ENVIRON

MEMORANDUM

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Cc:	Kevin Briggs, Chuck Machovec and Mike Silverstein, CDPHE/APCD
From:	Ralph Morris, ENVIRON International Corporation Dennis McNally, Alpine Geophysics, LLC
Date:	January 15, 2009
Subject:	2015/2020 Ozone Projections for the Denver Region and Proposed Improvements to the Denver Photochemical Modeling Databases

INTRODUCTION

During 2008ENVIRON International Corporation and Alpine Geophysics, LLC have developed a photochemical grid model (PGM) database for the June-July 2006 period and the Denver region that was used to develop the Denver 8-hour ozone State Implementation Plan (SIP). The current Denver 8-hour ozone SIP addresses the 1997 8-hour ozone National Ambient Air Quality Standard (NAAQS) that has a 0.08 ppm (85 ppb) threshold and demonstrated that the Denver region would achieve attainment by 2010. On March 12, 2008, EPA promulgated a new more stringent 8-hour ozone NAAQS with a lower threshold of 0.075 ppm (76 ppb); the 8-hour ozone SIP for the new 8-hour ozone NAAQS is due in 2013. The Denver Regional Air Quality Council (RAQC), along with the Colorado Department of Public Health and Environment Air Pollution Control Division (CDPHE/APCD), wish to use the June-July 2006 PGM modeling database to project 8-hour ozone concentrations to farther out years (2015/2020) to estimate whether additional emission controls will be needed for attainment of the new 8-hour ozone NAAQS and provide a preliminary assessment of the types and levels of controls that may be needed to attain the new 8-hour ozone NAAQS. The RAQC and CDPHE/APCD would also like to use what they have learned from the current ozone SIP modeling process to determine whether improvements to the modeling databases can be made. Currently available funding is sufficient to address the estimation of preliminary 2015/2020 ozone projections. The work associated with model database improvements will be addressed in the future. Thus, ENVIRON/Alpine have prepared this Scope of Work (SOW), cost estimate and schedule to perform the work in two phases:

- Phase I to address the near-term need to obtain 2015 and 2020 future-year 8-hour ozone projections using existing databases and currently available resources to occur in early 2009; and

- Phase II to perform model improvements and make future-year ozone projections using the improved Denver modeling database and new inventories that will be emerging in 2009 that will be performed later in 2009 as additional funding is available.

Overview of Current Denver 8-Hour Ozone SIP Photochemical Modeling

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) were 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. Figure 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 simulations). CAMx was then used to simulate ozone formation within the 12/4 km modeling domain using two-way interactive grid nesting (Figure 2). Once the 12 km BCs were defined from the 2006 and 2010 36 km CAMx Base Case simulations, sensitivity and control strategy evaluations runs were made on the 12/4 km modeling domain. Most of the Denver 8-hour ozone SIP modeling work was performed 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., 2008b; 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., 2008c; 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); and
- 2010 control strategy and attainment demonstration modeling (Morris et al., 2008d; http://www.ozoneaware.org/documents/modeling/Denver_2010ControlStrat_Draft_Sep22_2008.pdf).
- Final 2010 Ozone Attainment demonstration Modeling for the Denver 8-Hour Ozone State Implementation Plan (Morris et al., 2009)

The CAMx model achieved EPA's model performance goals and exhibited sufficient skill in predicting the observed ozone and precursor concentrations in the Denver area during the June-July 2006 period that it was determined to be a reliable tool for estimating future year ozone levels. However, as in any modeling analysis, there are uncertainties in the modeling and areas where improvements may be achieved. The reports listed above identify many of the

uncertainties and areas where improvements can be made in the modeling. The RAQC, CDPHE/APCD, ENVIRON and Alpine have had several conference calls discussing potential areas of model refinement and have identified the tasks in Phase II below as the most promising ones for achieving improvements in the Denver photochemical modeling database.

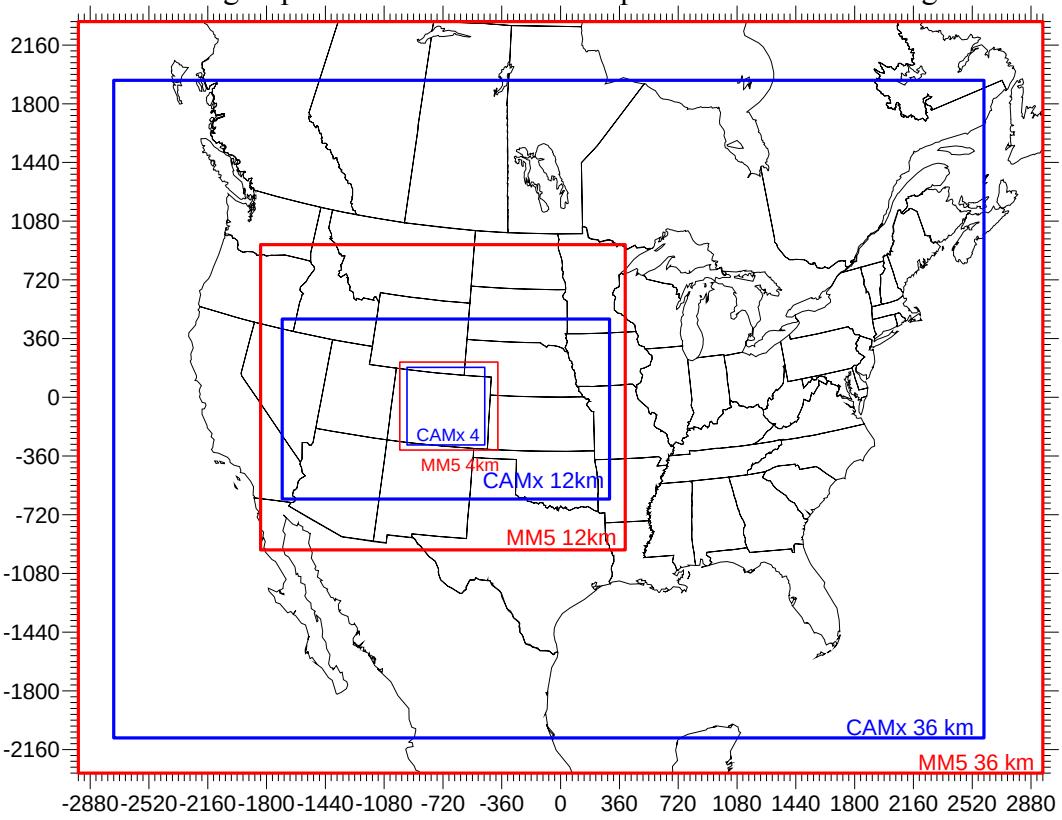

Figure 1a. Nested 36/12/4 km modeling domains for the Denver 8-hour ozone modeling study. Blue line domains are for CAMx/SMOKE domains that are nested in the MM5 red line domains.

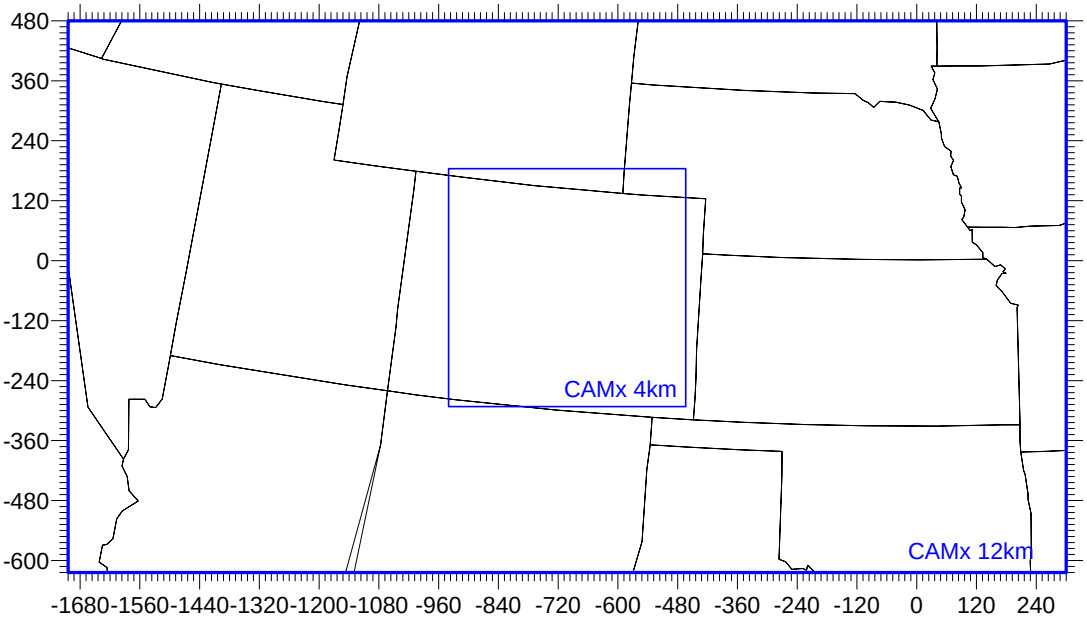

Figure 1b. Nested 12/4 km modeling domains for the Denver CAMx air quality and SMOKE emissions modeling.

SCOPE OF WORK

The Scope of Work (SOW) given below is broken out in two phases. The first Phase addresses the near-term need to obtain preliminary 2015/2020 ozone projections using the existing photochemical modeling database. The second Phase addresses approaches for improving the Denver photochemical modeling database.

Phase I: 2015/2020 Ozone Projections

On March 12, 2008, EPA promulgated a new 8-hour ozone NAAQS with a threshold of 0.075 ppm (76 ppb) that is more stringent than the 1997 8-hour ozone NAAQS (0.08 ppm or 85 ppb) that is being addressed by the current Denver 8-hour ozone SIP. Denver will likely be designated an 8-hour ozone nonattainment area (NAA) for the new 8-hour ozone NAAQS with a SIP due in 2013 and attainment date sometime between 2013 and 2023 depending on nonattainment classification. The purpose of the work effort described below is to obtain a preliminary indication of the degree the Denver area may exceed the new 8-hour ozone NAAQS in 2015 and 2020 (if at all) and perform sensitivity tests to assess the source categories, precursors and regions that most effectively reduce elevated ozone concentrations in 2015 and 2020.

As in the current Denver 8-hour ozone SIP work efforts, the CDPHE/APCD would provide the ENVIRON/Alpine Team with 2015 and 2020 emissions for Colorado area, non-road and point source. The ENVIRON/Alpine Team would be responsible for the 2015 and 2020 emissions outside of Colorado, which would be based on the WRAP 2002 and 2018 inventories. In addition, for Basins where data are available, the oil and gas (O&G) emissions would be updated for 2006, 2015 and 2020 using the WRAP Phase III O&G emissions data. Issues that need to be addressed are as follows:

- Point Sources: BART controls, closure of Arapahoe 1 & 2; RMNP deposition mitigation controls; other growth issues (CDPHE/APCD)
- Area & Non-Road Mobile: EGAS growth estimate given current economy, need to look at possible national regulations and their timing, review the RIA inventory/regulation assumptions for new standard (CDPHE/APCD)
- On-road Mobile Sources: These emissions would be generated by the ENVIRON/Alpine Team for 2015 and 2020 as follows (ENVIRON/Alpine):
    - For Denver area need to run CONCEPT using DRCOG 2015 and 2020 link-based network VMT data.
    - Outside of the DRCOG link-based networks, on-road mobile source emissions for 2015 and 2020 will be generated using projected county-level VMT data and the SMOKE-MOBILE6 module.
- Areas Outside Colorado: 2018 BART controls for regional haze from WRAP efforts, if available (CDPHE/APCD)

Task 1: Update of Oil and Gas Emissions using WRAP Phase III Database

Background: For the current Denver ozone SIP 2006/2010 modeling, the oil and gas (O&G) emissions for the Denver-Julesburg (D-J) Basin was based on the WRAP Phase III O&G inventory, whereas for the other areas in Colorado 2006/2010 O&G emission estimates and areas outside of Colorado the O&G emissions were based on the WRAP Phase II 2005/2018 inventories interpolated to 2006 and 2010. The WRAP Phase II inventories were focused on regional haze modeling so did not put emphasis on VOC emissions, which are not significant contributors to visibility impairment but are important for ozone formation. Since the Denver ozone modeling database was developed, the WRAP Phase III O&G inventories have been developed for 2006 and 2012 for several other Basins (in addition to the 2006/2010 D-J Basin) including the Pieance Basin in Colorado and Unita Basin in Utah. The WRAP Phase III O&G inventories are much improved and more appropriate for ozone modeling than the Phase II inventories.

Objective: To update the oil and gas (O&G) emissions in the Denver PGM database using the latest WRAP Phase III O&G emission estimates.

Approach: For those Basins in which WRAP Phase III 2006 and 2012/2010 O&G emissions are available at the time the task is initiated, we would use the WRAP Phase II projection factors to project the WRAP Phase III O&G emissions from 2010/2012 to 2015 and 2020. If WRAP Phase III emissions for some Basins in the western U.S. are not available, we would revert back to the WRAP Phase II O&G emissions. For those Basins in Colorado (i.e., D-J, Pieance and portions of the San Juan Basins), we would provide the WRAP Phase III 2006 and 2010/2012 as well as the projected 2015 and 20210 O&G emissions for these Basins to the CDPHE/APCD for their review. We would process the WRAP Phase III 2006 O&G emissions (and Phase II emissions for Basins whose Phase III emission are not yet available) for the CAMx 36/12/4 km domains to generate new 2006 base case O&G emissions. These new 2006 O&G emissions would be used in the revised CAMx 2006 Base Case simulation performed under Task 2. The projected 2015 and 2020 O&G emissions based on the WRAP Phase III O&G emissions would be processed under Tasks 3 and 4 below.

Deliverables: PowerPoint presentation on the updated 2006, 2015 and 2020 O&G emissions.

Task 2: 2006 Base Case Sensitivity Modeling using Plume-in-Grid

Background: The Denver ozone SIP modeling did not use the CAMx Plume-in-Grid (PiG) module. The PiG module treats the early evolution of large point source plume chemistry and dispersion. This results in a more realistic treatment of emissions from point sources than the instantaneous dilutions of the emissions across a 4 km by 4 km grid cell that occurs when the PiG is not utilized. For the initial CAMx runs for the Denver ozone SIP modeling there were issues with the PiG module in CAMx, so it was not used. Thus, when future-year modeling was performed, the PiG was also not used to be consistent with the current year modeling even though the issues with the PiG were resolved.

Objective: Perform CAMx 2006 base case simulation with the PiG treatment of major point sources in the 12/4 km domain. Also under this task will update the CAMx 2006 Base Case simulation with the 2006 WRAP Phase III O&G emissions prepared under Task 1, including results for the 36 km domain (the PiG module would not be invoked for the 36 km domain).

Approach: The largest point source emission sources within the 12/4 km modeling domain would be ranked by NOx emissions and the top 200-400 point sources, plus potentially smaller point sources in the Denver area, would be flagged for treatment by the CAMx PiG module. The 2006 WRAP Phase III O&G emissions prepared under Task I would be merged with the existing 2006 base case emissions scenarios. A CAMx 2006 36/12/4 km base case would be performed. For a portion of July 2006 period we would also run CAMx without the PiG module so we can obtain an assessment of the PiG update independently of the O&G emissions updates. Note that subsequent 2015/2020 future year model simulations would also be conducted using the PiG module. An abbreviated model performance evaluation would be conducted to assure the level of performance is not adversely affected by the updates.

Deliverables: PowerPoint presentation with results of revised 2006 Base Case using updated O&G emissions and with PiG module and model performance evaluation. Brief assessment of the effects of the O&G/PiG updates on model performance and the effects of running CAMx with and without PiG for a portion of the June-July 2006 episode.

Task 3: Development of Non-Colorado 2015/2020 Emissions

Objective: To develop 2015 and 2020 area, on-road mobile, non-road mobile, oil and gas and point source emissions for the non-Colorado portions of the 36/12/4 km modeling domain.

Approach: The WRAP 2002 and 2018 emissions modeling databases would be used to obtain area, non-road mobile and point source emissions for the 2015 and 2020 future years. For point sources the WRAP will be contacted concerning obtaining 2015 and 2020 emissions for those sources subject-to-BART. The WRAP 2018 Prp18b emissions inventory may be available in February 2009 and would be used in this study. If the 2018 Prp18b inventory is not ready, then the 2018 Prp18 inventory would be utilized. A specific advantage of the WRAP Prp18b inventory is the implementation of NOx BART controls; the previous Prp18a inventory only had approximations of SO2 BART controls for some sources.

The projected 2015/2020 O&G emissions from Task 1 would be processed using SMOKE to generate model-ready 2015/2020 O&G emissions for the CAMx 36/12/4 km grid domains.

The non-Colorado area, non-road and point source emissions would be processed by SMOKE to generate the hourly varying gridded speciated emission inputs used by CAMx. For on-toad mobile source emissions the WRAP county-level 2002, 2006 and 2018 VMT database would be interpolated/extrapolated to the 2015 and 2020 years and the SMOKE-MOBILE6 module would be used to generate the on-road mobile source emissions inputs using the appropriate years of fleet mix.

Biogenic and fire emissions would remain unchanged from the 2006 model year.

Deliverables: CAMx-ready emission inputs for non-Colorado sources and the June-July 2006 modeling period, the 36/12/4 km modeling domains and the 2015 and 2020 future years.

Task 4: Development of 2015/2020 Colorado Area, Point, Oil and Gas and Non-road Mobile Source Emission Inputs

Objective: To generate the CAMx emissions inputs for the 4 km grid and every source category but on-road mobile source emissions.

Approach: The CDPHE/APCD would provide the ENVIRON/Alpine Team with Colorado area, non-road and point source emissions and the years 2015 and 2020 using the same formats and units as used when they provided the 2006 and 2010 Colorado emissions.

The SMOKE emissions modeling system would be used to process the Colorado emissions into the hourly varying gridded speciated emission inputs used by CAMx. For on-road mobile sources, the CDPHE/APCD would provide or review the county-level VMT data and MOBILE6 inputs for 2015 and 2020 and Colorado. The SMOKE-MOBILE6 module would be used to generate Colorado on-road mobile source emission inputs.

The 2015 and 2020 oil and gas emission projections prepared under Task 1 would be processed by SMOKE to generate the model-ready gridded, speciated, hourly emissions for CAMx.

Deliverables: Pre-merged model-ready emissions for Colorado area, point, oil and gas, non-road mobile and on-road mobile sources.

Task 5: Development of 2015/2020 On-Road Mobile Source Emissions using DRCOG Network

Objective: To generate 2015 and 2020 on-road mobile source emission inputs on the 4 km grid domain for the Denver area using the DRCOG link-base VMT data

Approach: The DRCOG 2015 and 2020 link-based VMT network would be processed for input into CONCEPT. The fleet mix used in the CONCEPT 2006 and 2010 runs would be reviewed for appropriateness for 2015 and 2020 and updated as needed. The MOBILE6 inputs will be reviewed and compared with the inputs provided by the CDPHE/APCD. The CONCEPT MV would then be run using the 2015 and 2020 DRCOG link-based VMT data and Colorado MOBILE6 inputs, fleet mix and temporal allocations to generate hourly gridded speciated on-road mobile source emission inputs over the DRCOG area of the 4 km grid domain.

Deliverables: Pre-merged model-ready 2015 and 2020 on-road mobile source emission inputs over the DRCOG Denver transportation modeling region and PPT describing the 2015/2020 CONCEPT MV modeling.

Task 6: 2015/2020 CAMx Base Case Modeling and Ozone Projections

Objective: To perform 2015/2020 base case CAMx modeling and ozone projections.

Approach: Emissions for all the different source categories would be merged together to generate CAMx-ready emission inputs for a 2015 and 2020 base case emissions scenario. Source would be flagged for the PiG treatment consistent with the Task 2 2006 base case simulation. The Modeled Attainment Test Software (MATS) would be used to make 2015 and 2020 8-hour ozone Design Value Projections.

Deliverables: PowerPoint presentation on the 2015 and 2020 ozone projections.

Task 7: 2015 or 2020 Ozone Source Apportionment Modeling

Objective: To perform ozone source apportionment modeling using either the new 2015 or 2020 modeling database.

Approach: We would work with the RAQC and CDPHE to select either the 2015 or 2020 modeling year for Ozone source apportionment modeling. Both the OSAT and APCA versions of the ozone source apportionment approach would be used in the analysis. We would then perform a CAMx ozone source apportionment simulation using the same source regions and source categories as used in the 2010 source apportionment modeling. Similar displays would be generated as generated previously.

Deliverables: PowerPoint presentation summarizing the 2015/2020 ozone source apportionment modeling, CD of full displays.

Task 8: 2015/2020 CAMx VOC/NOx Sensitivity Modeling

Objective: To perform VOC/NOx emissions reduction sensitivity tests using the new 2015/2020 modeling databases.

Approach: After an analysis of the Task 7 ozone source apportionment modeling results we would work with the RAQC and CDPHE to define VOC/NOx emission sensitivity tests. Up to ten (10) VOC/NOx emissions sensitivity tests would be performed using the 2015/2020 CAMx modeling database. The definition of the sensitivity tests will be made with consultation of RAQC and CDPHE/APCD. For costing purposes we are assuming the emission changes would be across-the-board changes in VOC, NOx and/or CO emissions using the pre-merged emission files (i.e., no SMOKE emissions modeling).

Deliverables: PowerPoint presentation summarizing the 2015/2020 emission sensitivity tests.

Task 9: 2015/2020 Modeling Report, Meetings and Technology Transfer

Objective: To document the 2015/2020 modeling in a technical report, attend meetings and provide CDPHE with a hard drive with the latest modeling databases and results.

Approach: The results of the model enhancements and 2015/2020 modeling would be documented in a technical report. We would also attend informal meetings with the RAQC, CDPHE and others that they designate. The CDPHE would be provided with the new modeling databases and key inputs and outputs.

Deliverables: Draft, Draft Final and Final Technical Report documenting the 2015/2020 modeling and model enhancements. Attendance at meetings. Hard drive of modeling database and results.

Phase II: Potential Model Improvements

During the course of the current Denver 8-hour ozone SIP modeling, several areas of potential model improvement have been identified that are addressed in the Phase II SOW tasks given below.

A. Inventory underestimation of Mobile Source and Oil & Gas VOC based on model under-predictions of observed acetaldehydes, ethane, paraffin and formaldehyde requires investigation to improve these inventories

Background: The evaluation of the 2006 CAMx base case simulation against the measured early morning VOC concentrations found that the model generally underestimated VOC concentrations. This is believed to be partially due the fact that the model is predicting a grid cell average, whereas the observation is a point measurement; the modeled VOC emissions will be instantaneously spread across a 4 km x 4 km grid cell thereby diluting the VOC and NOx concentrations near the sources. For example, the downtown Denver CAMP site is located at an intersection close to mobile source emissions so the measured VOC concentrations would be expected to be higher than a grid cell average. The fact that there is generally good agreement between the modeled and measured VOC/NOx ratios at the Denver metropolitan area sites suggest that the on-road mobile source VOC emissions in the downtown Denver area may be reasonably well characterized (Note: it is generally accepted that mobile source NOx is well characterized, whereas mobile source VOC may be understated, so the evaluation of the emissions/modeled VOC/NOx ratio against measurements is a good indication of VOC model performance as it accounts for dilution.). However, specific VOC species appear to be much lower than others, which indicate there may be issues with the VOC speciation and/or mass emissions. This is especially true for ethane in Weld County; ethane is an indicator of natural gas sources. Thus, the first three tasks are designed to investigate the VOC model performance and potential causes and corrections for the VOC emissions shortfall.

Task 11: VOC Inverse Modeling to Identify Potential Sources of VOC Emissions Shortfall

Objective: To identify the source categories, locations and level of emissions needed for the modeled VOC species to match the observed VOC concentrations on the VOC sampling days during the June-July 2006 modeling period.

Approach: We would first perform a more detailed evaluation of the current CAMx 2006 base case simulation using all of the VOC samples collected during the summer of 2006. This would include both the morning emissions-based and afternoon high-ozone-receptor-based samples. This evaluation would be for VOC samples processed into the CB05 species used in the CAMx gas-phase chemical mechanism. In some cases (e.g., formaldehyde, acetaldehyde and ethane) the CB05 species are explicit species. The raw VOC samples would also be analyzed to assess whether VOC source signatures can be easily identified (this would not include CMB modeling).

We would then perform VOC source apportionment modeling for the July 2006 period and the CB05 species to determine the contributions of major source categories to the VOC species at the times and locations of the VOC samples. Based on these contributions, we would determine an adjustment (i.e., inverse modeling) to the inventories that would alleviate much of the VOC under-predictions tendency for several key species (e.g., aldehydes and ethane). A CAMx sensitivity run would then be performed for the July 2006 period using the adjusted emissions inventory to see whether it affects ozone formation in the region and model performance.

If the adjusted inventory achieves better model performance for ozone and VOCs, we would then review and identify scientifically justifiable approaches toward developing the VOC emissions inventory to account for at least part of the VOC emissions adjustments. Although the exact approach for doing this can not be defined at this time, we would expect that there could be both mass and speciation adjustments to the inventory. Note that the recommendations would also include input from Task 2.

Deliverables: PowerPoint presentation and Technical Memorandum documenting the VOC evaluation, inverse modeling and recommended adjustments and updates to the VOC inventory.

Task 12: Comparison of On-Road Mobile Source VOC Emissions from Photochemical and Air Toxics Emissions Inventories

Objective: To compare on-road mobile source emissions for specific VOC species generated using MOBILE6 run in its air toxics mode with the SMOKE-MOBILE6 PGM VOC emissions inventory.

Approach: For the 2006 Base Case emissions, on-road mobile sources for the Denver area were generated using the CONCEPT MV and MOBILE6 emissions models and link-based VMT data from the DRCOG network. The CONCEPT/MOBILE6 generated gridded VOC, NOx and other emissions for the on-road mobile sources where the VOC emissions were then speciated in the CB05 chemical mechanism classes using the default on-road mobile sources speciation profiles.

MOBILE6 also has an air toxics mode where it can generate emissions factors for six explicit VOC species: Benzene, MTBE, 1,3-Butadiene, Formaldehyde, Acetaldehyde and Acrolin. The CONCEPT MV model would be applied for the Denver DRCOG network using the MOBILE6 air toxics VOC mode to generate gridded model-ready emissions for the six air toxic VOC species and July 2006. The results for Formaldehyde and Acetaldehyde would be compared with the same species in the CB05 mechanism in the 2006 Base Case emissions inventory. If sufficiently different, a CAMx sensitivity test would be run for July 2006 using the substituted Formaldehyde and Acetaldehyde species from the MOBILE6 air toxics mode run to determine their effect on model performance (ozone and VOC).

Depending on the outcome, a review of the mobile source VOC speciation used in SMOKE would be made and recommendations for updates provided.

Deliverables: New on-road mobile source emissions for the Denver area and six air toxic VOC species. Technical memorandum that compares results of VOC species emissions from the air toxics and criteria pollutant and model performance evaluation (if a CAMx run is performed). Recommendations on updates to the mobile sources emissions would also be made and would also be used in the Task 1 deliverable.

B. Potential Improvements in Meteorological Modeling for Consideration Beyond the Initial Sensitivity Testing Performed in the SIP Modeling Phase that Could Not Be Performed due to Time and Resource Constraints

Background: The Denver region is a challenging area for meteorological models to accurately reproduce the observed meteorological conditions. The model performance of the MM5 model in the Denver area was not as good as seen in some other areas with simpler conditions, but was still mostly within the historical model benchmarks. In the course of the Denver ozone SIP study, several meteorological sensitivity runs were performed and evaluated in CAMx. As the CAMx model performance was deemed sufficient to proceed with the ozone attainment demonstration modeling, additional meteorological sensitivity tests were not pursued under the Denver ozone SIP study. The following two tasks have been identified to try and improve the meteorological representativeness of the June-July 2006 modeling period.

Task 13: Increased MM5 Nudging

Objective: To determine whether increased four dimensional data assimilation improves the meteorological and photochemical grid model performance.

Approach: The ENVIRON/Alpine Team would contact the CDPHE/APCD and others to assure that they have all available surface and upper-air meteorological observations in the greater Denver area for the June-July 2006 period. A series of MM5 sensitivity tests of the 4 km Colorado domain would then be conducted for two short episodes during June-July 2006:

- Inclusion of additional surface meteorological observations in the point wind observation nudging.
- Increased nudging coefficients for the surface wind data assimilation.
- Other change to be determined.

The 4 km MM5 output would be evaluated and processed by MM5CAMx to generate CAMx inputs for the two episodes and MM5 sensitivity tests. CAMx sensitivity tests would be performed and the effects of the meteorological sensitivity tests on ozone model performance assessed.

Deliverables: PowerPoint presentation on the results of the MM5 sensitivity tests and their effect on meteorological and ozone model performance.

Task 14: Meteorological Sensitivity Modeling using the Weather Research Forecast (WRF) Model

Objective: To perform meteorological sensitivity tests using the WRF meteorological model and assess its effect on meteorological and ozone model performance.

Approach: The Weather Research Forecast (WRF) meteorological model would be applied on the 36/12/4 km grid and the June-July 2006 using a model configuration similar to the best performing configuration identified for the MM5 model. The WRF output would be evaluated and processed with WRFCAMx to generate CAMx meteorological inputs. A revised CAMx 2006 base case would be performed and model performance evaluation conducted.

Deliverables: PowerPoint presentation on the WRF meteorological model sensitivity modeling and CAMx base case model performance.

C. Update Oil and Gas Emissions using 2018 WRAP Phase III Data

Task 15: 2015 and 2018 O&G Emission Updates

Background: By the time Denver Phase II modeling is initiated, the WRAP Phase III O&G emissions update study should be completed for all Basins in the western states and include updated 2010/2012 and 2018 emission projections. These projections are undergoing updates and refinements. In fact, the initial 2012 O&G projections for some Basins made in 2008 are being revised based on the recent economic activity and changes in the cost of gas.

Objective: To update the O&G gas emissions in the 36/12/4 km grid domains for the 2006, 2015 and 2020 base case emission scenarios.

Approach: The latest WRAP Phase III 2006, 2010/2012 and 2018 O&G emissions will be projected to 2015 and 2020. The 2006, 2015 and 2020 O&G emissions will then be processed with SMOKE to generate model-ready O&G emissions for the 36/12/4 km domains.

Deliverables: 2006, 2015 and 2020 model-ready O&G emissions on the 36/12/4 km grid domains based on the latest WRAP Phase III O&G emissions inventory and all Basins in the Western U.S.

D. 2006 Base Case Modeling using an Alternative Model

Background: Two photochemical grid models are in wide use for air quality planning in the U.S.: CAMx and the Community Multiscale Air Quality (CMAQ) modeling system. There have been numerous CMAQ/CAMx model intercomparison studies with the results inconclusive concerning which model performs better. The Task below would apply the CMAQ model for the Denver June-July 2006 base case and evaluate its performance.

Task 16: 2006 Base Case Modeling using CMAQ

Objective: To determine whether improved model performance can be achieved using the CMAQ modeling system.

Approach: The latest 36/12/4 km MM5 data would be processed by the CMAQ MCIP processor to generate CMAQ-ready emissions for the June-July 2006 episode and the 36/12/4 km modeling domains. The CAMx2CMAQ processors would be used to reformat the CAMx, emissions, initial condition and boundary condition (BCs) inputs into the format used by CMAQ using the latest 2006 base case emissions scenario. The CMAQ JPROC processor would be used to generate photolysis rates for the CMAQ model and the June-July 2006 episode.

CMAQ 2006 base case simulations would be performed for the 36 km, 12 km and 4 km modeling domains with BCs for the finer nests being based on the output from the next coarser grid nest. The CMAQ model would then be subjected to an ozone model performance evaluation and compared with the corresponding CAMx base case simulation.

Deliverables: PowerPoint presentation on the CMAQ 2006 base case simulation, model performance evaluation and comparison to CAMx performance.

E. Update Mobile Source Emissions using NFRCOG Link-Based VMT data and CONCEPT MV

Task 17: Development of 2006/2015/2020 On-Road Mobile Source Emissions using NFRCOG Network

Objective: To generate 2006, 2015 and 2020 on-road mobile source emission inputs on the 4 km grid domain for the North Front Range (NFR) area using the NFRCOG link-base VMT data

Approach: We would work with the NFRCOG to obtain the link-based VMT data, temporal variations and fleet mix for the NFR region. The NFRCOG 2006, 2015 and 2020 link-based VMT network would be processed for input into CONCEPT. Detailed information on fleet mix for 2006, 2015 and 2020 would be obtained from NFRCOG for input into COCEPT. The MOBILE6 inputs will be reviewed and compared with the inputs provided by the CDPHE/APCD. The CONCEPT MV would then be run using the 2006, 2015 and 2020 NFRCOG link-based VMT data and Colorado MOBILE6 inputs, fleet mix and temporal allocations to generate hourly gridded speciated on-road mobile source emission inputs over the NFRCOG area of the 4 km grid domain.

We would discuss with RAQC and CDPHE on how best to address the overlap of the DRCOG and NFRCOG link-based network and implement a solution that avoids double counting. For costing purposes, we are assuming that we would develop masks for the 4 km Colorado domain that would zero-out mobile source emissions from either the DRCOG or NFRCOG networks in portions of the domain where they completely overlap so when they are merged together they are not double counted. However, the DRCOG and NFRCOG have also discussed an approach whereby one or the other zero-out the VMT on common links in their networks. This would also be a valid approach but would require a reprocessing of the DRCOG network for the 2006, 2015 and 2020 years so would require more resources then allocated to this task.

Deliverables: Pre-merged model-ready 2006, 2015 and 2020 on-road mobile source emission inputs over the NFRCOG transportation modeling region.

F. Documentation of Model Improvement Efforts

Task 18: Final 2006 Base Case and MPE and 2015 and 2020 Modeling with Model Improvements

Objective: To perform a final 2006 base case simulation and model performance evaluation with all the model improvements along with revised 2015 and 2020 ozone projections.

Approach: A revised 2006 36/12/4 km CAMx base case simulation would be conducted using the improved database developed in Phase II along with a more complete model performance evaluation (MPE) that includes ozone, precursors and performance aloft. Revised 2015 and 2020 36/12/4 km CAMx base case simulations would also be conducted using the improved database and 2015 and 2020 ozone projections made. The results of the Phase II work effort along with the revised 2006 base case MPE and 2015/2020 ozone projections would be documented in a PowerPoint presentation.

Deliverables: PowerPoint presentations on final CAMx 2006, 2015 and 2020 base case runs with model improvements.

Task 19: Phase II Report and Meetings

Objective: To document the Phase II work effort in a final report and attend two 2-person meetings in Denver.

Approach: The results of the Phase II model improvements listed above would be documented in a draft final and final report. A draft final report would be submitted to RAQC/CDPHE for review. Based on their comments it would be updated and submitted as a final report.

Also under this task we would attend up to two 2-person meetings with associated development of PowerPoint presentations.

Deliverables: Draft final and final report and two 2-person meetings in Denver with preparation of associated PowerPoint Presentations.

SCHEDULE AND COSTS FOR TWO PHASED APPROACH

Figure 1 summarizes the cost and schedule for the proposed work effort outlined above that is broken out into the Phase I 2015/2020 ozone projections work effort that is currently funded and a Phase II work effort to improve model performance that is currently not funded. The total estimated costs for Phase I is $138,000. The estimated cost for all of Phase II is $160,000.

Most of the Phase I Tasks are interconnected. However, the first 7 Tasks of the Phase II work effort are mainly independent. For the most part, individual Tasks can be removed from the program without affecting the other Tasks. The exception to this is the Task 18 final 2006/2015/2020 CAMx runs and Task 19 final report and meetings.

Figure 1. Schedule (2009) and cost summary for the Denver 8-hour ozone 2015/2020 modeling and database enhancement study.

Task	Cost	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Phase I: 2015/2020 Ozone Projections												
Task 1: 2006/2015/2020 WRAP Phase III O&G EI Update	$10,806		T1	R1								
Task 2: 2006 PiG Sensitivity and Base Case Update	$5,546			T2 R1								
Task 3: 2015/2020 Non-Colorado Emissions Modeling	$14,515			T3 R1								
Task 4: 2015/2020 Colorado Emissions Modeling	$17,951			T4 R1								
Task 5: 2015/2020 DRCOG CONCEPT MV Link Mobile	$19,275			T5 R1								
Task 6: 2006/2015/2020 CAMx Base Case Modeling	$19,688				T6	R2						
Task 7: 2015/2020 Ozone Source Apportionment	$16,043				T7	R2						
Task 8: 2015/2020 VOC/NOx Sensitivity Modeling	$20,037						T8					
Task 9: Reporting, Meetings and Technology Transfer	$13,852		M1				T9a	M2 T9b				
Total	$137,712											
Phase II: 2006 Base Case Model Improvements												
Task 11: VOC Inverse Modeling for Emissions Shortfall	$22,486								T11	R3		
Task 12: MOBILE6 Air Toxics VOC Inventory	$12,778								T12	R3		
Task 13: Increased Nudging MM5 Sensitivity	$17,164								T13	R3		
Task 14: Weather Research Forecast (WRF) Sensitivity	$14,651								T14	R3		
Task 15: 2006 WRAP Phase III O&G EI Update	$10,806									T15 R3		
Task 16: 2006 CMAQ Base Case Modeling	$11,381									T16 R3		
Task 17: 2006 NFRCOG CONCEPT MV	$34,625									T17 R3		
Task 18: Final 2006/2015/2020 CAMx Modeling	$19,314										T18	
Task 19: Reporting and Meetings	$13,852									M3	T19a	M4 T19b
Total	$157,058											

Phase I: 2015/2020 Ozone Projections

T1: PPT WRAP Phase III O&G emissions 2006/2015/2020
T2: PPT of revised 2006 CAMx Base Case simulation with PiG and O&G Updates
T3: CAMx-ready 2015/2020 emissions on 36/12/4 km domains for non-CO sources
T4: CAMx-ready 2015/2020 emissions on 12/4 km domains for Colorado sources
T5: CAMx-ready 2015/2020 emissions for on-road mobile sources DRCOG network
T6: PPT summarizing 2015/2020 emissions and CAMx modeling
T7: PPT summarizing 2015 or 2020 ozone source apportionment modeling
T8: PPT summarizing 2015/2020 VOC/NOx sensitivity modeling
T9: (a) Draft Report; (b) Final Report

Phase II: 2006 Base Case Model Improvements

T11: PPT on Task 1 VOC Inverse Modeling
T12: PPT and Technical Memorandum on Task 1 VOC Inverse Modeling and Task 2 MOBILE6 toxics results plus recommendations for inventory improvements
T13: PPT on increased MM5 nudging sensitivity modeling
T14: PPT summarizing the results of the WRF sensitivity runs
T15: Use of 2018 WRAP Phase III O&G to make 2015/2020 projections
T16: PPT Task 8 CMAQ ozone model performance
T17: PPT on NFRCOG CONCEPT MV modeling for 2006/2015 and 2020
T18: PPT on final CAMx 2006, 2015 and 2020 base case run
T19: (a) draft final report; (b) final report

R1: RAQC/CDPHE review of the 2015/2020 emissions modeling end of March
R2: RAQC/CDPHE review of ozone projections & source apportionment in early May and select 2015/2020 VOC/NOx sensitivity tests
M1: Stakeholder meeting February 4th to discuss proposed work
M2: Stakeholder Meeting June

R3: CDPHE/RAQC Review of various model improvements and selection of final model configuration prior to final 2006 CAMx Base Case (Task 18
M3: Stakeholder meeting in September to discuss results from model improvements activities
M4: Stakeholder meeting to discuss CAMx results with model improvements