1. INTRODUCTION

Central California is a complex region from an air quality and meteorological perspective, owing to its proximity to the Pacific Ocean, its diversity of climates, and its complex terrain. As a result of progressively more stringent controls on emissions of reactive organic gases and oxides of nitrogen, the frequency and intensity of excessive ozone concentrations in central and northern California have been significantly reduced despite rapid increases in population, commercial activities and vehicle miles traveled. For example, the average annual maximum hourly ozone concentrations have declined by xx, yy, zz percent from the 1980s to 1990 (up to 1997) in the San Francisco Bay Area, Sacramento Valley, and San Joaquin Valley air basins, respectively. While progress has been made toward attainment of the 1-hour ozone standard, it continues to be exceeded frequently in central California. The average annual exceedances of the federal 1-hour ozone standard (0.12 ppm) in the San Francisco Bay Area Air Basin declined from 11 during the 1980s to 4 in the 1990s (to 1997), from 21 to 10 in the Sacramento Valley Air Basin and from 58 to 41 in the San Joaquin Valley Air Basin. Long-term trends in ozone concentrations also show that less progress is being made in reducing the frequency of exceedances of the state 1-hour (0.09 ppm) and the pending federal 8-hour ozone standards.

The Central California Ozone Study (CCOS) is being proposed to gather an aerometric database for modeling and to apply air quality models for the attainment demonstration portion of the SIP for the federal 8-hour and state 1-hour ozone standards. The modeling domain for CCOS will cover all of central California and most of northern California, extending from the Pacific Ocean to east of the Sierra Nevada and from Redding to the Mojave Desert. CCOS is an integrated effort that includes air quality and meteorological field measurements, emissions characterization, data analysis and air quality modeling. The CCOS field measurement program will be conducted in the summer of 2000 in conjunction with the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRPAQS), a major study of the origin, nature and extent of excessive levels of fine particles in central California (Watson et al, 1998).

This document describes the goals and technical objectives that will be addressed by the CCOS and describes alternative experimental and data analysis approaches for addressing the study objectives. It provides a summary of the current conceptual model of the relationship between meteorology, emissions, chemical and physical transformation, and ozone concentrations in northern and central California. It specifies requirements for data collection, quality control/assurance and data archiving to support data analysis and ozone modeling, and provides cost estimates of alternative program components. This conceptual plan identifies the major elements of an overall study plan with sufficient detail to examine options and tradeoffs. The next step in the CCOS program plan is to prepare an operational program plan, which reconciles the study objectives with available resources.

1.1 Ozone Air Quality Standards and SIP Requirements

In November 1990, Congress enacted a series of amendments to the Clean Air Act (CAA) intended to intensify air pollution control efforts across the nation. One of the primary goals of the 1990 amendments was an overhaul of the planning provisions for those areas do not meet the National Ambient Air Quality Standard (NAAQS). The NAAQS for ozone is exceeded when the daily maximum hourly average concentration exceeds 0.12 ppm more than once per year on average during a three-year period. The California State standard is more stringent: no hourly average ozone concentration is to exceed 0.09 ppm. The CAA identifies specific emission reduction goals, requires both a demonstration of reasonable further progress and attainment, and incorporates more stringent sanctions for failure to attain the ozone NAAQS or to meet interim milestones.

The 1990 CAA established a classification structure for ozone nonattainment areas based on the area's fourth worst exceedance during a three-year period ("design value"). These classifications are marginal (0.120-0.138 ppm), moderate (0.138-0.160), serious (0.160-0.180), severe-1 (0.180-0.190), severe-2 (0.190-0.280) and extreme (0.280 +). Each nonattainment area is assigned a statutory deadline for achieving the national ozone standard. Serious areas must attain the NAAQS by the end of 1999, severe areas by 2005 or 2007 (depending on their peak ozone concentrations), and extreme areas by 2010. The lower Sacramento Valley is classified as severe. The San Joaquin Valley is currently classified as serious but re-classification by EPA to severe is expected next year. This re-classification would impose additional requirements but would also extend the attainment deadline by six year to 2005. EPA designated the Bay Area in attainment of the national ozone standard on May 22, 1995. However, as a result of exceedances during the summers of 1995 and 1996, EPA redesignated the area in August 1998 from a "maintenance" area to an "unclassified nonattainment" area. This action required the Bay Area to submit an inventory of VOC and NOx emissions (1995), assess emission reductions needed to attain the national ozone standard by 2000, and develop and implement control strategies. The CAA prescribes minimum control measures for each ozone nonattainment area with more stringent controls required for greater degrees of nonattainment.

Emission reduction plans for ozone precursors in serious, severe, and extreme nonattainment areas were submitted to the U.S. Environmental Protection Agency (EPA) on November 15, 1994, as a revision to the California State Implementation Plan (SIP). Each ozone plan contained an emissions inventory, plans for enhanced monitoring of ozone and ozone precursors, and estimation of future ozone concentrations based on photochemical modeling. To ensure a minimum rate of progress, each plan shows a 15 percent reduction in emissions of reactive organic gases (ROG) between 1990 and 1996, an additional 9 percent reduction in ROG by 1999, and 3 percent reductions per year thereafter, quantified at three year intervals to the attainment date.

In July 1997, United States Environmental Protection Agency (EPA) announced that it will phase out and replace the 1-hour primary ozone standard (health-based) of 0.12 parts per million (ppm) with a new 8-hour standard to protect against longer exposure periods. The new standard would be attained when the 3-year average of the annual 4th-highest daily maximum 8-hour concentration is less than or equal to 0.08 ppm. The implementation of this standard is currently on hold. On May 14, 1999, a three-judge panel of the U.S. Court of Appeals for the District of Columbia set aside EPA's new air quality standards for ozone and fine particles. The court action prohibits EPA from enforcing the standard, but did not remove the standard. EPA intends to recommend an appeal to the Department of Justice and is currently reviewing its options. The previously existing one-hour ozone standard continues to apply in areas that have not attained the standard. In addition to areas that are currently in nonattainment of the 1-hour ozone standard, several areas in central and southern Sierra Foothills and northern Sacramento

Valley that are now in compliance of the 1-hour standard are also expected to become nonattainment for the 8-hour standard.

At the state level, pollutant transport is a recognized cause of air quality degradation. The California Clean Air Act of 1988 requires the California Air Resources Board (ARB) to assess the relative contributions of upwind pollutants to violations of the state ozone standard in downwind areas. The California Health and Safety Code, Division 26, paragraph 39610(b) states "The state board shall, in cooperation with the districts, assess the relative contribution of upwind emissions to downwind ozone ambient pollutant levels to the extent permitted by available data, and shall establish mitigation requirements commensurate with the level of contribution" (California Air Pollution Control Laws, 1992 edition, p. 14). Previous studies in California have demonstrated pollutant transport between air basins on specific days, but few studies have quantified the contribution of transported pollutants to ozone violations in downwind areas.

The implication of the state 1-hour ozone standard and the new federal 8-hour ozone standard is that they require a reappraisal of past strategies that have focused primarily on addressing the urban/suburban ozone problem to one that considers the problem in a more regional context. Retrospective analysis of the O_3 data for northern and central California during the 1990’s show larger downward trends in 1-hour-average peak O_3 concentrations than in 8-hour averages. This will require further departure from the local emission-control approach to ozone attainment and the development of region-wide management approaches. The Central California Ozone Study is intended to provide another milestone in the understanding of relationships between emissions, transport, and ozone standard exceedances, as well as to facilitate planning for further emission reductions needed to attain state and federal standards.

1.2 CCOS Goals and Technical Objectives

The goals of CCOS are to:

1. Obtain suitable aerometric and emission databases to update and improve model applications for representing urban and regional-scale ozone episodes in central and northern California in support of the attainment demonstration for the federal 8-hour and state 1-hour ozone standards and for determining the contributions of transported and locally generated ozone.

2. Assess the relative contributions of ozone generated from emissions in one basin to federal and state exceedances in neighboring air basins, and the implications for emission controls.

3. Assess the reliability associated with air quality model inputs and formulation, and reconcile model results with observation-based and other data analysis methods.

These goals are to met through a process that includes analysis of existing data; execution of a large-scale field study to acquire a comprehensive database to support modeling and data analysis; analysis of the data collected during the field study; and the development, evaluation, and application of an air quality simulation model for northern and central California. The

CCOS programmatic goal will elucidate the implications of currently planned emissions reduction strategies and will focus future emissions reduction efforts in those areas where they will have the greatest benefit on air quality for the least cost. The database obtained from the field study and subsequent modeling results could also be used for preparing the ARB's tri--annual transport assessment report, studying the impacts of various sources on air quality, planning for urbanization and growth, issuing permits, and determination of benefits of various environmental management activities.

The technical objectives of CCOS are as follows:

1. Review existing conceptual model of ozone formation in northern and central California. Review the findings of relevant modeling and analysis studies upon which it is based and their implications for the design of CCOS.

2. Summarize monitoring data over the past decade in northern and central California with respect to locations and frequency of exceedances of the threshold value for the federal 1-hour and 8-hour ozone standards and the state 1-hour ozone standard. Identify meteorological scenarios related to exceedances of federal and state ozone standards and specify the characteristics of episodes for which monitoring would be sought as part of CCOS.

3. Obtain documented data sets, with appropriate data qualification statements, which are suitable for characterizing the nature and causes of ozone exceedances in and around northern and central California by modeling and data analysis.

4. Document the frequency, intensity, spatial distribution, and temporal variation of high ozone concentrations and its VOC and NOx precursors within and between neighboring northern and central California air basins, and determine how these have changed over the past decade.

5. Identify and describe transport pathways between neighboring air basins, and estimate the fluxes of ozone and precursors transported at ground level and aloft under meteorological conditions associated with high ozone concentrations.

6. Measure and characterize the structure and evolution of the boundary layer and the nature of regional circulation patterns that determine the transport and diffusion of ozone and its precursors in northern and central California.

7. Quantify the uncertainty of meteorological models in simulating transport and mixing of precursors and end-products within and between air basins.

8. Provide the meteorological and air quality measurements needed to estimate, with stated uncertainty intervals, the contributions from background, regional mixing and transport, and local emitters to ozone concentrations that exceed standards in each of the air basins.

9. Quantify the uncertainty of emissions rates, chemical compositions, locations, and timing of ozone precursors that are estimated by emission models.

10. Quantify source contributions to ozone precursors, identify the limiting precursors, and assess the extent to which reductions in volatile organic compounds and nitrogen oxides, would be effective in reducing ozone concentrations.

11. Quantify the uncertainty of air quality models in simulating atmospheric transformation and deposition.

12. Evaluate and improve the performance of emissions, meteorological, and air quality simulations. Apply simulation methods to estimate ozone concentrations at receptor sites and to test potential emissions reduction strategies.

13. Provide the meteorological and air quality measurements needed to estimate the effects of different emission reduction strategies on ozone concentrations within and beyond each air basin, and identify those that cause the greatest reduction for the least cost.

14. Refine conceptual models that explain the causes of elevated ozone concentrations and interactions between emissions, meteorology, and ambient ozone concentrations.

1.3 CCOS/CRPAQS Integration

The California Regional PM10/PM2.5 Air Quality Study (CRPAQS) intends to improve scientific understanding of excessive PM levels in central California. Specifically, this understanding is needed to determine where and when populations experience excessive exposures, as defined by NAAQS and state air quality standards, and how to cost-effectively reduce those exposures to acceptable levels. CRPAQS is an integrated effort that includes air quality and meteorological field measurements, emissions characterization, data analysis and air quality modeling. CRPAQS activities are complementary to long-term monitoring and research activities being conducted by the California Air Resources Board (ARB) (Turkiweicz and O'Brian, 1998), the U.S. Environmental Protection Agency (EPA), the SJVUAPCD, the BAAQMD, the GBAPCD, and other air quality districts in the region.

The CRPAQS field study will consist of a long-term campaign from 12/1/1999 through 1/31/2001, a winter intensive study within the period of 11/15/2000 through 1/31/2001, and a fall intensive study within the period of 9/1/2000 through 10/31/2000. Several experiments will be conducted during the summer period of 7/1/98 through 8/31/98. Details of these measurements are described by Watson et al. (1998). The baseline measurements for CRPAQS, which will begin in December 1999 and continue to the end of the study, can be incorporated and leveraged into the CCOS field program.

1.4 Study Planning

A technical committee comprising of staff from the ARB, local air pollution control agencies, and other sponsoring organizations will direct CCOS with technical input from a consortium of university researchers in California and the Desert Research Institute (DRI). A draft scope of work for CCOS was prepared by the Planning and Technical Support Division of the California Air Resources Board on January 19, 1999. This document states the rationale and preliminary technical objectives, and outlines a draft scope for a field measurement program. DRI was selected to document the program design and provide field management support.

The CCOS program plan consists of this conceptual program plan (Volume I) and two related documents – the operational program plan (Volume II) and the field operations protocol (Volume III). These documents correspond to the three main phases of the planning process for CCROS

The conceptual program plan (Volume I) states the goals and technical objectives for the study and describes the rationale and elements of a "strawman" study for planning purposes. It provides a preliminary conceptual picture of the relationship between meteorology, emissions, chemical and physical transformation, and ozone concentrations in Central California. The conceptual program plan provides cost estimates of alternative program components, descriptions of data collection, quality control/assurance and data archiving, and requirements for data analysis and ozone modeling. The conceptual plan is not intended to be a complete plan, but it will identify the major elements that should be included in the overall study plan with sufficient detail to examine options and tradeoffs.

The operational program plan (Volume II) describes the design for the field measurement program and specifies the details that will allow the study plan to be executed with available resources. The operational program plan will be the basis for preparing requests for proposal to potential measurement contractors. It identifies measurement locations, observables, and monitoring methods. It specifies data management and reporting conventions and outlines the activities needed to ensure data quality.

The field operations protocol (Volume III) is a short document that serves as the guide for those in the field. It is a concise overview of the field study, enumerating the most pertinent information needed by those conducting the measurements. The contents include: (1) a brief summary of the study objectives; (2) a list of the measurements; (3) a schedule of measurements; (4) a roster of participants; (5) a description of sites; (6) a description of communications channels; (7) protocols for determining and announcing intensive measurement periods; (8) an outline of deployment and operational logistics; (9) an outline of on-site quality assurance activities; (10) basic rules regarding site access and operations; and (11) reporting procedures. The field operations protocol will be prepared by May, 2000.

The field study plan is accompanied by two other plans for emission modeling and for meteorological and air quality modeling.

The emission plan describe how to:

1. Develop a spatially and temporally (including day-specific inventories for weekdays and weekends) resolved inventory of emission estimates of ROG, NOx, and CO from anthropogenic sources.

2. Improve and extend the existing biogenic ROG emission estimates for northern and central California, and develop estimates of NOx emission from fertilized soils and ROG emissions from geogenic sources.

3. Develop, evaluate, and apply methods to propagate ROG, NOx, and CO emission inventory uncertainties.

4. Project the effects of future activity and alternative controls on emission estimates.

5. Acquire, archive, and manage activity data from which emission estimates can be developed.

6. Estimate costs, schedules, and responsibilities for emission modeling activities.

The modeling plan describes procedures to:

1. Evaluate and select existing modeling codes and recent innovations in computation methods to determine the optimal software and hardware platforms for meteorological and chemical simulation.

2. Specify model domain boundaries, grid sizes, layers, and surface characteristics.

3. Identify performance measures and performance evaluation methods, and specify methods by which these will be applied.

4. Estimate costs, schedules, and responsibilities for meteorological and air quality modeling activities.

1.5 Guide to Field Study Plan

This introductory section has provided a background for the proposed study and has specified the goals and technical objectives. Section 2 presents a "conceptual model" of the ozone episodes and transport scenarios of interest that serves as the basis for the experimental design of CCOS. Section 3 describes the requirements for data analysis and modeling. Section 4 presents the proposed experimental approach and discussion of alternatives and Section 5 provides the corresponding budget estimates. Section 6 defines the program management and schedule. Section 7 includes a list of references cited in this document. Appendix A describes the existing meteorological and air quality measurement network and options for the supplemental measurements during the field study. Appendices B and C describe the required quality assurance and data management activities of the study, respectively.