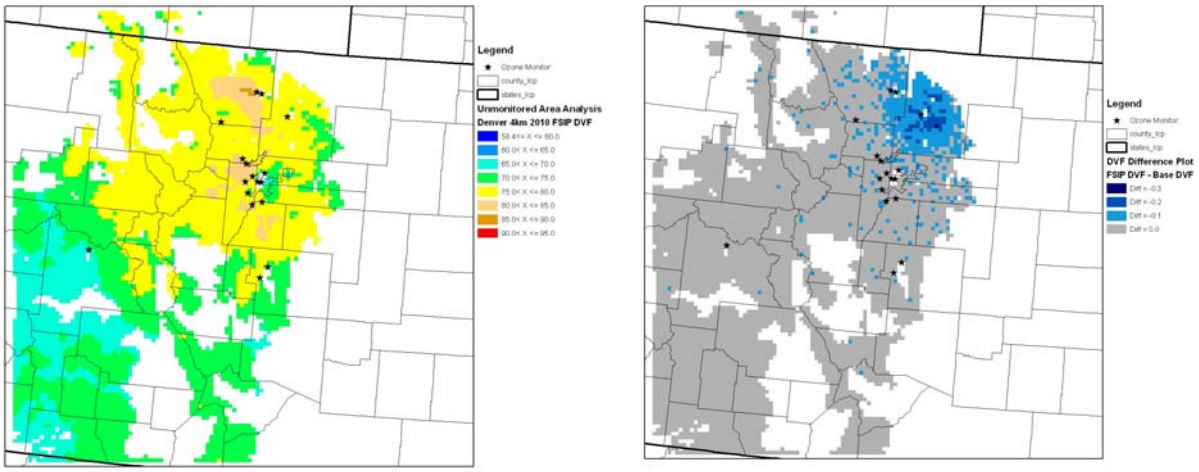


Figure ES-2. Projected 2010 8-hour ozone Design Values (DVF) for the Final 2010 Control Strategy (left) and differences in projected 2010 DVFs between the 2010 Base Case and Final 2010 Control Strategy (2010 Control – 2010 Base) (right).

2010 OZONE ATTAINMENT DEMONSTRATION MODELING

The 2010 ozone modeling indicates that the Denver region would achieve attainment of the 1997 0.08 ppm 8-hour ozone NAAQS by 2010 under both the 2010 Base Case and Final 2010 Control Strategy. Both 2010 emission scenarios pass the modeled attainment demonstration test at the monitoring sites (EPA, 2007). Examining the unmonitored area analysis, both 2010 emission scenarios have several grid cells (5-6) that are projected to still exceed the ozone NAAQS in 2010. However, these residual 2010 ozone exceedances were due to the assumed 86 ppb current year DVC at the Fort Collins West monitoring site that is based on two years (2005-2007) of ozone observations. The inclusion of ozone observations from 2008 results in an 8-hour ozone Design Value for the Fort Collins West monitoring site of 82 ppb, which if used for the DVC would eliminate the residual ozone exceedance areas in the unmonitored area analysis. Although both 2010 emissions scenarios demonstrate attainment of the ozone NAAQS in 2010, the additional controls in the Final 2010 Control Strategy 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 is a lot of year-to-year variability in the meteorological for the Denver area that greatly affects 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, at least 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 early 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 1997 0.08 ppm 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 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 Denver 8-hour ozone 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.

This document presents the ozone attainment demonstration modeling of the 2010 Base Case and Final 2010 Control Strategy for the Denver 8-hour ozone SIP that was approved by the Colorado Air Quality Control Commissions (AQCC) during their December 11-12, 2008 hearing.

1.2 APPROACH

The Denver 8-hour ozone attainment demonstration modeling was performed using the following meteorological, emissions and photochemical grid models: 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). These models were applied to a June-July 2006 modeling period for the purposes of demonstrating attainment of the 8-hour ozone standard by 2010. Figure 1-1 displays the 36/12/4 km modeling domains used for the MM5 and SMOKE/CAMx modeling. CAMx simulations were first performed for the 36 km continental U.S. Inter-RPO modeling domain and the results processed to generate boundary conditions (BCs) for the 12 km modeling domain (i.e., one-way grid nesting between the 36 km and 12 km CAMx domains). CAMx was then used to simulate ozone formation within the 12/4 km modeling domain using two-way interactive grid nesting (Figure 1-1b). Once the 12 km BCs were defined from the 2006 and

2010 36 km CAMx simulations, sensitivity and control strategy evaluations runs were made on the 12/4 km modeling domain. The Denver 8-hour ozone SIP modeling work was performed mostly during the 2008 calendar year and produced the following reports:

- 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).
  - http://www.ozoneaware.org/documents/MM5_Eval_DENSIP_Feb25_2008.pdf
- 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., 2008a).
  - http://www.ozoneaware.org/documents/Prelim_Ozone_Eval_Denver_SIP_Feb27_2008.pdf
- Final base case modeling and model performance evaluation for the June-July 2006 DMA episode (Morris et al., 2008b).
  - http://www.ozoneaware.org/documents/modeling/Denver_2006MPE_DraftFinal_Aug29_2008.pdf
- 2010 base case modeling, emission sensitivity tests and ozone source apportionment modeling (McNally et al., 2008b).
  - http://www.ozoneaware.org/documents/modeling/Exec_Sum1.pdf
- 2010 control strategy and attainment demonstration modeling (Morris et al., 2008c).
  - http://www.ozoneaware.org/documents/modeling/Denver_2010ControlStrat_Draft_Sep22_2008.pdf

The last report listed above (Morris et al., 2008c) presented ozone attainment demonstration modeling for a 2010 Base Case, a proposed 2010 SIP Control Strategy (Cntl1) and a 2010 Control Strategy that included the proposed federally-enforceable SIP control measures as well as additional state-only control measures (Cntl2). The Colorado Air Quality Control Commission (AQCC) held a hearing on the proposed Denver 8-hour ozone 2010 SIP Control Strategy and passed a motion for a slightly modified Ozone Action Plan to produce a Final 2010 Control Strategy for the Denver 8-hour ozone SIP (AQCC, 2008).

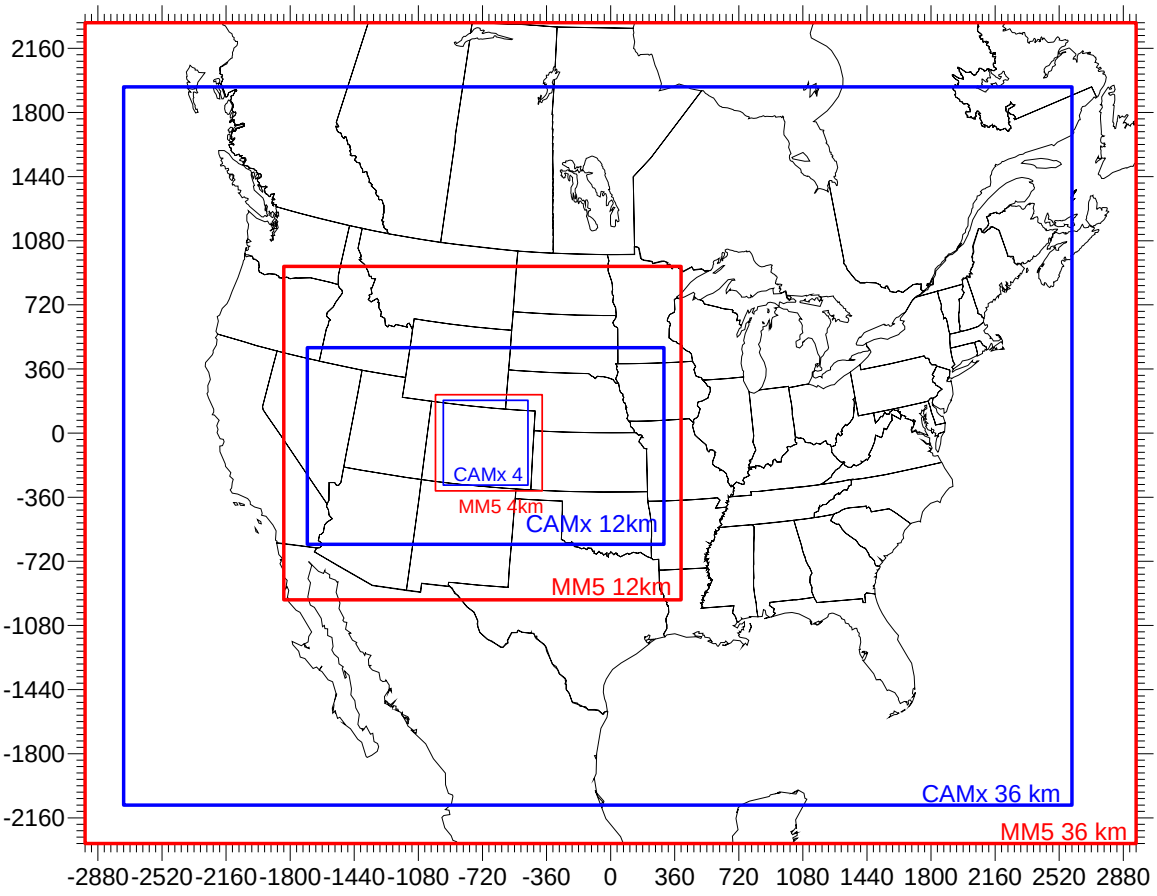


Figure 1-1a. Nested 36/12/4 km modeling domains for the Denver 8-hour ozone modeling study. Blue line domains are for CAMx/SMOKE domains that are nested in the MM5 red line domains.

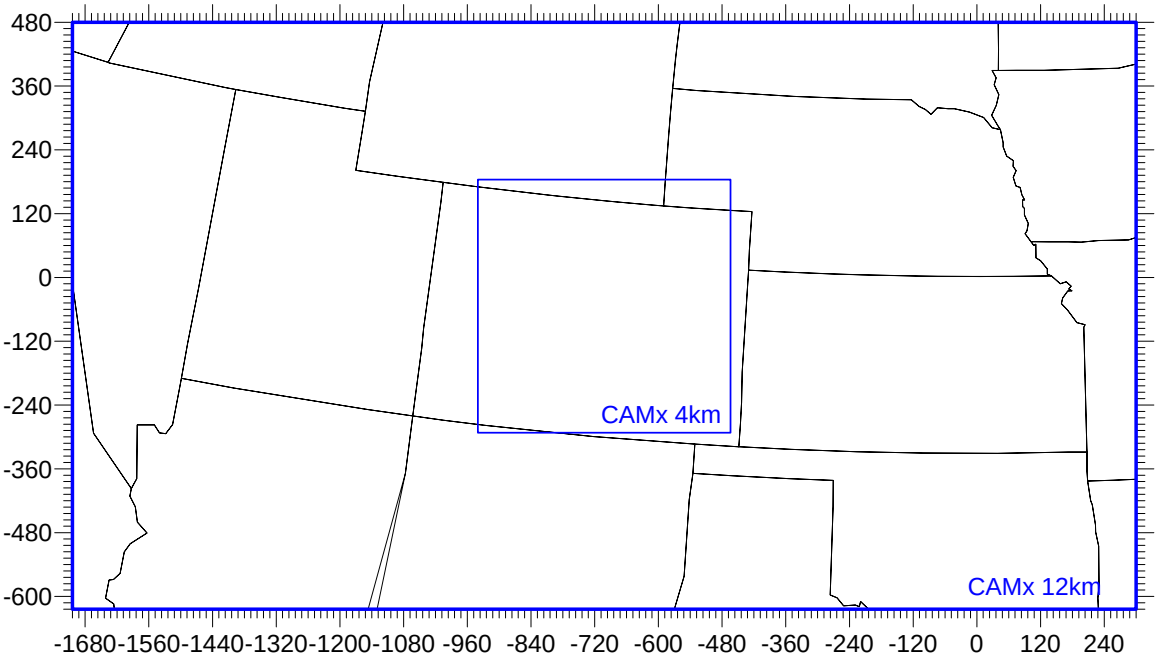


Figure 1-1b. Nested 12/4 km modeling domains for the Denver CAMx air quality and SMOKE emissions modeling.

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., 2008a,b) and the 2010 Base Case and emissions sensitivity scenarios 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 for on-road mobile sources and 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., 2008a,b). 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 and 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 emission scenarios.

Colorado emissions for the 2010 Base Case and Final 2010 Control Strategy were either provided by the CDPHE or, in the case of on-road mobile sources, modeled using the CONCEPT MV and SMOKE-MOBILE6 on-road mobile source emissions modeling systems. Table 1-1 summarizes the VOC, NOx and CO emissions within the 4 km Colorado domain (Figure 1-1b) for the 2006 Base Case, the 2010 Base Case and the Final 2010 Control Strategy. Between the 2006 and 2010 Base Case emissions scenarios, VOC, NOx and CO emissions are estimates to be reduced by, respectively, 42 tons per day (TPD) (-1%), 50 TPD (-5%) and 386 TPD (-10%). Note that the emissions in Table 1-1 are model-ready emissions for the July 27, 2006 representative day (Thursday) and may differ from the planning inventories and other modeling days. In particular, the model-ready emissions have day-specific adjustments for several source categories (e.g., on-road mobile sources and biogenic emissions) and the VOC emissions have been speciated into the CB05 chemical mechanism used in the CAMx photochemical grid model so that any organic compounds that are considered non-reactive in the original VOC inventories have been dropped for ozone modeling.

The Denver 8-hour ozone SIP Final 2010 Control Strategy implemented two additional control measures over the 2010 Base Case (AQCC, 2008):

- 85% control of VOC emissions on all condensate tanks with annual VOC emissions greater than 2 tons per year; and
- Revisions to condensate tank flaring controls that phases in the auto igniters on flares controlling tanks greater than or equal to 50 TPY by May 1, 2009 and on all remaining tanks greater than 2 TPY in the Denver NAA by May 1, 2010.

The two control measures in the Final 2010 Control Strategy results mainly in VOC emission reductions over the 2010 Base Case. Across Colorado, the 2010 Final Control Strategy emissions scenario has 28 TPD less VOC emissions than the 2010 Base Case. This results in a -3.6 percent reduction in anthropogenic and a -0.6% reduction in total VOC emissions across Colorado over the 2010 Base Case due to the implementation of the two control measures in the

Final 2010 Control Strategy. Note that the flaring used in the condensate tank VOC control measure in the Final 2010 Control Strategy results in increases in NOx and CO emissions over the 2010 Base Case. NOx and CO emissions are estimated to be 0.04 and 0.21 TPD higher in the Final 2010 Control Strategy than the 2010 Base Case, respectively. However, these increases in NOx and CO emissions are minor representing less than 0.01% of the Colorado NOx and CO emissions.

Table 1-1. 2006 Base Case, 2010 Base Case and Final 2010 Control Strategy VOC, NOx and CO emissions (tons per day) across the Colorado 4 km domain.

Emissions Scenario	Total Colorado Emissions (tons/day) July 27, 2006		
	CO (tons/day)	NOx (tons/day)	VOC * (tons/day)
Total Colorado Emissions			
2006 Base Case	4401.1	930.7	4671.4
2010 Base Case	4015.2	880.7	4629.2
Final 2010 Control Strategy	4015.4	880.7	4601.6
Biogenic Emissions for Colorado 4 km Grid			
2006 MEGAN Biogenics	618.4	44.2	3871.5
Anthropogenic Colorado Emissions			
2006 Base Case	3782.8	886.5	799.9
2010 Base Case	3396.8	836.5	757.7
Final 2010 Control Strategy	3397.0	836.5	730.1
Percent Change in Total Colorado Emissions			
2006 Base Case	--	--	--
2010 Base Case	-8.8%	-5.4%	-0.9%
Final 2010 Control Strategy	-8.8%	-5.4%	-0.9%
Percent Anthropogenic in Total Colorado Emissions			
2006 Base Case	--	--	--
2010 Base Case	-10.2%	-5.6%	-5.3%
Final 2010 Control Strategy	-10.2%	-5.6%	-8.7%

* VOC emissions from CBO5 chemical mechanism.

2.0 2010 OZONE ATTAINMEANT DEMONSTRATION

2.1 INTRODUCTION

This section presents the 2010 ozone Design Value projections for the 2010 Base Case and the Final 2010 Control Strategy approved by the Colorado Air Quality Control Commissions at their December 11-12, 2008 hearing (AQCC, 2008). The future year ozone projections demonstrate that the Denver area will achieve the 0.08 ppm 8-hour ozone NAAQS by 2010 under the 2010 Base Case conditions. The 2010 Final Control Strategy includes federally-enforceable control measures that will be included in the Denver 8-hour ozone State Implementation Plan (SIP) that provide additional certainty that ozone attainment will be achieved in 2010. The 8-hour ozone projections are made using the CAMx modeling results for the 2006 Base Case (Morris et al., 2008a,b) and the 2010 Base Case and Final 2010 Control Strategy emission scenarios. These ozone projections are made using EPA's Modeled Attainment Test Software (MATS) tool that can be found at:

- http://www.epa.gov/scram001/modelingapps_mats.htm

The procedures used by MATS to make ozone projection are described in detail by McNally and co-workers (2008b) that presented the 8-hour ozone projections for the Denver 2010 Base Case and 2010 sensitivity simulations. Below we provide a brief overview of the ozone projection procedures used by MATS, whose results for the 2010 Base Case and Final 2010 Control Strategy are presented later in this Chapter.

2.2 OZONE PROJECTION PROCEDURES

The Denver 2010 8-hour ozone projections were made using default procedures in EPA's latest modeling guidance (EPA, 2007), with one exception that is 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 = [Σ 2010 scenario] / [Σ 2006 base case]

DVF = DVC x 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) at each monitoring site that serves as the starting point for the ozone projections.

   EPA guidance recommends using an average of three years of 8-hour ozone Design Values centered on the modeling year, which for the Denver June-July 2006 episode modeling would mean averaging 8-hour ozone Design Values from the 2004-2006, 2005-2007 and 2006-2008 periods. This results in averaging the fourth highest daily maximum

8-hour ozone concentration at a monitor across five years of data centered on 2006 using weighting factors of 1, 2, 3, 2, and 1 for the years 2004-2008, respectively. However, for the Denver 2010 8-hour ozone projections the "five year Design Value" approach recommended in EPA's guidance was not used as the DVCs for the following reasons:

a. The Denver 2010 ozone projections were initially made before the 2008 ozone season was completed so use of the "five year Design Value" approach for the DVCs that included 2008 observations was not possible.

b. Using such a "five year Design Value " approach would result in the DVCs that attain the 0.08 ppm 8-hour ozone NAAQS for all monitors in the Denver region, which seemed inconsistent with the designation of the Denver area as 8-hour ozone nonattainment in November 2007.

Thus instead, with one exception, for the DVCs the 8-hour ozone Design Values from the 2005-2007 three year period that resulted in Denver being classified as nonattainment were used. The exception is for the Fort Collins West ozone monitor that started monitoring in 2006 so the DVC was based on the average fourth highest measured 8-hour ozone for two years (2006-2007).

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 highest 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. If there are less than 5 modeled days with the 2006 base case highest daily maximum 8-hour ozone concentration near the monitor greater or equal to 70 ppb, then no RRF and 2010 ozone projection is made for that monitoring site.

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 OZONE ATTAINMENT DEMONSTRATION FOR THE 2010 BASE CASE AND THE FINAL 2010 CONTROL STRATEGY

The same emissions modeling procedures used for the 2006 Base Case and 2010 sensitivity tests and preliminary control strategies were used for the 2010 Base Case and Final 2010 Control Strategy (Morris et al, 2008c,d; McNally et al., 2008b). The on-road mobile source emissions were modeled using either the CONCEPT MV (area covered by the Denver link-based network) or SMOKE-MOBILE6. The two control measures for the Final 2010 Control Strategy were included in emissions files provided by the CDPHE/APCD. Table 1-1 presented in Chapter 1 summarizes the emissions within the Colorado 4 km grid domain for the 2006 Base Case, 2010 Base Case and Final 2010 Control Strategy. The Final 2010 Control Strategy was based on a slight modification to the CDPHE's Ozone Action Plan – Alternative Proposal #2 (CDPHE, 2008) presented at the Colorado Air Quality Control Commission hearing December 11-12, 2008 (AQCC, 2008) and contained two federally-enforceable control measures beyond the 2010 Base Case: 85% condensate tank VOC controls on tanks greater than 2 tpy and revised controls on condensate flaring.

2.3.1 Attainment Demonstration at the Monitoring Sites

Table 2-1 displays the projected future year 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and the Final 2010 Control Strategy emission scenarios. Included in this table are the 2010 DVFs (Table 2-1a) and the RRFs (Table 2-1b) the ozone cut-off threshold concentrations (Table 2-1c) and the number of modeling days (Table 2-1d) used in the construction of the RRFs. The first set of DVFs in Table 2-1a (columns 4 and 5) follow EPA's guidance approach (EPA, 2007) to truncate the final DVFs to the nearest ppb for comparison with the NAAQS. Whereas the last set of DVFs for the 2010 Base Case and Final 2010 Control Strategy display the DVFs to the nearest tenth of a ppb so that we can distinguish any differences in the ozone projections between the 2010 Base Case and Final 2010 Control Strategy. The maximum projected 8-hour ozone Design Value for the 2010 Base Case and Final 2010 Control Strategy is 84 ppb at the Rocky Flats North (RFNO) and Fort Collins West (FTCW) monitoring sites. As all projected 2010 8-hour ozone Design Values are below 85 ppb, the 2010 Base Case and Final 2010 Control Strategy both pass the modeled ozone 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 (Table 2-1a). The implementation of the federally-enforceable SIP control measures in the Final 2010 Control Strategy reduces the DVF at the FTCW monitoring site by 0.1 ppb (84.8 ppb) and has no effect at the RFNO monitoring site (84.9 ppb). Of the 18 sites listed in Table 2-1, the Final 2010 Control Strategy is projected to reduce the 2010 DVF by 0.1 ppb at four sites and by 0.2 ppb at one site, with the remainder of the monitoring sites having identical DVFs for the 2010 Base Case and Final 2010 Control Strategy. The largest ozone reduction due to the control measures in the Final 2010 Control Strategy (0.2 ppb) occurs at the Weld County Tower monitoring site (Greely), which is not surprising given that it is the closest monitor to the O&G developments that occur primarily in Weld County, which is where the largest VOC emission reductions occur due to the Final 2010 Control Strategy control measures. 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 2-1a. Projected 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and Final 2010 Control Strategy.

Name	County	DVC (2005-2007)	2010 DVF (EPA Guidance)		2010 DVF (nearest 0.1 ppb)	
			Base Case	Final Strategy	Base Case	Final Strategy
Welby	Adams	70.0	70	70	70.2	70.2
Highland	Arapahoe	78.0	77	77	77.3	77.3
S. Boulder Creek	Boulder	81.0	80	80	80.8	80.7
Denver - CAMP	Denver	56.0	56	56	56.0	56.0
Carriage	Denver	74.0	74	74	74.1	74.1
Chatfield State Park	Douglas	84.0	83	83	83.4	83.4
USAF Academy	El Paso	73.0	72	72	72.0	72.0
Manitou Springs	El Paso	74.0	73	73	73.7	73.7
Arvada	Jefferson	79.0	79	79	79.2	79.1
Welch	Jefferson	75.0	75	75	75.0	75.0
Rocky Flats North	Jefferson	85.0	84	84	84.9	84.9
NREL	Jefferson	82.0	82	82	82.3	82.2
Fort Collins - West	Larimer	86.0*	84	84	84.9	84.8
Fort Collins	Larimer	74.0	73	73	73.0	73.0
Greeley-WeldTower	Weld	78.0	77	77	77.7	77.5
Gunnison	Gunnison	68.0	67	67	67.8	67.8
Larimer	Larimer	76.0	75	75	75.2	75.2
Larimer	Larimer	76.0	75	75	75.2	75.2

* Fort Collins West DVC based on two-years of measured data. With the 2008 zone season data now available the 2006-2008 8-hour ozone Design Value at Fort Collins is now 82 ppb.

Table 2-1b. Relative Response Factors (RRFs) used to project 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and the Final 2010 Control Strategy.

Name	County	DVC	RRF	
			Base Case	Final Strategy
Welby	Adams	70.0	1.0042	1.0040
Highland	Arapahoe	78.0	0.9916	0.9915
S. Boulder Creek	Boulder	81.0	0.9976	0.9974
Denver - CAMP	Denver	56.0	1.0017	1.0014
Carriage	Denver	74.0	1.0022	1.0019
Chatfield State Park	Douglas	84.0	0.9934	0.9933
USAF Academy	El Paso	73.0	0.9873	0.9873
Manitou Springs	El Paso	74.0	0.9966	0.9966
Arvada	Jefferson	79.0	1.0026	1.0023
Welch	Jefferson	75.0	1.0004	1.0002
Rocky Flats North	Jefferson	85.0	0.9994	0.9992
NREL	Jefferson	82.0	1.0039	1.0036
Fort Collins - West	Larimer	86.0	0.9874	0.9869
Fort Collins	Larimer	74.0	0.9878	0.9871
Greeley-WeldTower	Weld	78.0	0.9964	0.9944
Gunnison	Gunnison	68.0	0.9984	0.9984
Larimer	Larimer	76.0	0.9903	0.9902
Larimer	Larimer	76.0	0.9903	0.9902

Table 2-1c. Ozone threshold Cutoff Concentration used to project 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and Final 2010 Control Strategy.

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

Table 2-1d. Number of days used to project 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case and Final 2010 Control Strategy.

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

2.3.2 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 so that the gridded DVCs may have some locations that are higher than the observed DVCs at the monitoring sites. 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 RRFs are based on the model estimates 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) 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 0.08 ppm NAAQS (i.e., 85 ppb or higher) that occur west of Fort Collins (Figure 2-1).

The projected DVFs for the 2010 Base Case (Figure 2-2) have greatly reduced the spatial extent of the DVFs in excess of 80 ppb and the 12 cells with DVCs exceeding the 0.08 ppm NAAQS have been reduced by half to 6 grid cells in the 2010 Base Case emissions scenario. Note that the unshaded areas in the unmonitored area analysis 2010 ozone projections are areas in which there were less than 5 days with 2006 Base Case daily maximum 8-hour ozone estimates of 70 ppb or greater so no 2010 ozone projection were made for those grid cells.

Figure 2-3 displays the unmonitored area analysis projected DVFs for the Final 2010 Control Strategy emissions scenario. There are slight reductions in the 2010 DVFs over the 2010 Base Case, which can be seen more clearly in the 2010 DVF difference plot shown in Figure 2-4. The 6 remaining exceedance grid cells with projected DVFs that are 85 ppb or higher in the 2010 Base case are reduced to 5 grid cells under the Final 2010 Control Strategy.

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. 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. These high 2010 projected ozone DVFs west of Fort Collins are driven by the high DVC of 86 ppb at the FTCW

monitor that is based on two-years (2006-2007) of monitoring data. When a third year of monitoring data is included (2008) the 8-hour ozone Design Value at FTCW is reduced from 86 ppb to 82 ppb. If the 82 ppb lower actual 8-hour ozone Design Value was used for the DVC at the FTCW monitor in the unmonitored area analysis instead of 86 ppb, there would be no grid cells exceeding the 8-hour ozone NAAQS in the unmonitored area analysis for both the 2010 Base Case and Final 2010 Control Strategy emission scenarios.

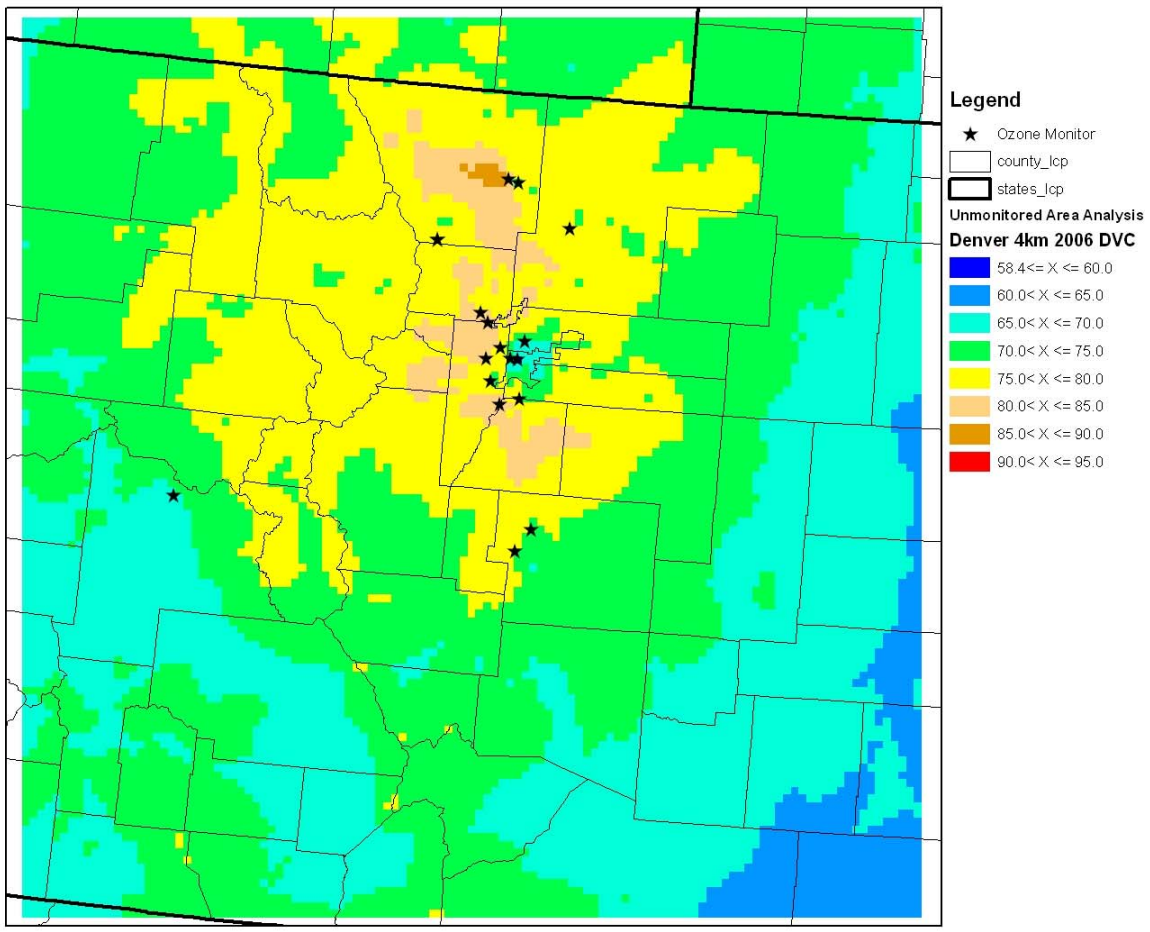


Figure 2-1. Interpolated current year observed 8-hour ozone Design Values (DVCs) using the MATS tool (ppb).

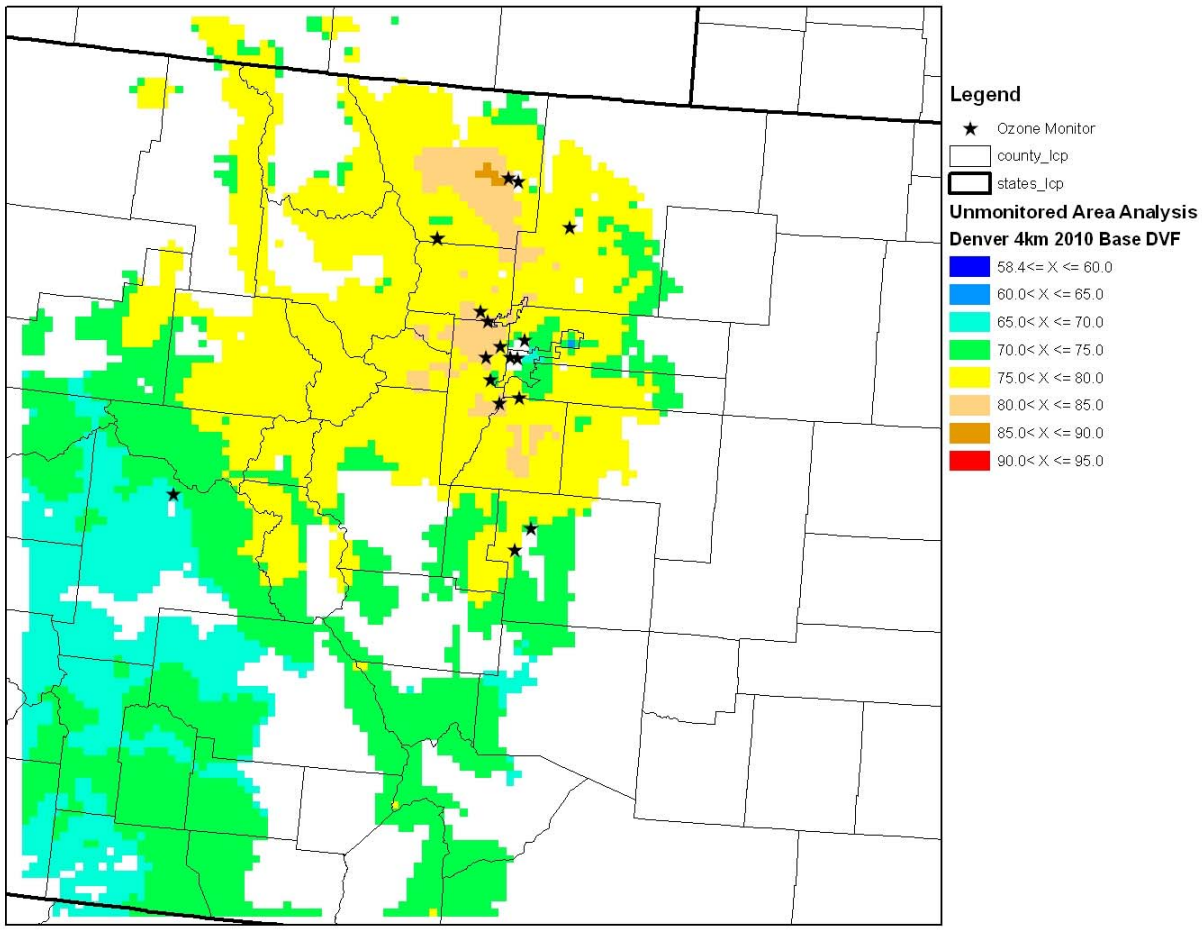


Figure 2-2. Projected 2010 8-hour ozone Design Values (DVFs) for the 2010 Base Case emissions scenario using the MATS tool (ppb).

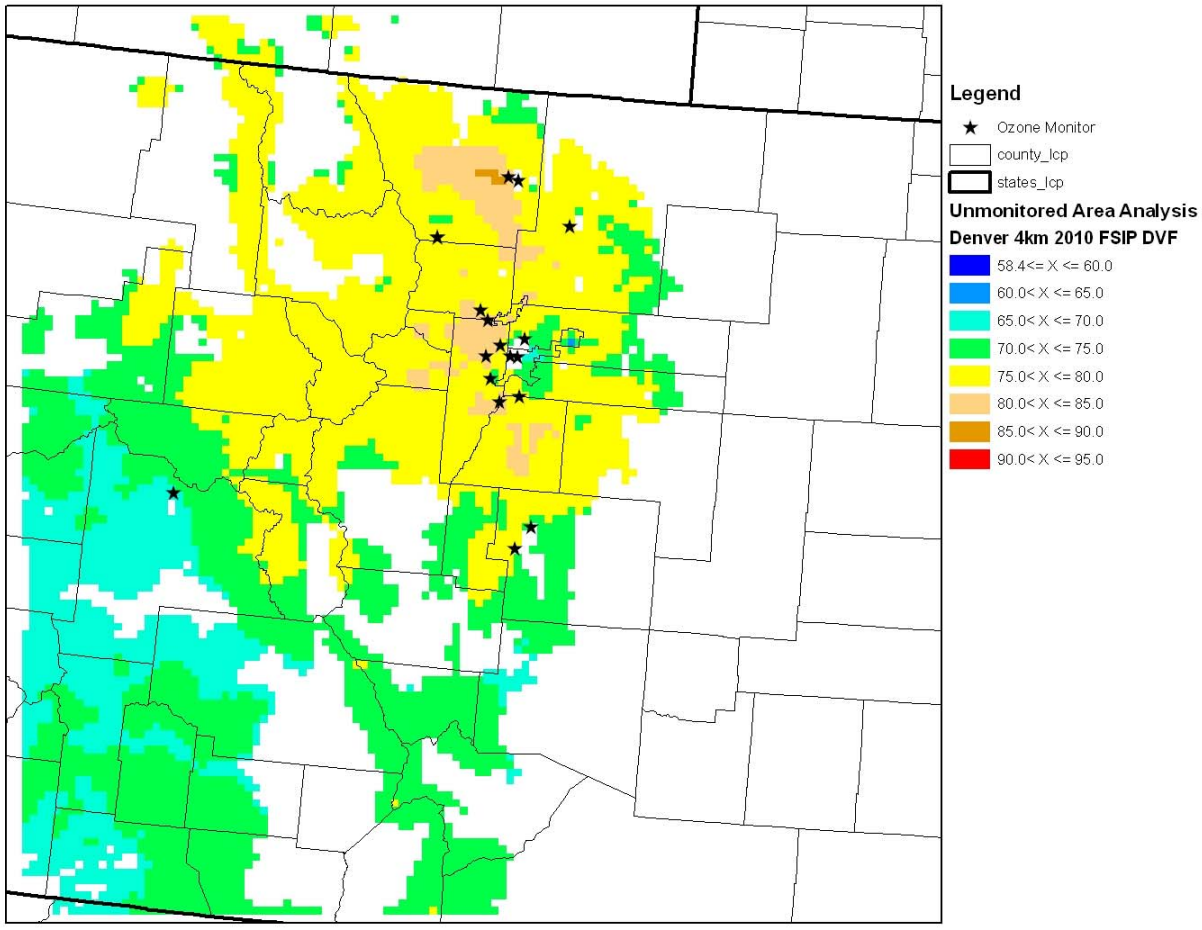


Figure 2-3. Projected 2010 8-hour ozone Design Values (DVFs) for the Final 2010 Control Strategy emissions scenario using the MATS tool (ppb).

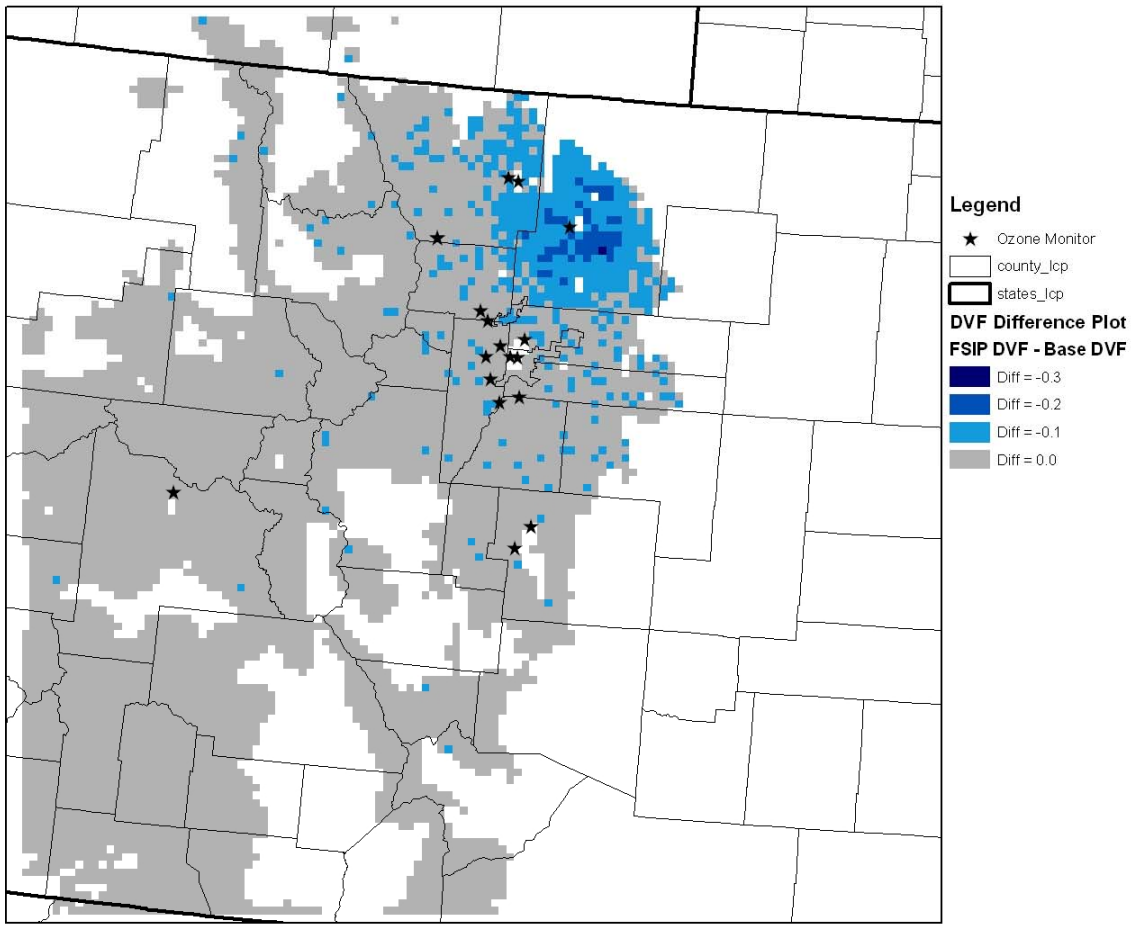


Figure 2-4. Differences in projected 2010 8-hour ozone Design Values (DVFs) between the 2010 Base Case and the Final 2010 Control Strategy emissions scenarios using the MATS tool (2010 Control – 2010 Base).

2.4 ATTAINMENT DEMONSTRATION CONCLUSIONS

The photochemical modeling of the Denver region demonstrates that the 2010 Base Case emissions scenario is sufficient to achieve attainment of the 0.08 ppm ozone NAAQS by 2010. The additional control measures in the Final 2010 Control Strategy provide additional assurances that ozone attainment will be achieved in the Denver area by 2010.

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 Case and Final 2010 Control Strategy is 84 ppb at the Rocky Flats North (RFNO) and Fort Collins West (FTCW) monitoring sites, so both 2010 emission scenarios pass the modeled attainment demonstration test. As these projected 2010 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 PROJECTION PROCEDURES

Several alternative 2010 ozone projection procedures were analyzed for the 2010 Base Case, and Final 2010 Control Strategy 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. 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:

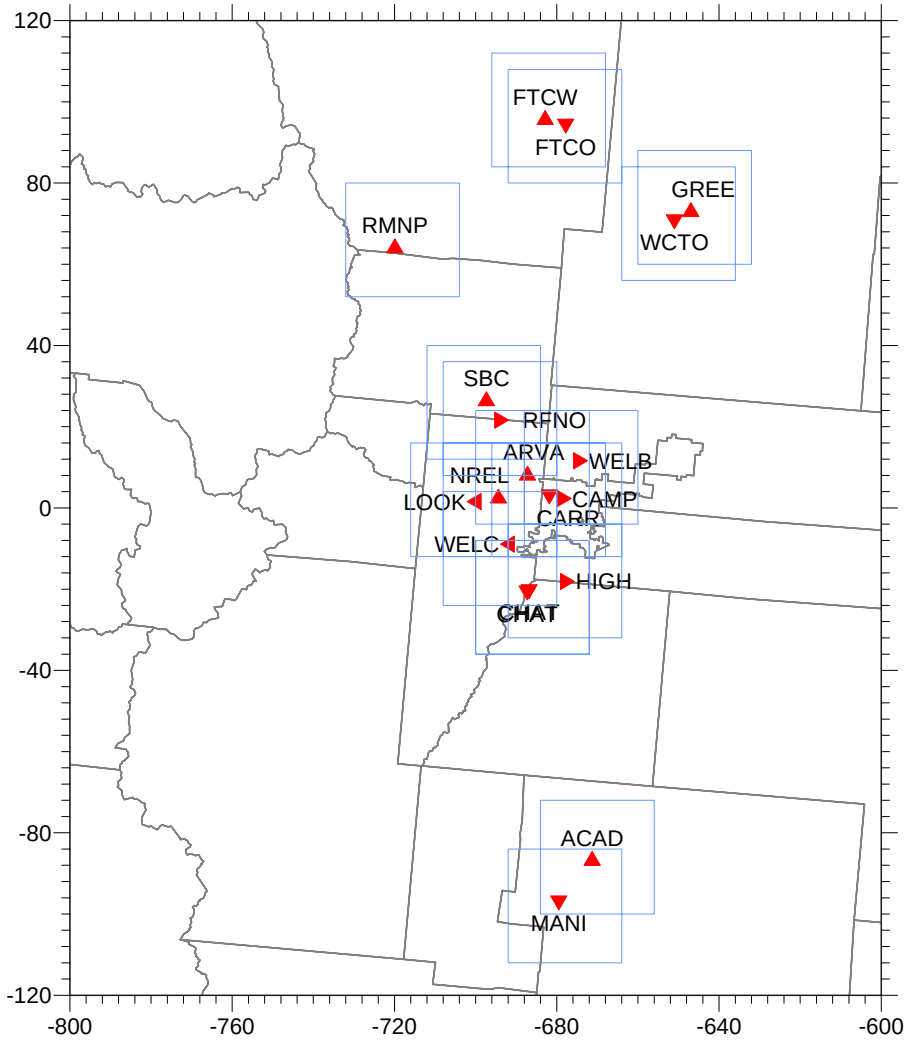
Minimum 5 Days to Develop RRF using 85-70 ppb Sliding Threshold (5dth): In the EPA default approach, modeling days are selected for use in constructing RRFs based on whether the maximum daily maximum 8-hour ozone concentration near the monitor (with 7 x 7 array of grid cells) in the 2006 Base Case is 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 maximum 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 monitor, and other more urban Denver monitoring sites, is clearly affected by the high NOx concentrations in metropolitan Denver 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 high NOx concentration region for use in the RRFs thereby not capturing the NOx inhibition effect of these monitoring sites in the metropolitan Denver region (Figure 3-1).



Denver Ozone Monitoring Sites with surrounding 7x7 cells

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

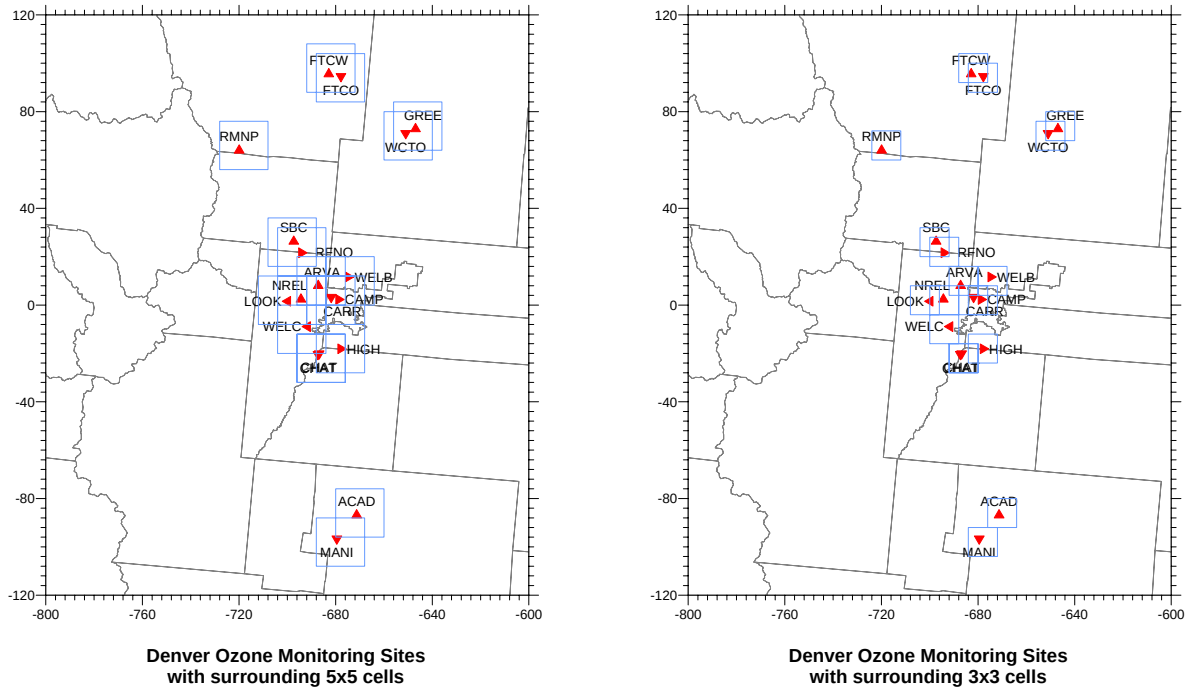


Figure 3-1b. Arrays of 5 x 5 (left) and 3 x 3 (right) 4 km grid cells around monitors in the DMA.

Table 3-1 lists the projected 2010 DVFs at the RFNO and FTCW monitoring sites for the 2010 Base Case and Final 2010 Control Strategy using 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.

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 DVF relative to the EPA default approach 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 84.950 ppb. A similar range for the FTCW monitor is 84.6 to 85.2 ppb with an average of 85.013 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%).

Final 2010 Control Strategy: The 2010 ozone projections at the RFNO monitoring site for the Final 2010 Control Strategy are the same as for the 2010 Base Case using all the alternative projections procedures (e.g., average 84.950 ppb). At the at the FTCW monitoring site, the projected DVFs for the Final 2010 Control Strategy range from 84.6 to 85.1 ppb with an average of 84.963 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 Base Case the projected DVF using the 7 x 7, 5 x 5 and 3 x 3 array of grid cells are, respectively, 56.0, 56.8 and 57.3 ppb (Table 3-2a). This reflects the selection of modeling results closer to the urban core where the model is less responsive and where ozone increases from the 2006 to 2010 due to NOx emissions reductions (NOx disbenefits). It is encouraging that the EPA default 2010 ozone projection approach falls in between the alternative approaches and, in most cases, the average of the seven ozone projection approaches is close to 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 Final 2010 Control Strategy.

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	84.950
Fort Collins - West	86.0	84.9	84.6	84.6	84.9	85.1	84.8	85.2	85.013
Final 2010 Control Strategy DVFs (ppb)									
Rocky Flats North	85.0	84.9	85.2	85.1	84.9	85.0	85.0	84.5	84.950
Fort Collins - West	86.0	84.8	84.6	84.6	84.8	85.0	84.8	85.1	84.963
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 Final 2010 Control Strategy modeling results.

Final 2010 Control Strategy								
Name	**DVC**	**EPA**	**5dth**	**1dth80**	**1dth75**	**1dth70**	**5x5**	**3x3**
Welby	70.0	70.2	69.4	69.4	70.3	71.1	70.3	71.3
Highland	78.0	77.3	76.2	77.4	77.5	78.0	77.6	78.0
S. Boulder Creek	81.0	80.7	80.5	80.5	80.5	80.5	80.8	80.4
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	84.0	83.4	82.9	83.3	83.6	83.9	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	79.1	78.9	78.9	79.3	79.7	79.4	79.3
Welch	75.0	75.0	75.0	75.0	74.7	74.9	74.5	74.5
Rocky Flats North	85.0	84.9	85.2	85.1	84.9	85.0	85.0	84.5
NREL	82.0	82.2	82.5	82.5	82.2	82.0	82.0	81.8
Fort Collins - West	86.0	84.8	84.6	84.6	84.8	85.0	84.8	85.1
Fort Collins	74.0	73.0	72.8	72.8	73.0	73.2	73.2	73.6
Greeley - Weld	78.0	77.5	77.8	77.3	77.5	77.5	77.6	77.7
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 3-2c. 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 3-2d. 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.

Figure 3-2 displays the percent change in the Total Ozone and Grid Cells between the 2006 Base Case and the 2010 Base Case and Final 2010 Control Strategy emission scenarios. Using the 70 ppb threshold, there are small reductions between 2006 and 2010 in the Total Ozone

(approximately -5%) and Grid Cell (approximately -3.5%) modeling metrics. However, the emission reductions between 2006 and 2010 are having their intended effect by having more reductions in the higher 8-hour ozone concentrations in the Denver region. For example, the changes in Total Ozone and Grid Cells with ozone greater than the 85 ppb threshold are reduced by approximately -21% and -14%, respectively. These reductions are even greater for the Final 2010 Control Strategy scenario than the 2010 Base Case. For example, the Total Ozone above 85 ppb is reduced by -21.9% in the 2010 Base Case and reduced event more (-23.4%) in the Final 2010 Control Strategy.

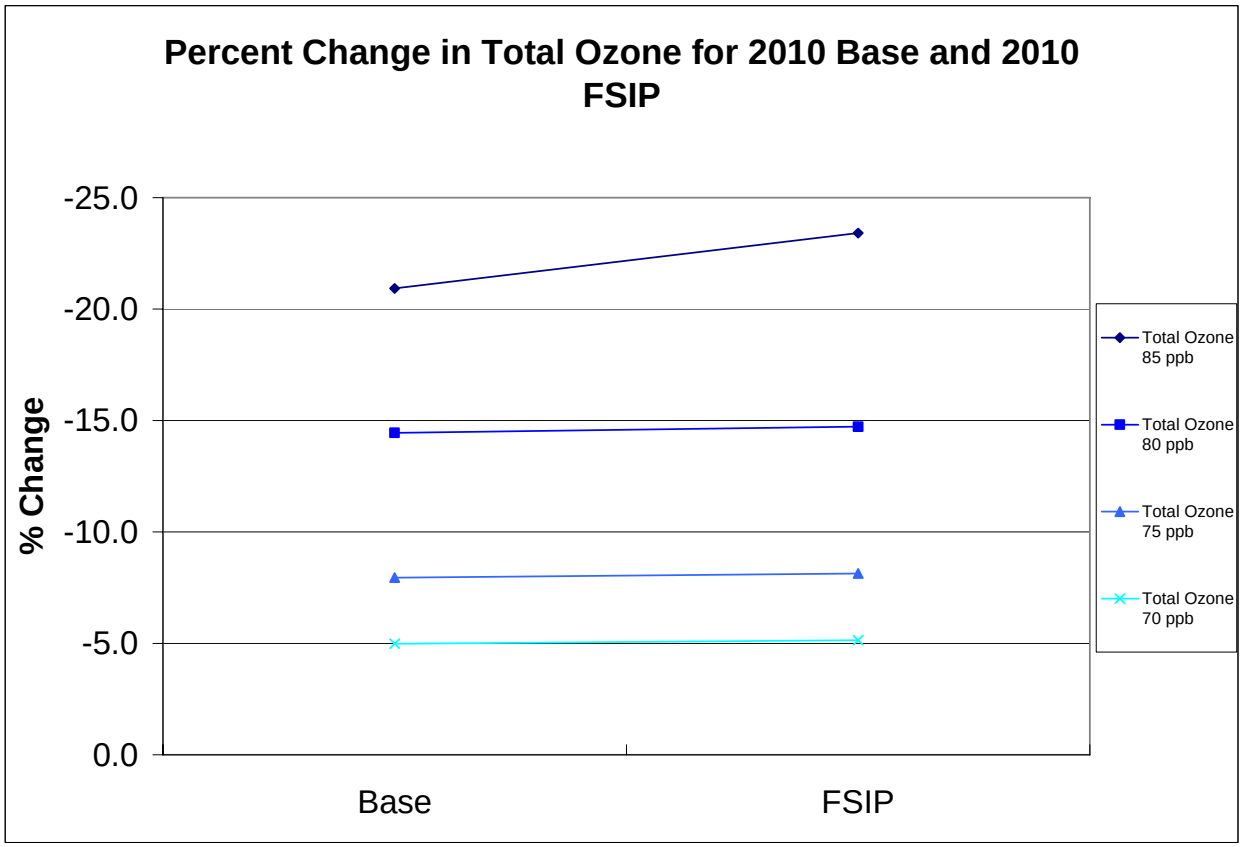


Figure 3-2a. Percent change in Total Ozone greater than 85, 80, 75 and 70 ppb between the 2006 Base Case and the 2010 Base Case (Base) and Final 2010 Control Strategy (FSIP) emission scenarios.

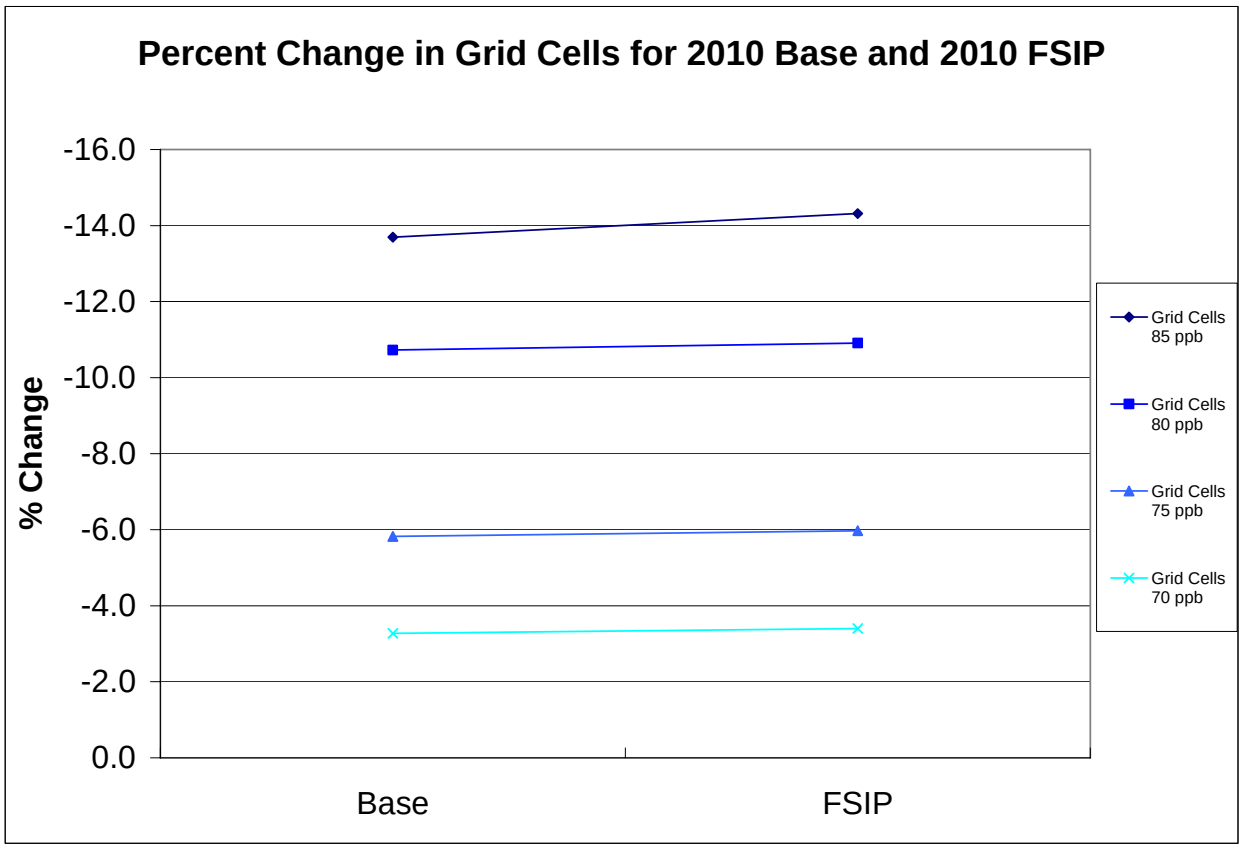


Figure 3-2b. Percent change in Grid Cells greater than 85, 80, 75 and 70 ppb between the 2006 Base Case and the 2010 Base Case (Base) and Final 2010 Control Strategy (FSIP) emission scenarios.

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