DRAFT DENVER 8-HOUR OZONE ATTAINMENT DEMONSTRATION MODELING AND ANALYSIS

Scope of Work, Schedule and Cost Estimate

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October 5, 2007

BACKGROUND

In December 2002, the Denver Regional Air Quality Council (RAQC), Colorado Department of Public Health and Environment (CDPHE) and others entered into an 8-hour ozone Early Action Compact (EAC) with the U.S. Environmental Protection Agency (EPA). EPA's EAC allows an area to submit an enforceable 8-hour ozone State Implementation Plan (SIP) that demonstrates 8-hour ozone attainment by 2007, which is earlier than the 2010 attainment date for most nonattainment areas. In return, EPA will defer the nonattainment classification of the area until 2007.

The RAQC/CDPHE contracted with ENVIRON International Corporation and their subcontractor Alpine Geophysics, LLC (ENVIRON/Alpine) to perform the meteorological, emissions and photochemical modeling necessary to develop an 8-hour ozone EAC SIP attainment demonstration. At the time, the Denver Metropolitan Area (DMA) attained the 8-hour ozone standard. ENVIRON/Alpine applied the MM5/EPS/CAMx meteorological/emissions/photochemical grid modeling system for episodes from the summer of 2002 and projected 8-hour ozone Design Values in 2007 under a 2007 base case and 2007 EAC control plan emissions scenario. Due to the adverse meteorological conditions of the summer of 2003, the DMA violated the 8-hour ozone National Ambient Air Quality Standard (NAAQS) based on 2001-2003 observed air quality data. EPA designated 8-hour ozone nonattainment areas based on observed 2001-2003 8-hour ozone Design Values. 8-hour ozone Design Values are defined as the three-year average of the fourth highest daily maximum 8-hour ozone concentration at a monitoring site. Although the DMA was violating the 8-hour ozone NAAQS based on 2001-2003 ozone observations, because of the EAC the DMA was not designated a nonattainment area but was instead designated as "nonattainment deferred". The RAQC/CDPHE designed an EAC control plan under which the photochemical modeling projected a maximum 2007 8-hour ozone Design Value of 85 ppb. As this is still slightly above the NAAQS (0.08 ppm or 84 ppb), a weight of evidence (WOE) attainment demonstration was used in the DMA 8-hour ozone EAC SIP. Details on the 8-hour ozone EAC SIP can be found on the following WebPages:

- http://www.raqc.org/ozone/EAC/ozone-eac.htm
- http://apcd.state.co.us/documents/eac/

Based on the latest measured ozone air quality data in the DMA and surrounding areas from 2005-2007, the DMA would violate the 8-hour ozone NAAQS. Thus, on November 20, 2007 EPA will designate the DMA as an 8-hour ozone Marginal nonattainment area under Subpart 2 of the Clean Air Act Amendments (CAAA) with an attainment date of 2010. Additional photochemical modeling will need to be performed to demonstrate attainment of the 8-hour ozone NAAQS by 2010.

On June 20, 2007 EPA proposed new primary and secondary ozone NAAQS that would likely be more stringent than the current NAAQS. EPA requested comments on proposed 8-hour ozone NAAQS in the 0.070 to 0.075 ppm (70-75 ppb) range, as well as whether values as low as 0.060 ppm (60 ppb) or keep it at 0.08 ppm (84 ppb) should be considered. Thus, a new 8-hour ozone NAAQS will likely be lower than the current value with values in the 70 to 75 ppb range being most likely. Although the DMA does not need to address this proposed lower 8-hour ozone NAAQS at this time, it would be prudent to keep it in mind when demonstrating attainment of the current 8-hour ozone NAAQS.

Purpose

The RAQC/CDPHE has continued their contracting arrangement with ENVIRON/Alpine to perform new photochemical modeling analysis to demonstrate 8-hour ozone attainment by 2010. They also wish to look toward the future and examine the potential effects of the new proposed 70-75 ppb 8-hour ozone NAAQS. This document presents a scope of work (SOW), schedule and cost estimate for conducting the photochemical modeling necessary to demonstrate attainment of the 8-hour ozone NAAQS by 2010, perform supporting analysis and prepare documentation that can be included with an 8-hour ozone SIP by the end of 2008 and project 8-hour ozone Design Values out to 2020 to provide an indication of where the DMA will be in regards to potential new 8-hour ozone NAAQS..

OVERVIEW OF APPROACH

Photochemical modeling would be conducted for the DMA and surrounding areas for a June-July 2006 two-month period during which nine (9) days exceeded the 8-hour ozone standard. Emissions modeling would be conducted using the CONCEPT-MOBILE6 emissions model with linked-based VMT data for on-road mobile sources in the DMA and the SMOKE emissions modeling system for all other emission sources.

Meteorological modeling would be conducted using the MM5 model on a 36/12/4 km grid. The CAMx photochemical grid model would be used to simulate ozone and PM formation on a continental U.S. 36 km domain and a Denver-focused 36/12/4 km grid. CAMx would be configured to simulate ozone, particulate matter (PM) and visibility. Figure 1 displays the 36 km grid that would be used for the continental U.S. photochemical modeling (the MM5 36 km grid is slightly larger). This grid is the Inter-RPO grid and was used by the WRAP, CENRAP and VISTAS Regional Planning Organizations for their Regional Haze modeling. CAMx would be operated on the 36 km grid using approximated 2006 emissions and the resultant output processed to provide boundary conditions (BCs) for a smaller 36/12/4 km domain (i.e., one-way grid nesting). Figure 2 displays a proposed 36/12/4 km CAMx modeling domain (with the larger MM5 modeling domains). CAMx would be run on the 36/12/4 km grid using two-way interactive grid nesting using BCs generated by the continental U.S. 36 km domain simulation. The 4 km CAMx modeling domain, which includes the DMA and adjacent regions, extends from Pueblo in the south to Cheyenne in the north and has a western boundary on the west side of the continental divide.

The CAMx model would be applied using the CB05 chemistry and with full particulate matter (PM) modeling capability. Thus, in addition to the VOC, NOx and CO emissions, as used in the previous EAC SIP modeling, emissions for SO2, NH3 and primary PM species would also be included to simulate PM and visibility. Although the primary focus of this work effort is on the 2010 8-hour ozone attainment demonstration modeling, we would also examine the effects on $PM_{2.5}$ concentrations, nitrogen deposition and visibility. We would also project 8-hour ozone Design Values out to 2020 for comparisons with proposed new 8-hour ozone NAAQS (e.g., 70-75 ppb).

The MM5/SMOKE/CAMx modeling system would be applied to the June-July 2006 on the Denver-focused 36/12/4 km grid. The first emissions scenario to be modeled would be a 2006 Actual Base Case scenario that uses day-specific hourly Continuous Emissions Monitoring (CEM) data for SO2 and NOx emissions from large stationary sources in the 4 km domain. Heat input values from these CEM data would further be used to distribute non-CEM reported emissions (e.g., VOC, CO, etc.). Additional 2006 VOC, NOx and CO emissions from other source categories in the Denver nonattainment area (NAA) would be provided by the CDPHE. 2006 emissions for the rest of the PM precursors in the DMA (e.g., SO2, NH3 and PM) would be estimated from other sources, such as the RPO 2002 databases projected to future years. There will also likely be a new 2006 oil and gas emissions inventory for the Denver basin ready in early 2008. The CAMx 2006 Actual Base Case modeling results would be used in the model performance evaluation (MPE). Diagnostic sensitivity tests would be conducted for the 2006 Actual Base Case simulation and the 4 km grid. Although the exact definition of the diagnostic tests will depend on the performance issues of the initial 2006 Actual Base Case simulations, we expect the following issues would be explored:

- Alternative MM5 meteorological realizations of the June-July 2006 episode using different MM5 parameterizations (e.g., PBL, LSM or cumulus schemes).
- Different algorithms for defining vertical turbulent mixing (Kz) from the MM5 output.

- Suppression of the MM5 convective rainfall activity that is frequently overstated in MM5 at fine horizontal grid spacing.
- Emissions sensitivity tests:
  - o Increase on-road mobile VOC;
  - o Increase on-road mobile VOC and NOx;
  - o Increase on-road and non-road mobile emissions;
  - o Area source emissions sensitivity;
  - o Oil and gas emission sensitivity; and
  - o Other.

Each 2006 Actual Base Case sensitivity test would be subjected to an operational model performance evaluation for ozone and potentially other related species. An optimal 2006 base case configuration would be selected based on the configuration that performs adequately[1] and meets regulatory requirements[2].

Once the optimally performing 2006 Actual Base Case CAMx simulation has been identified, we would run the 2006 Typical Base Case and 2010 Base Case CAMx simulations. The EPA Modeled Attainment Test Software (MATS) Tool would be used to project 2020 8-hour ozone Design Values. MATS uses the modeling results in a relative fashion to scale a current observed 8-hour ozone Design Value (DVC) to obtain a future-year projected 8-hour ozone Design Value (DVF). The model derived scaling factors are called relative response factors (RRFs) are the ratio of 2010 Base Case to 2006 Typical modeled 8-hour ozone concentrations near a monitor:

$$DVF = DVC \times RRF$$

When performing visibility projections EPA guidance recommends using a current year Design Value (DVC) based on an average of three 8-hour ozone Design Values centered on the modeling year (EPA, 2007). For example, when modeling 2002 episodes then the three-year average 8-hour ozone Design Values for years ending in 2002, 2003 and 2004 are used. This has in effect of weighting the fourth highest daily maximum 8-hour ozone concentrations from the years 2000-2004 with weights of 1, 2, 3, 2 and 1, respectively. For the new Denver 8-hour ozone modeling we will be modeling episodes from 2006. Following EPA guidance (EPA, 2007) the 5-year current years DVC would use a 3 year average of Design Values for years ending 2006, 2007 and 2008, which is not possible as 2008 has not yet occurred. Thus, instead we will start with a DVC based on the 8-hour ozone Design Value ending in 2007, so is based on the 2005-2007 three-year period.

2010 VOC/NOx across-the-board emissions reduction sensitivity simulations would be conducted to map out which source categories and species in the region have the largest influence on projected 2010 8-hour ozone Design Values in the DMA. This can be done

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[1] EPA guidance (EPA, 2007) does not include specific performance goals and recognizes that when modeling longer periods it is not possible to achieve “good” performance every day. Adequate performance will be defined based on EPA guidance and historical model performance.

[2] Regulatory requirements may preclude selecting the best performing model configuration from the sensitivity modeling. For example, if a doubled on-road mobile source VOC emissions produced the best model performance it may not be possible to use the modified MOBILE6 emissions in a SIP.

for a subset of the modeling domain and a subset of the modeling period to keep the computational requirements sufficiently low to examine a wide range of source categories. For example, we could look at the effects of a 20% VOC or NOx reduction (separately) across the Denver nonattainment area by major source category:

- On-road mobile sources.
- Non-road mobile sources.
- Oil and gas sources.
- Other area sources.
- Other point sources.

We would also conduct 2010 ozone source apportionment modeling using the CAMx Ozone Source Apportionment Technology (OSAT) tool. The 2010 ozone source apportionment modeling would be designed to compliment and provide additional information over the emission reduction sensitivity modeling. For example, the source apportionment modeling provides more information on geographical region contributions.

Based on the 2010 emission reduction sensitivity tests, RAQC/CDPHE would provide packages of recommended control measures to evaluate using the full model. These control packages would be evaluated and 2010 8-hour ozone Design Values calculated using MATS. The results would be documented in an air quality technical Support Document (TSD) and all final databases and modeling runs provided to RAQC/CDPHE.

Once the 2010 control plan has been determined we would perform 2020 base case modeling and emission reduction sensitivity tests.

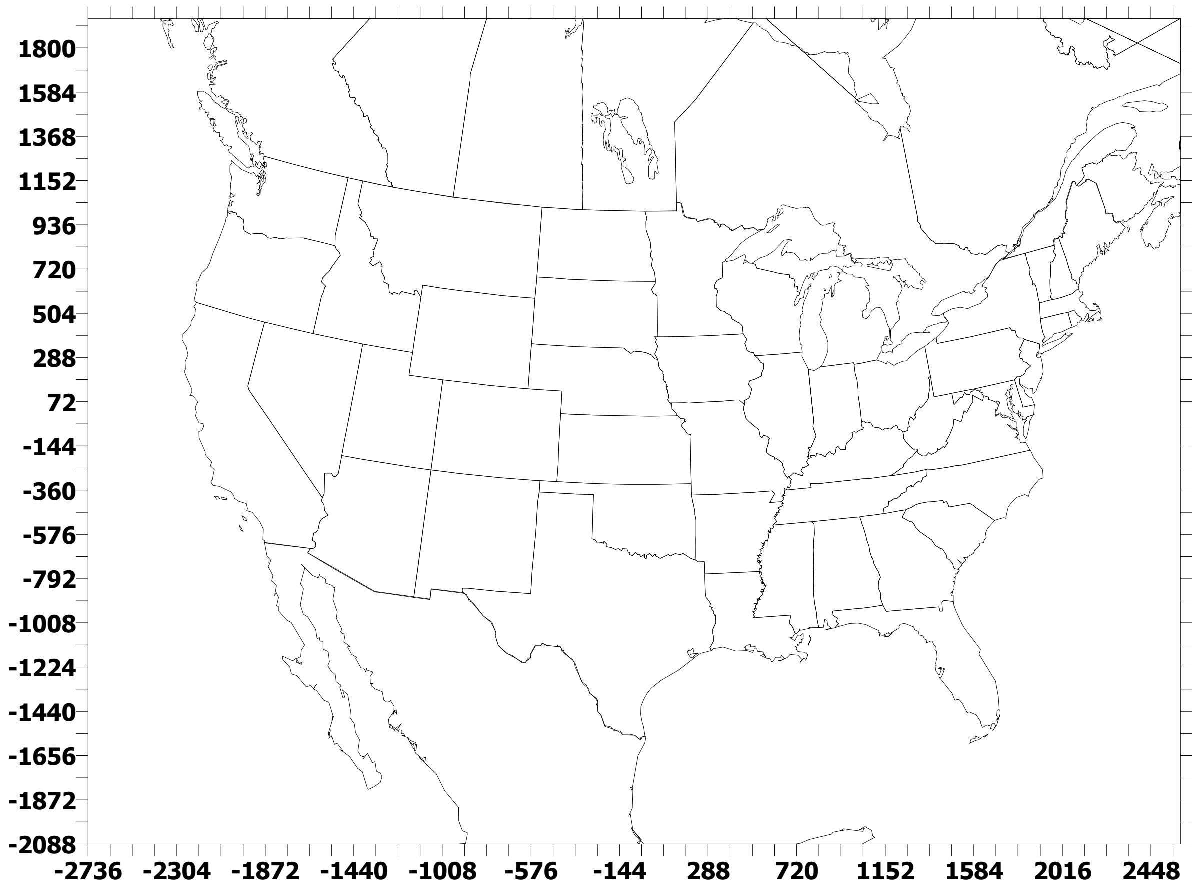

Figure 1. National Inter-RPO 36 km modeling domain used for by WRAP, CENRAP and VISTAS. Results from simulation of this domain will be used to define boundary conditions (BCs) for the Denver 36/12/4 km domain like the one shown in Figure 2.

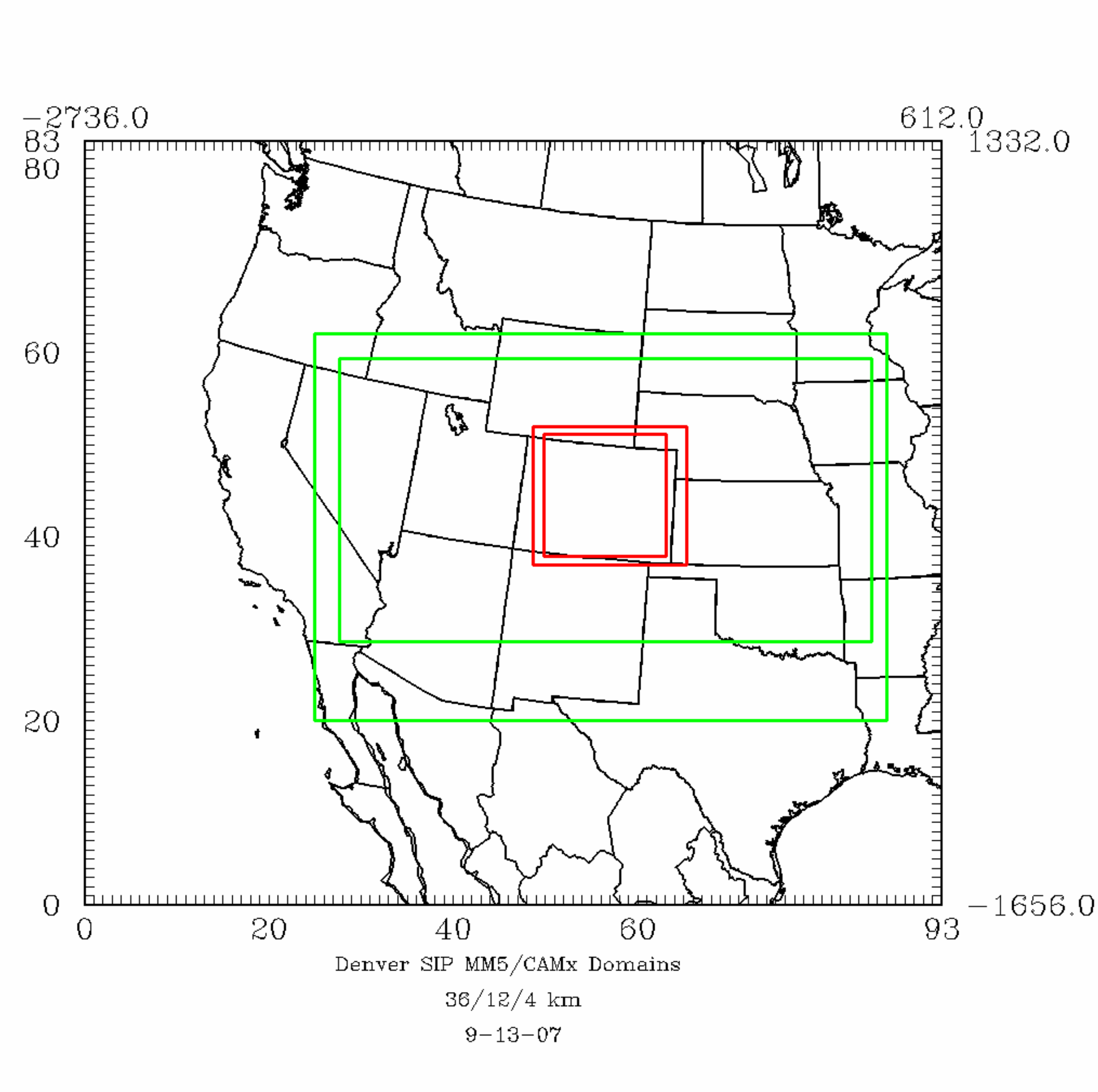

Figure 2. Potential 36/12/4 km modeling domains for MM5 meteorological (outer domains) and SMOKE emissions and CAMx air quality (inner domains) modeling of the June-July 2006 period and the DMA.

SCOPE OF WORK

We propose to perform the Denver 8-hour ozone attainment demonstrations modeling in ten tasks as follows.

Task 1: Modeling Protocol

Objective: To prepare a Modeling Protocol outlining the approach to be used for the Denver 8-hour ozone SIP modeling.

Approach: We would prepare a draft Modeling Protocol following EPA guidance (EPA, 2007) and submit to RAQC/CDPHE for review. Based on the comments from RAQC/CDPHE we would update the Modeling Protocol and resubmit a draft final version to RAQC/CDPHE. During the course of the study the modeling approach may be modified which would require additional updates to the Modeling Protocol.

Deliverables: Draft Modeling Protocol and Draft Final Modeling Protocol. Additional updated Draft Final Modeling Protocols as needed.

Schedule: This work would be performed during October 2007.

Task 2: Meteorological Modeling

Objective: To generate 36/12/4 km meteorological fields for the June-July 2006 period that are used to generate meteorological inputs for photochemical modeling of ozone formation in the Denver NAA and vicinity.

Approach: The MM5 would be set up on a 36/12/4 km grid sufficiently large to generate meteorological inputs for a photochemical grid modeling domain like those shown in Figures 1 and 2. The MM5 domains would be at least 5 cells larger than the photochemical grid modeling domain along each lateral boundary in order to minimize any boundary artifacts on the air quality model meteorological inputs. Over 30 vertical layers would be specified up to a region top of 100 mb (approximately 15 km AGL). Details on the MM5 modeling would be provided in the Task 1 Modeling Protocol. Our current thinking is to run MM5 in 5½ day chunks for the two month period using cold starts (i.e., the meteorological and land soil parameters would be based on observe values rather than on the previous days MM5 simulation every 5½ days). The first 12 hours of each simulation chunk would not be used. We would first run the 36/12 km MM5 simulation using two-way nesting with feedback and analysis nudging of winds, temperature and humidity above the PBL, but just analysis nudging of winds below the PBL including at the surface. The MM5 36/12 km modeling results would be used to provide boundary conditions (BCs) to the 4 km grid (i.e., one-way nesting) and the MM5 would be exercised for the 4 km grid using the same 5½ day modeling methodology.

Additional MM5 sensitivity tests would be conducted for the 4 km grid and the July 20-30, 2006 period. The variables to be studied could include, but not be limited to, the following:

- Planetary Boundary Layer (PBL) scheme (e.g., ACM, MRF, Blackadar).
- Land Surface Module (LSM) (e.g., PX, NOAH).
- Cumulus Parameterization (e.g., KF2, KF1, none).
- Moisture (e.g., Reisner 1 and 2).
- Data Assimilation (analysis only, surface wind observations).
- Other.

Based on our past experience, we expect the initial MM5 configuration for the 4 km grid would be as follows (36/12 km simulation except where indicated):

- PBL: Asymmetric Convective Mixing (ACM)
- LSM: Pleim-Xiu
- Cumulus: None (Kain-Fritcsh 2 in 36/12 km grid)
- Moisture: Reisner 2
- Data Assimilation: Analysis Nudging of winds, temperature and moisture above PBL, analysis nudging of wind only below the PBL and surface observation nudging of winds only (for 36/12 km runs no observations nudging)

The MM5 fields would be evaluated against surface and upper-air meteorological observations using METSTAT and RAOBS, respectively. The precipitation and convective activity would also be evaluated. The best performing MM5 fields would be tested in the photochemical grid model for the ten-day July 20-30, 2006 period to determine the optimal model configuration. Based meteorological and ozone model performance, we would select the optimal MM5 simulation and rerun for the entire June-July 2006 period on the 36/12/4 km grid.

<u>Deliverables</u>: Photochemical grid model meteorological inputs for the June-July 2006 period and the 36/12/4 km Denver grid. PowerPoint presentations on meteorological model sensitivity analysis and model evaluation. Brief Report suitable for inclusion as an Appendix in the Task 7 TSD.

<u>Schedule</u>: The preliminary 36/12 km and 4 km MM5 simulations of the June-July period using the initial configuration would be completed during October-November 2007. These fields would be used for emissions modeling (e.g., biogenics, on-road mobile sources, wind blown dust and ammonia). The MM5 sensitivity runs would be performed during the two-month period of December 2007 and January 2008 with the final MM5 simulations finished in January-February 2008.

Task 3A: 2006 Emissions Modeling

<u>Objective</u>: To generate 2006 Base Case emissions inputs for a 2006 Actual and 2006 Typical base case emission scenarios.

Approach: The CDPHE will provide 2006 emissions of VOC, NOx and CO for area, point, and non-road mobile for the Denver NAA and 2006 MOBILE6 inputs and link-based Vehicle Miles Traveled (VMT) for the Denver Metropolitan Area (DMA). The DMA link-based VMT data would be used in Task 3B to generate on-road mobile source emissions for the DMA using the CONCEPT emissions model, whereas the rest of the emissions modeling would use the SMOKE emissions model. Additionally, the CDPHE would provide regional 2006 fire emission inventories for the episode of interest. The ENVIRON/Alpine Team will work with the RAQC/CDPHE to determine the best source of the 2006 VOC, NOx and CO emissions for the rest of the domain outside of the Denver NAA and for the additional PM precursor emissions [i.e., SO2, NH3, primary PM by species, SO4, NO3, EC, OMC, other $PM_{2.5}$ and Coarse Mass (CM)] for the entire domain. Among the sources of data we would use are:

- The RPO 2002 baseline inventories projected to 2005/2006 that has a complete accounting of all sources and species and would serve as starting point for a complete inventory that would be updated with newer and better information as available.
- CDPHE 2006 VOC, NOx and CO emissions for area, point and non-road mobile sources in the Denver NAA.
- 2006 day-specific hourly Continuous Emissions Monitoring (CEM) data for large point sources in the vicinity of Denver (e.g., Pawnee). These data would be used for the 2006 Actual Base Case emissions inventory. The data would be analyzed to also develop point source emissions for the 2006 Typical Base Case emissions inventory. 2005-2007 CEM data will be analyzed to develop typical emissions for the 2006 base case.
- For on-road mobile sources in the DMA we would use the CONCEPT on-road mobile link-based emissions model as described in Task 3B.
- For on-road mobile sources outside of the DMA we would use 2006 county-wide VMT data and the SMOKE-MOBILE6 emissions modeling module along with spatial surrogates.
- The EPA NONROAD model would be used to estimate non-road mobile source emissions outside of the Denver NAA.
- We would look at the suitability of using the WRAP ammonia model along with updated land cover data and the 2006 MM5 data for generating ammonia emissions for the 36/12/4 km grid.
- Wind blown dust (WBD) emissions would be generated using the WRAP WBD emissions model and 2006 MM5 data.
- Initially, oil and gas (O&G) development emissions would be based on data obtained from the CDPHE and the WRAP Phase II work efforts. Additional updates to the O&G inventory will likely become available during the study. We would work with RAQC/CDPHE to identify the best source of O&G emissions for 2006, 2010 and 2020.
- Biogenic emissions would be generated using the MEGAN biogenic emissions model and the 2006 MM5 data.
- Fire emissions for 2006 will be provided by CDPHE.

We would develop an initial placeholder 2006 Actual base case emissions inventory for the June-July 2006 period using data available in the October-November time frame. This placeholder inventory would be updated with new information to achieve a draft final 2006 Actual Base Case inventory by February 2008. In order to keep to this schedule any new information needs to be provided to the ENVIRON/Alpine Team by January 30, 2008.

Deliverables: Model-ready emission inputs for the 36/12/4 km grid and the 2006 Actual and 2006 Typical Base Case emissions scenarios. PowerPoint presentation of the 2006 base year emissions development and data sources. Technical report suitable for inclusion as a Chapter of the Task 8 TSD.

Schedule: 2006 Actual placeholder inventory by December 15, 2007. 2006 Actual and Typical base case inventories by end of February 2008.

Task 3B: CONCEPT Line-Based On-Road Emissions for DMA

Objective: To generate link-based on-road mobile source emissions for the DMA at 4 km and the June-Jul 2006 period and the 2006 base case emission scenario.

Approach: The link-based CONCEPT emissions modeling system would be used along with the MOBILE6 emissions model and link-based VMT data to generate on-road mobile source emissions for the DMA.

Consolidated Community Emissions Processing Tool (CONCEPT) Overview

The Consolidated Community Emissions Processing Tool (CONCEPT) is an emissions processing model that performs the three key features of emissions processing models: temporal allocation of the emissions (to hourly), spatial allocation of the hourly emissions to the grid cells in the modeling domain, and emissions speciation for use in air quality modeling.

The main features of the CONCEPT modeling system are as follows:

- Open Source: Written primarily in PostgreSQL, the software required for running CONCEPT is in the public domain. The model itself is GNU Public License (GPL) compliant and users are encouraged to make additions and enhancements to the modeling system.

- Transparent: The database structure of the model makes the system easy to understand, and the modeling codes themselves are extremely well documented to encourage user participation in customizing the system for specific modeling requirements.

- Quality Control: The CONCEPT model structure and implementation allows for multiple levels of QA analysis during every step of the emissions calculation process. Using the database structures, an emissions modeler can easily trace a process or facility and review the calculation procedures and assumptions for any emissions value. CONCEPT can be run with a variety of debug and QA options that control the number of intermediate tables and reports that are available for the user to review.

The core development software for the CONCEPT system is the PostgreSQL database engine, running on the Red Hat Linux operating system. In addition, the following plug-in packages, all in the public domain, are also required: perl (to facilitate data input-output from the SQL data base and data reporting); and PostGIS, GEOS and PROJ4 (to facilitate spatial processing).

The CONCEPT emissions model has been developed in a modular fashion, with five primary source category models, and a group of secondary support models that will serve each of the primary models. The major emission source categories are treated as the primary models:

- Area Source;
- Point Source;
- On-road Motor Vehicle, with EPA's MOBILE6 model;
- Non-road Motor Vehicle with the EPA's NONROAD model; and
- Biogenics.

The overall framework architecture and database design were created during the development of the point and area models. During the development process, structural requirements were refined for the unique attributes of the motor vehicle, biogenic, and NONROAD models. The supporting system modules accommodate all of the primary models, as required. The supporting modules are:

- Speciation profile development;
- Spatial surrogate development; and
- Growth & Control with Cost Analysis.

CONCEPT MV code, User's Guide, and related documentation are available on the CONCEPT web site, http://www.conceptmodel.org/.

The original CONCEPT model development, funded by LADCO, was a joint effort of ENVIRON and Alpine Geophysics. ENVIRON staff did a majority of the coding: ENVIRON programmed the on-road sources, nonroad sources, area sources, and point sources. Alpine coded the speciation module, and the biogenics emissions. Since the original project, ENVIRON has done extensive code enhancement on the mobile sources portion of the code, including mobile source toxics speciation just completed under EPA funding.

A key feature of CONCEPT is that the motor vehicle emissions module (CONCEPT MV) estimates on-road emissions in a more sophisticated and detailed way than any other emissions processing system available.

The CONCEPT MV emissions model estimates and grids link-level emissions using the output from Transportation Demand Models (TDMs). The TDMs typically provide VMT or volume for multi-hour periods, and CONCEPT uses temporal allocation factors and VMT mix fractions to estimate hourly emissions for each vehicle class for each roadway type. Because there are multiple transportation models in use, all with different requirements and inputs/outputs, ENVIRON developed the TDM Transformation Tool, or T3, to process the traffic demand model vehicle types, road networks, and vehicle activity to the activity data and create the file formats required by CONCEPT MV. The primary goals of T3 are to provide an easy mechanism for incorporating TDM model outputs in as "raw" a format as possible, while simultaneously providing a great degree of flexibility in representing the TDM projections in terms acceptable to most air quality models.

EPA's MOBILE6 model is executed within CONCEPT to generate the g/mile (for running emissions) and gram/trip (for trip start and trip ends) emission factors. The emission factors depend on meteorological data (temperature and humidity), which are obtained from MM5 meteorological modeling runs, for every grid cell in the modeling domain. CONCEPT then estimates emissions for each emissions mode by multiplying the activity data (VMT or trips by vehicle class) by the appropriate MOBILE6 emission factors. CONCEPT then speciates the emissions as required for input to an air quality model. The result is an hourly, gridded, speciated inventory ready for input to CMAQ or CAMx air quality modeling.

Vehicle activity data for CONCEPT come primarily from the T3 pre-processing model. The link-level traffic volume data are typically provided as an average day, in multi-hour periods (e.g., am peak, pm peak, midday, overnight) average day, annual average, or partial day periods) and are temporally allocated to hourly values for the CONCEPT scenario period. In addition, the activity data are spatially allocated to the model grid since the MOBILE6 emission factors are generated by grid cell using the gridded meteorological data.

CONCEPT also reads speed data from the input files, and accepts a variety of instructions for adjusting speeds using volume delay functions. Inputs may specify a Bureau of Public Roads (BPR) style adjustment curve, or a detailed lookup table of adjustments. The curve coefficients and adjustment factors may vary by network link, speed, and volume-capacity ratio, providing a great deal of flexibility in how speeds are calculated.

Most urban transportation modeling networks cover all major roads (interstates, freeways, major arterials), and some lesser roads (minor arterials and collectors). The smallest roads – local roads – are typically not covered in transportation models. In CONCEPT, the VMT for local roads can be provided as a county total, and then the emissions are estimated and spatially allocated to grid cells by CONCEPT using a spatial surrogate, such as population. In rural areas not covered by a transportation network, county-level VMT by roadway type can be processed and emissions estimated by CONCEPT in a similar way.

The steps in CONCEPT MV that are followed to estimate model-ready emissions using the TDM data are as follows:

1. Input QA. CONCEPT imports VMT, trips, volumes, network capacity, speeds, network definition, speed adjustments, and meteorological data and performs QA checks. CONCEPT generates both summary and error reports.

2. Temporal Allocation. TDM data are typically provided for multi-hour periods, e.g., annual average day, or am peak/pm peak/off-peak. CONCEPT uses total-volume hourly profiles to split the multi-hour volumes to hourly volumes per link. The total volume temporal profiles are specified by State, roadway type, hour of day, day of week, and month. Temporal allocation is applied to the VMT, volume, capacity, and trips data. The profiles are typically determined from analyses of traffic counter data available from State Departments of Transportation (DOT) and/or local transportation planning agencies.

3. Speed Adjustment. If the user has indicated that speed adjustments are to be applied, CONCEPT calculates the hourly volume-capacity ratios and applies appropriate adjustments to the free-flow speeds for each link to estimate hourly actual speeds. Some networks provide these data as output from their TDM or TDM post-processors, in which case no speed adjustments are performed.

4. Spatial Allocation. MOBILE6 is executed using gridded meteorological data from MM5 modeling, so the activity data must be spatially allocated prior to determining the required MOBILE6 runs. The link-based VMT data are spatially allocated using an overlay of the link network on the model grid. County-based VMT, and TAZ/county based trip data, are typically allocated to the model grid using spatial surrogates.

5. Application of VMT Mix Profiles. VMT data are split by the MOBILE6 vehicle classes as input to CONCEPT. The vehicle classes are converted to match the eight MOBILE5 vehicle classes used in CONCEPT using vehicle mix profiles provided as input to CONCEPT. The vehicle mix profiles vary by roadway type, month, day of week, and time of day.

6. Define Required MOBILE6 Runs. MOBILE6 is run for each combination of representative county, minimum and maximum (min/max) temperature combination, calendar year, season (January or July), roadway type, and speed bin. The min/max temperature combinations use a user-defined tolerance level so that similar temperature ranges are considered equal. The speeds for which the model is run are also defined with speed bins in the user input. Finally, the MOBILE6 model is run

using a single set of 24 hourly values for temperature and relative humidity for each group of grid cells.

7. Execute MOBILE6. MOBILE6 is executed with the database output; CONCEPT MV uses a customized version of MOBILE6 (developed by Air Improvement Resource under contract to LADCO) that includes options for summarizing the database output across model years within each vehicle class, and across the detailed MOBILE6 vehicle classes (into the eight MOBILE5 vehicle classes used in CONCEPT). This significantly reduces both the size of the database files, and also processing time.

8. Combine Activity Data and Emission Factors. Generally speaking, for each hour of each episode day, for each link in each grid cell, CONCEPT uses the grid cell ID, county, temperature increase bin, road type, and speed to determine the correct emission factor for each vehicle class, pollutant and (non-start) emission mode. Emissions for each vehicle class, emission type, and pollutant are estimated as the product of the emission factor and the VMT on that link associated with the vehicle class.

9. Speciate the Emissions. CONCEPT MV applies the appropriate speciation profiles by pollutant and emission mode to generate the speciated emissions.

Under this task we would set up and run CONCEPT using the DMA link-based TDM data to generate 2006 base case on-road mobile source emissions for the June-July 2006 episode at 4 km resolution. Additional data from the DMA area would be used to develop DMA-specific diurnally varying fleet mixes and day-of-week adjustments.

Deliverables: 2006 base case on-road mobile source emission inputs.

Schedule: 2006 base case on-road mobile source emissions for the DMA would be generated by February 2007.

Task 4: 2006 Photochemical Modeling

Objective: To perform sensitivity and base case photochemical modeling of 2006 Actual base case and model performance evaluation and perform a 2006 Typical base case simulation.

Approach: The CAMx model would be used to simulate ozone, PM and visibility on the continental U.S. 36 km and the Denver 36/12/4 km modeling domain. The remaining CAMx model inputs would be developed for the June-July 2006 episode and the 36/12/4 km Denver grid (e.g., land cover, ozone column, photolysis rates, etc.). We would review available data sources for defining BCs around the lateral edges of the 36 km RPO continental U.S. modeling domain (Figure 1). Currently the best identified source is the monthly average diurnally varying results from a 2002 application of the GEOS-

CHEM global chemistry model. The CAMx model would be applied on the 36 km RPO domain for the ten-day June-July 2006 period and the results processed to generate BCs for the lateral boundaries of the Denver 36/12/4 km domain. CAMx would then be applied for the June-July 2006 period on the Denver 36/12/4 km grid (two-way nesting) using the 2006 Actual placeholder inventory and an ozone operational model performance evaluation conducted. The model output would be processed to generate BCs for the 4 km grid (one-way nesting) for the July 20-30, 2006 period for sensitivity modeling. We would then conduct a series of CAMx sensitivity tests on the 4 km grid for the July 10-30, 2006 period. We have budgeted seven (7) such sensitivity tests. Based on the diagnostic sensitivity test we would identify the optimally performing model configuration and inputs. When the final 2006 Actual base case emissions become available we would first run them for the July 10-30, 2007 test period and the 4 km grid to assure they did not dramatically alter the conclusion regarding the optimal configuration. We would then run the full June-July 2006 episode on the 36/12/4 km grid using the final 2006 Actual base case emissions. A detailed operational model performance evaluation would then be conducted focusing on ozone and ozone precursors and product species. We would also examine the model performance for PM species, visibility and deposition, although it would not be as in-depth as for ozone. A 2006 Typical 36/12/4 km CAMx base case simulations would also be conducted using the final 2006 inventory.

Deliverables: PowerPoint presentation on the results of the CAMx diagnostic sensitivity tests and summary of optimal model configuration. PowerPoint presentation of final 2006 Actual base case model performance evaluation. Technical report on diagnostic analysis and model performance evaluation suitable for inclusions as an Appendix in the TSD.

Schedule: A preliminary PowerPoint presentation on diagnostic testing would be available in January with the final version by the end of February. The PowerPoint presentation on the final 2006 Actual base case simulations and model performance evaluation would be available by the end of March 2008. The Technical Report would be submitted around April 15, 2008.

Task 5A: 2010 Emissions and Photochemical Modeling

Objective: To generate a 2010 base case emissions inventory and perform 2010 base case CAMx simulation and 8-hour ozone Design Value projections.

Approach: The 2006 emissions would be projected to 2010. For on-road mobile sources in the DMA, the CONCEPT model would be used along with the MOBILE6 model and 2010 link-based VMT for the DMA provided by CDPHE. For on-road mobile source emissions outside of the DMA, the SMOKE-MOBILE6 module would be used with projected county-level 2010 VMT and the 2010 vehicle fleet. Other source categories would be projected using appropriate growth and control factors or existing 2010 inventories as available (e.g., for O&G from WRAP or newer studies) with concurrence with RAQC/CDPHE. The 2010 base case would include growth and on-the-book (OTB) control measures.

The CAMx model would first be run on the RPO 36 km grid (Figure 1) using 2010 forecasted emissions for the June-July 2006 period. Concentrations would be extracted to generate boundary conditions for the Denver 36/12/4 km domain. CAMx would then be run using the 2010 base case emissions and the Denver 36/12/4 km grid. Ozone observations from the 2005-2007 period would be analyzed to generate 3-year 8-hour ozone Design Values. These data would be implemented in the EPA MATS tool. MATS would then be used to project 2010 8-hour ozone Design Values using the CAMx results for the 2006 Typical and 2010 base case emission scenarios. Results would be documented in a PowerPoint presentation.

Deliverables: PowerPoint presentation on the 2010 CAMx base case modeling and the 2010 8-hour ozone Design Value projections.

Schedule: The PowerPoint presentation on the 2010 modeling and ozone projections would be submitted to RAQC/CDPHE by April 30, 2008.

Task 5B: 2020 Emissions and Photochemical Modeling

Objective: To perform 2020 emissions and CAMx modeling and 8-hour Design Value projections.

Approach: We would perform 2020 emissions modeling to generate 2020 base case emissions for the Denver 36/12/4 km modeling domain (Figure 2). The SMOKE-MOBILE6 module would be used along with projected 2020 VMT data to generate 2020 on-road mobile sources emissions. 2020 O&G emissions would be used as available from WRAP or other newer sources. For other source categories the WRAP 2020 emissions would be used.

BCs for the Denver 36/12/4 km modeling domain would be generated from a 2020 simulation from the RPOs (e.g., WRAP). CAMx would be run for the 2020 base case emissions inventory and 8-hour ozone Design Values projected. Results would be documented in a PowerPoint presentation.

Deliverables: PowerPoint presentation discussing 2020 emissions and CAMx modeling and 8-hour Design Value projections.

Schedule: This task would be performed after the 2010 control plan has been determined in Task 6A.

Task 6A: 2010 Control Plan Modeling

Objective: To perform 2010 emission reduction sensitivity simulations and 2010 control strategy modeling.

Approach: We would first run the MATS tool for the July 10-30, 2006 subset of the June-July 2006 episode using the CAMx 2006 Typical base case results generated in Tasks 4A and 4B and 2010 OTB base case results generated under Task 5A to determine whether the projected 8-hour ozone Design Values using this subset of ten modeling days are sufficiently close to the those generated under Task 5 using the full June-July 2006 episode modeling results so that we can perform meaningful emission reduction sensitivity tests on a subset of the episode. This will allow us to examine more sensitivity tests than might be analyzed otherwise if we had to run the full episode for each test. We would extract BCs from the CAMx 2010 36/12/4 km base case run for the 4 km domain so that CAMx can be run on the 4 km grid alone using one-way nesting (Figure 2). We would then run CAMx on the 4 km grid for the July 10-30 period (with 5 day initialization period) for the emission reductions sensitivity tests. The 2010 emission reduction sensitivity tests would separately reduce VOC and NOx emissions by 20% from 2010 OTB base case levels within the Denver NAA for the following major source categories (note that the area could be expanded if desired):

- On-road mobile sources;
- Non-road mobile sources;
- Oil and gas sources;
- Other area sources; and
- Point sources.

This results in ten (10) 2010 emission reductions sensitivity tests. We would perform two more additional 2010 sensitivity tests to be determined. The MATS tool would be used to project 8-hour ozone Design Values and a PowerPoint presentation would be prepared on the 2010 emission reductions sensitivity tests. We would also look at the effects of the 2010 emissions reductions sensitivity tests on $PM_{2.5}$, visibility and nitrogen deposition.

Based on the emission reduction sensitivity tests, the RAQC/CDPHE would provide the ENVIRON/Alpine Team with two (2) control strategies that include a package of control measures for 2010. We would implement the control measures in the SMOKE emissions modeling system and generate 2010 emission inputs for the CAMx model and two 2010 control strategies. The CAMx model would be run for the full June-July 2006 period on the 36/12/4 km grid for the two 2010 control strategies. We would work with the RAQC/CDPHE in the implementation and QA of the control strategy modeling. 2010 8-hour ozone Design Value projections would be made using MATS and the results of the 2010 control strategy modeling documented in a PowerPoint presentation.

The results of this task would be documented in a brief technical report suitable for inclusions as a chapter in the AQ TSD.

Deliverables: PowerPoint presentations on the 2010 emission reduction sensitivity analysis and 2010 control strategy modeling. Brief report on the 2010 modeling.

Schedule: The 2010 emission reduction sensitivity modeling would be conducted during May 2008 with the PowerPoint presentation submitted by mid-June. The 2010 control strategy modeling would be conducted during June-July 2008 with the PowerPoint presentation prepared by mid-August and the brief Task 6 report prepared by the end of August 2008.

Task 6B: 2020 Emissions Reductions Sensitivity and Control Plan Modeling

Objective: Perform 2020 emission reductions sensitivity modeling.

Approach: This approach would follow the same scope of work as in Task 6A only using the 2020 future-year instead of 2010. Ten (10) emission reductions sensitivity tests would be performed along with two (2) control strategies. This work would be performed after the 2010 control strategy has been determined and after Task 5B has been performed.

Deliverables: PowerPoint presentation on 2020 emission reductions sensitivity simulations and results from the two 2020 control strategies.

Schedule: This work would be performed after Task 5B.

Task 6C: 2010 Ozone Source Apportionment Modeling

Objective: Perform 2010 ozone source apportionment modeling.

Approach: The CAMx Ozone Source Apportionment Technology (OSAT) would be used to identify the source regions and categories that contribute to elevated ozone and 2010 8-hour ozone Design Values in the DMA. The 2010 PSSAT analysis would be designed to compliment and provide more specific information than generated by the 2010 emission reductions sensitivity tests performed under task 6A. The modeling domain could be divided up by county within the DMA and larger geographic regions outside of the DMA to provide more specific information on the contributions of different geographic regions and the role of transport. In addition, for each geographic region the contributions due to source categories would also be obtained (e.g., on-road mobile, non-road mobile, area, EGU point, non-EGU point, oil and gas and biogenic sources).

Deliverables: PowerPoint presentation on the CAMx 2010 OSAT modeling. Document suitable for inclusion as an appendix to the TSD.

Schedule: This work would be completed in May 2008.

Task 7: Technical Support Document

Objective: To prepare a air quality modeling Technical Support Document for the Denver 8-hour ozone SIP.

Approach: The interim documents prepared under Tasks 1-6 would be integrated into a draft Technical Support Document (TSD) and submitted to RAQC/CDPHE for comments. A draft final TSD would be submitted within a week of receiving comments from RAQC/CDPHE.

Deliverables: Draft and Draft Final TSD.

Schedule: The Draft TSD would be submitted by mid-September 2008 with the Draft Final version within one week of receipt of comments from the RAQC/CDPHE.

Task 8: Meetings

Objective: To attend five (5) meetings on the Denver 8-hour ozone SIP modeling.

Approach: Mr. Ralph Morris of ENVIRON and Mr. Dennis McNally of Alpine would attend up to 5 one-day meetings that are assumed to occur in Denver.

Deliverables: Attendance of Mr. Morris and McNally at 5 meetings.

Schedule: To be determined.

Task 9: Technology Transfer

Objective: To transfer the modeling databases and key model output files to the RAQC/CDPHE and assist them in running on their computers.

Approach: Mr. Dennis McNally would lead the technology transfer. He would prepare hard disks with the SMOKE and CAMx modeling databases, scripts and models and transfer to RAQC/CDPHE. The databases would be set up on the CDPHE computer and tested. He would be available to answer addition questions from the RAQC/CDPHE

Deliverables: Hard drives of modeling databases and key outputs.

Schedule: This task would be performed in September 2008.

Task 10: Contingency

Objective: To provide backup funding to address additional needs quickly as they arise.

Approach: Contract would be set up with an unallocated contingency Task 10 that has funds available to perform unanticipated work elements in a timely fashion.

Deliverables: TBD.

Schedule: TBD.

SCHEDULE AND COSTS

Table 1 summarizes the schedule for the proposed Denver 8-hour ozone attainment demonstrations modeling study including time lines and deliverables. A detailed breakdown of the costs of the study by task is provided in Table 2.

Table 1. Schedule and key deliverables for the Denver 2010 8-hour ozone attainment demonstration modeling study.

Task	**--------------2007--------------**			**---2008---**								
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
1. Modeling Protocol	1. 2.											
2. MM5 Modeling		3.		4.	5.							
3A. Emissions Modeling			6.		7.	8.						
3B. CONCEPT DMA					7.	8.						
4. 2006 CAMx Modeling				9.	10.	11.	12.					
5A. 2010 Emissions/CAMx							13.					
5B. 2020 Emissions/CAMx												14.
6A. 2010 Control Plan									16.		17. 18.	
6B. 2020 Reductions												14.
6C. 2010 Apportionment								15.				
7. Air Quality TSD												19 20.
8. Meetings (5 TBD)												
9. Technology Transfer												21.

Deliverables

1. Draft Modeling Protocol (Report)
2. Draft Final Modeling Protocol (Report)
3. Initial 36/12/4 km MM5 simulation and model evaluation (PPT)
4. MM5 sensitivity results (PPT)
5. Final 36/12/4 km MM5 results (PPT)
6. Placeholder 2006 Actual emissions (PPT)
7. Final 2006 Actual emissions (PPT)
8. Final 2006 Typical emissions and emissions summary report (PPT and Report)
9. Preliminary CAMx model sensitivity analysis (PPT)
10. Final CAMx model sensitivity analysis (PPT)
11. Final CAMx 2006 Actual Base Case simulation and model evaluation (PPT)
12. Task 4 report summarizing CAMx sensitivity analysis, final 2006 base case simulation and model evaluation (Report)
13. 2010 emissions and CAMx modeling results including 8-hour ozone Design Value projections for the 2010 ITB base case (PPT)
14. 2020 emissions and CAMx modeling results (PPT)
15. 2010 ozone source apportionment modeling results (PPT)
16. 2010 emission reductions sensitivity modeling (PPT)
17. 2010 control strategy modeling (PPT)
18. Report on 2010 emission sensitivity and control plan modeling (Report)
19. Draft air quality TSD (Report)
20. Final air quality TSD (Report)
21. Disk Drives with SMOKE and CAMx modeling databases, models, scripts and key output files (Disks)

Table 2. Cost breakdown for the Denver 2010 8-hour ozone attainment demonstration modeling study.

Lbr Category/Name	Task 1 Modeling Protocol Hrs	Task 1 Dollars	Task 2 Meteorological Modeling Hrs	Task 2 Dollars	Task 3A 2006 Emissions Hrs	Task 3A Dollars	Task 3B CONCEPT DMA On-Road Emissions Hrs	Task 3B Dollars	Task 4 2006 Photochemical Modeling Hrs	Task 4 Dollars	Task 5A 2010 Emissions & Photochemica Modeling Hrs	Task 5A Dollars
Principal												
Ralph Morris	16	3,520	8	1,760		0	2	440	32	7,040	8	1,760
Sr. Consultant												
Chris Emery	8	1,140	32	4,559	4	570		0	20	2,849		0
Gerry Mansell		0		0	32	4,269		0		0		0
Bonyoung Koo		0		0		0		0	40	4,522	8	904
Sr. Associate												
Susan Kemball-Cook	8	825	80	8,249		0		0		0		0
Michele Jimenez		0		0	0	0	80	9,793		0	20	2,448
Stella Shepard		0		0	0	0	60	6,657		0	32	3,550
Ed Tai		0		0		0		0	40	3,965		0
Associate												
Bo Wang		0		0	20	2,032	60	6,097	40	4,064	40	4,064
John Grant		0		0	32	2,762		0		0		0
Jeremiah Johnson	16	1,356	120	10,166	0	0		0	80	6,778	8	678
Support	6	534	4	356	2	178	2	178	4	356		0
ENVIRON Labor Subtotal	54	7,374	244	25,090	90	9,811	204	23,164	256	29,574	116	13,405
Subcontractor												
Alpine Geophysics												
Dennis McNally	16	2,266	32	4,532	0	0		0	16	2,266	32	4,532
Gregory Stella	16	2,266		0	120	16,996		0		0	40	5,665
Cyndi Loomis	8	1,133		0	120	16,996	16	2,266		0	60	8,498
ODCs - travel						100		50		50		50
10% G&A on Subcontractors		567		453		3,409		232		232		1,875
Labor Subtotal	94	13,605	276	30,075	330	47,311	220	25,712	272	32,122	248	34,025
Other Direct Costs												
Communications (1)		221		753		294		695		887		402
Computing (2)		221		753		294		695		887		402
Travel		0		0		0				0		
Misc. - contingency				100				50		50		50
ODCs Subtotal		442		1,605		589		1,440		1,824		854
GRAND TOTAL	94	14,048	276	31,680	330	47,900	220	27,152	272	33,946	248	34,879

Lbr Category/Name	Task 5B 2020 Emission & Photochemical Modeling Hrs	Task 5B Dollars	Task 6A 2010 Control Plan Support Hrs	Task 6A Dollars	Task 6B 2020 Control Plan Modeling Hrs	Task 6B Dollars	Task 6C 2,010 Source Apportionment Hrs	Task 6C Dollars	Task 7 Techncial Support Document Hrs	Task 7 Dollars	Task 8 Meetings Hrs	Task 8 Dollars	Task 9 Technology Transfer Hrs	Task 9 Dollars	Task 10 Contingency Hrs	Task 10 Dollars	Total All Tasks Hrs	Total Dollars
Principal																		
Ralph Morris	2	440	16	3,520	16	3,520	8	1,760	16	3,520	40	8,800		0		0	164	36,080
Sr. Consultant																		
Chris Emery		0		0		0		0		0		0		0		0	64	9,117
Gerry Mansell		0		0		0		0		0		0		0		0	32	4,269
Bonyoung Koo		0		0		0	8	904		0		0		0		0	56	6,331
Sr. Associate																		
Susan Kemball-Cook		0		0		0		0		0		0		0		0	88	9,074
Michele Jimenez	20	2,448		0		0		0		0		0		0		0	120	14,689
Stella Shepard	32	3,550		0		0		0		0		0		0		0	124	13,758
Ed Tai		0		0		0		0		0		0		0		0	40	3,965
Associate																		
Bo Wang	40	4,064	40	4,064	44	4,471	32	3,252		0		0		0		0	316	32,109
John Grant		0		0		0		0		0		0		0		0	32	2,762
Jeremiah Johnson		0		0		0	40	3,389		0		0		0		0	264	22,366
Support	2	178		0	2	178	2	178	8	712		0		0		0	32	2,846
ENVIRON Labor Subtotal	96	10,681	56	7,584	62	8,169	90	9,483	24	4,232	40	8,800	0	0	0	0	1,332	157,366
Subcontractor																		
Alpine Geophysics																		
Dennis McNally	32	4,532	70	9,914	64	9,064		0	8	1,133	25	3,541	20	2,833		0	315	44,613
Gregory Stella	32	4,532	20	2,833	20	2,833		0		0		0		0		0	248	35,124
Cyndi Loomis	40	5,665	40	5,665	44	6,232		0		0		0		0		0	328	46,455
ODCs - travel		20		30		30								200				530
10% G&A on Subcontractors		1,475		1,844		1,816		0		113		354		303		0		12,672
Labor Subtotal	200	26,905	186	27,870	190	28,143	90	9,483	32	5,478	65	12,695	20	3,336	0	0	2,223	296,760
Other Direct Costs																		
Communications (1)		320		228		245		284		127		264		0		0		4,721
Computing (2)		320		228		245		284		127		264		0		0		4,721
Travel		0										2,500				0		2,500
Misc. - contingency		20								25						51,000		51,295
ODCs Subtotal		661		455		490		569		279		3,028		0		51,000		63,237
GRAND TOTAL	200	27,566	186	28,326	190	28,633	90	10,052	32	5,757	65	15,723	20	3,336	0	51,000	2,223	359,997

Notes:
(1) ENVIRON charges a communications rate of 3% of direct labor dollars for telephones, copier services, and facsimile charges.
(2) ENVIRON charges a computer rate of 3% of direct labor dollars for use of computers and printers.