

THE CENTRAL CALIFORNIA OZONE STUDY (Comprehensive Plan)

I. AIR QUALITY PLANNING AND MANAGEMENT NEEDS

- Planning to effectively meet the new ozone and PM standards throughout central California – developing a control strategy that is likely to accomplish this, and doing so using approaches that are expected to be effective and reliable
- Assessing the likely impacts of urbanization and development and the introduction of new emissions and emissions controls
- Providing insight into the relative contributions of local vs transported pollutants and the implications for emissions controls

Specifically,

- Determining the precursor reductions needed to move effectively toward meeting the new 8-hour standard.
- Characterizing the contributions of key source categories, such as motor vehicles and power plants.
- Establishing the impacts of precursor controls within each air basin and on neighboring air basins.
- Estimating uncertainties associated with results and findings.
- Assessing the level of confidence in the soundness of the emissions strategy recommended.

II. OBJECTIVES OF THE STUDY

- Developing the technical/scientific foundation that will enable meeting the needs outlined under I.
- Acquiring an aerometric data base suitable for use in modeling and analysis in support of a year 2003 SIP submission for ozone.
- Developing results and findings that are reliable based on this technical/scientific foundation.

III. PREMISES AND CONCERNS

- Much can be learned from retrospective analysis and evaluation.
- Past experience suggests that modeling estimates may not be accurate and that we generally will not know whether or not this is the case. Thus, prudence would dictate that one should not restrict efforts to the use of photochemical modeling. Instead, it would be wise to adopt a combination of approaches that, when taken together, can be used to address issues for which they are anticipated to be robust.

- Analysis of one or a few episodes has always raised questions about representativeness and completeness. Now, with a new standard, a desire to characterize conditions over longer periods, and the ability to simulate lengthy period, it is both desirable and feasible to study longer periods of time, up to a full season.
- It would be wise to adopt a “weight of evidence” approach to developing a control strategy, with participating parties committing to this a priori.
- Estimation of uncertainties and assessment of the risks of developing flawed strategies are of critical factors in evaluating evidence and giving context to decision-making.

IV. PROPOSED COMPONENTS

The proposed approach is segmented into components in such a way that each category is designed to enhance that preceding. The first component, *evaluative studies*, is intended (a) to take advantage of information now available to enhance our understanding of prior successes and failures so that the basis for further planning will be more firm. Also, some of the analyses conducted will be continued in time to provide some of the results and findings of future interest. The second component, *photochemical modeling*, continues and extends to longer periods the practice initiated in the early 1980s of simulating one or more episodes following evaluation of predictive performance using the best available data base. However, since concerns persist relating to the reliability of modeling, a third component is proposed, one that provides both *complementary and corroborative analyses*, with the intent of producing a more robust set of findings. The fourth component focuses on *improving scientific knowledge* in specific areas where there are gaps. This information will be incorporated in modeling and other (corroborative and complementary) analyses. Finally, the fifth component is devoted to *integrating, synthesizing, and documenting* results and findings.

A. Evaluative Studies

1. Analysis of Trends and Characterization of Variability Its Consequences

a. Program scope

Trends. First, develop time series for ozone concentrations for all areas and sites of interest. Second, set forth hypotheses as to why the effects observed actually occur. Third, conduct analyses – including sensitivity analyses using a photochemical model – to examine the hypotheses in depth. Conduct similar analyses for other relevant pollutants (i.e., precursors) if suitable data are available.

Variability. Conduct analyses of data aimed at quantifying the various contributions to variability: patterns not included in relationships developed heretofore and associated with variables that may be stratified through analysis (such as day of the week); natural (random) variability; and errors in sampling, observation, or analysis. Adjust the initial trends

analysis to account for meteorological variability. Synthesize a functional relationship describing variability. Include variability in trends analysis.

Findings. Develop a set of findings that characterize trends in ozone concentrations at a representative series of sites. As feasible, provide explanations as to why the trends behavior observed might have occurred. Use this information to focus on key unresolved issues in the planning stages of this overall effort.

Also, provide recommendations on monitoring needs, as appropriate, based on the findings and their interpretation.

b. Justification.

Central California monitoring sites such as Edison, Fresno, Livermore, and Sacramento have shown little or no progress toward attainment of the ozone standard despite extensive efforts to reduce precursor emission during the past two decades. Unless we understand why we are maintaining status quo when we have anticipated significant reductions in ozone concentrations, we are unlikely to be in a position to develop an effective strategy for attaining the standard.

c. Analyses envisioned

Techniques that may be used for the analysis of time series include time series modeling and analysis methods applied in the time domain, such as the autoregressive moving average (ARMA) model (Box and Jenkins, 1970), and in the frequency domain, such as spectral analysis. Trends are to be adjusted to take into account the effect of meteorological variation on the desired “emissions - ambient concentration relationship”. Once specific analytical objectives are stipulated and data have been acquired and reviewed, a plan for analysis can be developed, reviewed, and pursued.

d. Rough cost estimate

Estimated budget range: \$40-70K.

e. Deliverables

A final report and publishable manuscript describing in depth objectives, methods, results, and implications.

2. Analysis and Evaluation of Past SIP Modeling Projections of Air Quality

a. Program scope

Modeling projections reported in SIPs rarely materialize; ozone concentrations tend to decline less rapidly and less overall than estimated in analyses conducted in support of SIPs. This appears to be the case for most if not all California submissions.

There are a number of potential causes of the shortfall in air quality improvement. For example:

- Models used may be flawed.
- Supporting aerometric data bases may be inadequate in quality or coverage of variables of interest.
- Episodes studied may not have been representative.
- Emissions modeling may contain errors that affect the calculations.
- Emissions projection efforts may have been inadequate.
- Some projected emissions reductions may not have been implemented or may have been delayed.
- Some emissions controls may not have the effectiveness anticipated.

Before preparing the next SIP, it would be very helpful to understand the causes of biases in estimates of air quality improvement. To accomplish this, we propose that modeling reported in the last three SIPs (1994, 1987, 1984) for each of the following areas be scrutinized: the Bay Area, the San Joaquin Valley, the Sacramento area, the South Coast Air Basin, and possibly the San Diego area. We envision the following tasks:

- Obtain the submitted reports from the submitting District, the ARB, or the EPA. This may be a greater effort than might be suspected.
- Conduct a thorough review of the modeling carried out: choice of model and episodes, nature of the data bases used, evaluation of model performance, estimation of emissions, projection of emissions, and other relevant aspects of the work.
- Carry out diagnostic analyses, where feasible, to check the accuracy and adequacy of the various components of the calculations made.
- Estimate the “real world” changes in emissions that have occurred, and compare them with projections.
- Determine the contributions to biases in air quality projections.
- Evaluate the results and prepare findings that will be of use in future planning.

b. Justification

The enduring pattern of overestimation of the benefits of emissions control strategies is a serious concern. We must understand why this pattern has persisted if we are to break the cycle in the next study. The proposed effort would be devoted to gaining this understanding.

Also, as concentrations decline and analyses to support the new 8-hour standard are conducted, the demand for models to perform accurately at lower concentrations becomes heightened. There is only limited information on the ability of models to simulate concentrations for ambient conditions in the range of 60-100 ppb ozone. In question is the ability of chemical mechanisms to mirror chemical dynamics at low concentrations.

c. Analyses envisioned

Evaluation of suitability of the aerometric data base, evaluation of the accuracy of the emissions estimates (see, for example, the approach of Fujita, et al, 1994), review of the models used and model performance evaluations conducted, comparison of actual and projected emissions reductions, review of actual efficiencies of emission control equipment or strategies.

d. Rough cost estimate

Estimated budget range: \$200-300K.

e. Anticipated concerns and their potential consequences

If it is difficult to obtain past SIP reports, planned efforts may have to be delayed or curtailed.

f. Deliverables

Detailed analyses and interpretations presented in a final report.

3. Appraisal of Past Findings and the Current “Conceptual Model”

a. Program scope

Review findings of all relevant modeling and analysis studies conducted using the 1990 SJV ozone study database. Critically appraise findings, conclusions, implications. Develop insights concerning the design of a future study. Document efforts, findings, recommendations.

b. Justification

A variety of analyses have been conducted for the 1990 ozone study in central California, and several final reports presenting results and findings are available. In addition, Pun, Louis, and Seigneur (Oct 1998) have presented a conceptual model for ozone formation in the SJV, based on findings to date. This foundation will provide useful insights and should aid in setting premises for the design of CCOS. A first step then should be a comprehensive review of the findings and their implications

c. Rough cost estimate

Estimated budget range: \$20-35K.

d. Deliverables

A comprehensive report.

B. Photochemical Modeling: Monitoring, Model Evaluation, and Model Application

Level-2 monitoring, perhaps enhanced by some level-3 measurement elements, as described in the draft scope of work, “The Central California Ozone Study” (CCOS), prepared by the Air Resources Board, is intended to support a full program of photochemical modeling. See this document for a summary of monitoring components. [A discussion of modeling and analysis plans is to be prepared]. Note that:

- Modeling specifications should be prepared prior to fully developing and finalizing a monitoring program.
- It has yet to be demonstrated that modeling has been or will in the future be sufficiently accurate that one can rely on its estimates.
- Consequently, the planning of a program should involve simultaneous design of photochemical modeling (and supporting monitoring) and corroborative and complementary studies. Measurements planned in other elements of the overall program would be available for inclusion in the photochemical modeling study as well. Thus, integrated planning and analysis will clearly be beneficial. Hence, this plan – at the time of completion of a final draft – should reflect integration of all work elements.

1. Program scope

Main elements include specification of defining parameters of the study, such as the size of the study region and the duration of monitoring; study protocol (for modeling and monitoring); modeling plan, including performance evaluation procedures; corroborative modeling approaches and explicit specification of

uncertainty and risk analysis methodologies; objectives of and plans for data analysis; specification of the monitoring program; planning to fill scientific gaps (see Section IV); quality assurance and control for both modeling and monitoring; data documentation and archiving of the database; model application, including sensitivity studies; and a priori plans for evaluating and using modeling results.

Monitoring and modeling are to cover a period of up to four months in duration.

[Note: Documenting and archiving the data collected for convenient distribution and future reference is essential. Adequate budget should be provided for this effort. In addition to standard reports prepared by monitoring contractors, a standard meta-data model, such as that developed by the Federal Geographic Data Committee (FGDC) (see <http://www.fgdc.gov>) or others, should be used to identify and describe the data collected, the instruments used, and key technical contacts. An Internet-accessible, modern database system will allow researchers to conveniently contribute, access, and review the collected data.]

2. Justification

Photochemical modeling provides the best means available, in principle, for relating changes in emissions to changes in ambient ozone concentrations. A reasonably comprehensive monitoring program is required to support evaluation of model performance and application to control strategy assessment. Thus, both the potential for meeting objectives and the cost of data acquisition are high.

Photochemical modeling is recommended by both the U.S. EPA and the ARB as the approach of choice for demonstrating attainment of the ambient air quality standards.

A very considerable effort has been expended on photochemical modeling for central California during the past decade. This work will draw on the accomplishments and lessons learned from earlier efforts.

3. Analyses envisioned

Modeling is to include air quality, emissions, and meteorological modeling. Improved air quality models have recently been developed and may soon become models of choice. These include Models 3+ (EPA), MAQSIP (NCSC), and CAMx (Environ). These models, along with SAQM and perhaps CALGRID, should be compared and evaluated. Additional desired capabilities should be identified, and the options available should be evaluated. Examples include plume-in-grid treatment, numerical solution procedures, and an aerosol chemistry module.

MM5 remains the meteorological model of choice for the region. While the model appears to perform well in the SJV, it has been noted recently by Jeffries

and Wang that MM5 does not conserve mass in some areas of the modeling region. This error passes into the air quality model, and in some circumstances can badly distort results. Thus, it becomes quite important to test the model for its ability to conserve mass at various spatial scales.

Two or three emissions information management programs that develop inputs to photochemical models are available. More critical, however, is the estimation of emission rates and activity levels for various categories of sources. Some of the preferred algorithms are imbedded in some of the emissions programs. However, identifying preferred algorithms and aggregating them in one program or management system should be considered.

Corroborative analyses are also envisioned. Examples include (a) independent estimation of emissions rates through analyses of ambient concentrations and (b) use of MAPPER© to compare its results with those of the air quality model.

4. Measurement program

See the ARB CCOS draft scope of work, level 2 and portions of level 3, for an overview of the proposed scope of a monitoring program.

5. Rough cost estimate

Estimated budget range: \$8-12M.

6. Developmental or adaptation needs

Several. An air quality simulation program. An emissions program, with biogenic estimation capability. Methodology and program for estimating uncertainty and risk. Deposition estimates for selected pollutants. Improved procedures for determining boundary conditions. Use of LIDAR for air quality measurements aloft. Accurate NO₂ measurements. Use of receptor modeling techniques.

7. Anticipated concerns and their potential consequences

A number of potential problems may materialize. A major objective of early planning is to minimize the chances of their arising. Such concerns exist for each topic listed under developmental or adaptation needs. These include soundness and reliability of modeling, accuracy of measurement, and degree of success in developing new procedures, such as estimation of uncertainty. If problems do arise, they have the potential for putting at risk the reliability of air quality modeling. Because of this, a portion of this proposal is devoted to complementary and corroborative modeling. These efforts provide alternative methods of analysis or independent means of checking modeling results.

8. Deliverables

Many. To be delineated.

Option: Develop a prototype photochemical modeling system to model any multi-day period of interest

a. Scope

Developing the capability to run a photochemical model for any episode (series of days) desired, with concentration estimates for ozone and other pollutants that show a satisfactory degree of correspondence to actual pollutant concentrations. Automating this process to make the collection and processing of required input data easy and straightforward.

b. Justification

Currently, modeling individual episodes is a cumbersome process taking months, or even years, per episode. Each modeling episode is treated as a special case, requiring a significant amount of custom set up. The result is that photochemical models are applied to a small fraction of the episodes of interest. In central California--because of its complex terrain, coastal and bay influences--ozone episodes can occur under a variety of conditions. Understanding transport to surrounding areas requires examining still more conditions.

An alternative approach is to set up a modeling system that can be run on a routine basis for many different episodes. After the initial set up of the system, the same modeling configuration will be applied to a number of episodes or periods of interest. This work element would explore the usefulness of such an alternative approach.

Boundary conditions will be moved far from the region of interest so that emissions, not inflow at the boundaries, supply most of the precursors.

c. Analyses envisioned

- i. Develop a system to automate the process of preparing and “inputting” routine meteorological data and analysis fields. “Inputting” of these data is a first step in generating emissions and meteorological inputs to the air quality model.
- ii. Routinely acquire other data fields, such as cloud cover and ozone column from routine satellite data.

- iii. Automate the process of running a parallel version of a prognostic meteorological model.
 - vi. Automate the process of running a gridded photochemical model.
 - v. Incorporate routine and special-study observations to compare to modeled results. Produce and distribute via the Web a set of analysis products for review.
 - vi. Produce follow-on runs as required.
- d. Rough cost estimate
- Initial capital costs: \$300,000. New ongoing costs: \$200,000. Ongoing costs already met by the BAAQMD: \$200,000.
- e. Deliverables
- A photochemical modeling system that can be run for any multi-day period of interest.

C. Complementary and Corroborative Pursuits

1. **Study of limiting pollutants and transport between the Bay Area and the Sacramento / San Joaquin Valley (SJV) area**
 - a. Program scope

Monitoring ambient NO, NO₂, and ozone concentrations (and perhaps other pollutants) downwind of the flux plane. Using receptor-driven data analysis methods to determine the limiting pollutant as a function of location and time.

Monitoring pollutant fluxes along a vertical plane east of the East Bay hills, from Carquinez Strait to south of Pacheco Pass. Conducting meteorological modeling to determine flow paths and thus to identify areas impacted by the transported pollutants. Preparing a “best effort” emissions representation for ozone precursors in downwind areas. This information will allow estimation of the relative contributions of local emissions and transport.
 - b. Justification

This effort will identify if VOC or NO_x is limiting in the formation of ozone downwind and when it is limiting. Flux measurements and emissions information will be used to evaluate the benefits of local control vs mitigation of transport. This program component is not intended to estimate the amount of control needed to attain the standard. However, this latter need has yet to be met adequately by any approach.

The proposed study is intended to identify what types of controls are likely to be effective in reducing ozone, the benefits of a local vs regional (upwind) control program, and the extent of the area which, if controlled, would result in effective reductions. Since the effort is focused, its cost should be considerably less than that of a comprehensive study, although the cost of monitoring air quality aloft is an issue. Finally, the results will provide a complement to a more comprehensive monitoring study: the higher density of measurements at the flux plane will facilitate a more detailed analysis of transport in a crucial area.

c. Analyses envisioned

Estimation of flux rates as a function of time, altitude, and location, as feasible. Estimation of the area impacted by transport of pollutants crossing the flux plane. Estimation of emissions rates downwind as a function of location and time. Comparison of flux and emissions rates.

d. Requirements for monitoring program

Profilers and sodars for velocity fields at the flux plane. Lidar for monitoring air quality aloft, if reliable concentration estimates can be made; otherwise, use of aircraft. Detailed, thorough emissions estimation effort for areas downwind.

e. Rough cost estimate

Estimated budget range: \$1-1.5M.

f. Anticipated concerns and their potential consequences

g. Deliverables

2. Emissions characterization

Efforts envisioned under this work element encompass, in part, studies being conducted or planned by the ARB. While the work outlined constitutes an essential component of the overall effort described, the proposed activity is limited to working with ARB staff to ensure that needs are defined and specified and, to the extent possible, met through

the ARB research program. If some of the work elements listed below will not be pursued by the ARB, then they will be considered for inclusion and funding in CCOS, or support for them will be pursued with other agencies. Work elements of interest:

- a. Estimating motor vehicle emissions, rates and variability, by vehicle and driving characteristics, incorporating day-specific traffic type and count data.
- b. Characterizing composition profiles for key source categories (other than motor vehicles); characterizing source categories using near-real-time data feeds for major sources; identifying and applying marker compounds for distinguishing sources
- c. Characterizing variability in emissions rates with season, day of week, time of day, holiday periods, and special situations; assuring consistency across political boundaries
- d. Characterizing VOC emissions rates and reactivity; corroborating updated emissions model results using independent data where possible.
- e. Estimating biogenic VOC emissions rates and their variability
- f. Characterizing pollutant fluxes from soil
- g. Instituting methods of conveniently describing and distributing emissions data for review and use in models.

Efforts should include evaluating the accuracy of emissions estimates, the soundness of techniques for estimating emissions for each key source category, reconciling differences between emissions estimates and ambient precursor data, improving emissions modeling methods, and acquiring day-specific data.

Because of the wide variation of high ozone episodes that can occur in Central California, meeting the needs of interested parties in this study may require that modeling is conducted for a large number of days. For example, evaluating the prospects for attaining the eight-hour standard will require that a broad range of meteorological conditions be studied. Satisfying this modeling need, will, in turn, create more stringent demands for accurate representation of emissions in a variety of circumstances. It is therefore desirable that an emissions modeling system be developed that can provide a day-specific gridded inventory for any day of interest during the summer ozone season. The emissions representation should be:

- useful for this as well as future studies;
- supported by acquiring the necessary day-specific inputs in near real-time;
- available for the entire State; and
- designed for resolution of 1 km because modeling may include high-resolution grids along some transport corridors.

3. Evaluation of the emissions model

a. Program scope

Perform sampling and statistical analyses to assess and perhaps improve the correspondence between actual emissions and the emissions model. The program would be ongoing in order to confirm how well emissions estimates track future emissions trends.

b. Justification

Reliable estimates of current and future emissions are crucial to the development of sound air quality plans and photochemical modeling. Presently, emissions estimates suffer from a number of limitations. There is no systematic and ongoing effort to evaluate the estimates of emissions models (using ambient data, source sampling experiments, or perhaps other means), and there is a relatively high degree of uncertainty in emissions estimates.

c. Analyses envisioned

- i. Perform tunnel monitoring at prescribed intervals to assess actual changes in hydrocarbon emissions from motor vehicle and their relationship with NO_x and CO emissions and their ratios.
- ii. Use remote sensing along with gasoline sales to provide alternative estimates of emissions of NO_x and CO.
- iii. Survey the available data on traffic counts. Design and implement a study to increase traffic count information including, if possible, the ability to obtain a range of counts for specific days.
- iv. Analyze uncertainty in emissions inventory, by comparing the inventories from various years.
- v. Regularly update other source profiles, including raw gasoline.

vi. Perform receptor modeling to estimate contributions from various sources to NMOC.

d. Rough cost estimate

For i. and ii. \$200,000 annually. For iii. \$100,000 initially. For iv. \$25,000. For v. \$20,000 annually. For vi. \$20,000.

e. Deliverables

Estimates of emissions distributions of heavy trucks and light duty vehicles and their respective contributions to NO_x, hydrocarbon, PM-2.5, and SO₂ emissions. Periodic comparisons of these estimates with those of the emissions model. Detailed traffic count data for use in modeling. A report presenting an analysis of emissions uncertainty. Periodic reporting analyzing NMOC source composition and estimating the contributions from various sources.

4. Monitoring to track trends in ozone and its precursors

a. Program scope

Improve the instrumentation for and analysis of ozone and its precursors to be able to track trends as a check on the effectiveness of emissions control programs.

b. Justification

Currently there is no program to obtain accurate measurements of hydrocarbon species routinely. Further, we don't know how closely measured total NMOC compares with the actual concentrations. Although NO_x is measured, there is interference with other nitrogen species.

c. Analyses envisioned

i. Develop the capability to measure total NMOC accurately on a continuous basis at a number of sites. This might involve the calibration of Bendix 8202 Analyzers with canister samples on a regular and ongoing basis, or else the purchase of more accurate instruments.

ii. Establish a regular program of measuring hydrocarbon species at selected urban sites in the morning and perhaps the afternoons (on a 1-in-3 day or 1-in-6 day schedule).

Perform additional sampling when ozone is predicted to exceed the state standard.

- iii. Deploy monitors that measure NO_y (NO+NO₂+other nitrogen species) at several sites, collocated with standard NO_x instruments. Deploy an instrument that measures true NO₂ at one or more selected sites.

- d. Rough cost estimate

Setup costs: \$100,000 per site. Ongoing costs: \$50,000 per site per year

- e. Deliverables

High quality measurements of NO and NO₂. Speciated ambient hydrocarbon data on a regular and ongoing basis. Better NMOC measurements. Periodic analyses comparing emissions inventory trends with these measurements. Analysis of the extent of reaction to determine to what extent and at what times of the day selected areas are NO_x- or VO-limited.

5. Estimation of uncertainties and characterization of the risks of inaccurate estimates of emission control needs (and thus of developing policies whose outcomes vary significantly from those anticipated)

- a. Program scope

Development, adaptation, and prototype application of methods for estimating uncertainties associated with estimates of air quality – primarily ozone and precursor concentrations, changes in concentrations, and identification of limiting precursors - made through modeling and data analysis. Design and prescription of means for communicating uncertainty information. Formulating “statements” that, if supported successfully through analysis, will communicate the risk of an unsuccessful outcome when analyses suggest that it will, in fact, be successful. [Example: Estimating the probability that the ozone standard will not be attained when technical/scientific analysis suggests otherwise.] Developing or adapting for use methods for assessing risk.

- b. Justification

Results of calculations that embody a single outcome or “number” are difficult to interpret, as context is lacking. One must know something about the size of the “signal of interest” as well as the magnitude of the uncertainties that attend the estimates of outcomes of instituting an action. For example, if one estimates a reduction in ozone concentrations of 20

ppb, but the uncertainty in the estimate is 25-35 ppb, a wide range of outcomes is possible. In fact, the latitude given to interpretation can cover virtually all possibilities – a not very helpful result. Without uncertainty information, this insight cannot be had.

c. Analyses envisioned

To be specified as a product of task 1 of the overall effort.

d. Rough cost estimate

Suggested budget allowance: \$300-700K. This estimate is for a limited, well focused effort. A comprehensive program would cost much more.

DOE has received a proposal to develop approaches to sensitivity analysis under consideration. If CCOS is willing to cost-share, DOE may be willing to fund a significant portion of the study.

e. Developmental needs

Methods to be applied must first be developed or adapted for use. Developing uncertainty and risk estimates is a challenging – likely a daunting – undertaking. Some desired outcomes – in terms of methodology - may not be brought to fruition within the time frame needed or at the available funding levels. Since testing may be difficult or impossible, some means for evaluating the quality of the estimates would be desirable. This development will be challenging as well.

f. Anticipated concerns and their potential consequences

See e. above.

g. Deliverables

A series of reports detailing the efforts and results.

D. Supporting Scientific Studies

The studies outlined here are intended to provide scientific support for components that in the past have received inadequate attention or that have insufficient foundation to support analyses envisioned. Their results will be provided as input to the study components discussed prior.

1. Improved estimates of deposition rates for selected precursors in rural and urban environments

a. Program scope

Monitor the controlling variables and deposition rates for selected ozone precursors and surface types. Give early consideration in planning to the study of NO₂, in particular, and formaldehyde, NO, and acetaldehyde.

b. Justification

Deposition is an important secondary determinant of ozone concentrations. As ozone precursors are removed from the atmosphere, they are no longer available to participate in atmospheric transformations. Deposition rates for most ozone precursors have not been adequately characterized.

c. Analyses envisioned

Estimate surface conductances by chemical species and surface type. Compare estimated surface conductances with aerodynamic conductances; determine which chemical species will have deposition rates limited by aerodynamic (not surface) conductance. Place in priority order remaining species by photochemical activity and the uncertainty associated with their estimated surface conductances. Determine the feasibility of measurements for high priority species.

Measure surface conductances and deposition rates for selected species along with controlling meteorological and surface variables.

Verify expected relationships (or develop new relationships) between surface conductance and chemical and physical properties by surface types. Utilize those relationships to estimate surface conductances for all species of interest and apply those conductances with existing models of deposition to estimate deposition rates.

Compare modeled and observed deposition rates.

Incorporate refined and tested algorithms into air quality models and test their operation.

d. Rough cost estimate

Estimated budget range: \$350-750K

Components –

Literature review and initial planning	\$30K
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Design measurement program	\$20K
Measurement program	\$100-500K
Analysis of results, testing of relationships	\$80K
Model implementation and testing	\$100K

e. Planning needs

Initial survey and design scope:

- Review existing literature for species of interest and estimate confidence intervals for their surface conductance based upon chemical and physical properties.
 - Identify those photochemically important species whose deposition rates will likely be controlled by their surface conductance rather than aerodynamic conductance.
 - Determine availability of reliable fast-response instruments.
 - Determine feasibility of relaxed eddy accumulation (REA) method for those chemical species lacking fast-response instruments.
 - Determine approximate ambient concentrations and instrument or laboratory levels of detection and precision and from this information determine feasibility of measurements by chemical species.
 - Select species for measurements.
 - Select important surfaces.
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- f. Anticipated concerns and their potential consequences

Some species may not be feasible to measure with existing methods.

g. Deliverables

- Initial estimates of surface conductance and confidence intervals
- Priority-ordered list of chemical species for further study.
- Results of feasibility assessment for fast response measurements and REA method.
- Recommended measurement program.
- Analysis results.
- Tested algorithms for estimation of surface conductance by species and surface.
- Recommended algorithms for incorporation into a deposition module of an air quality model.

2. Characterization of plume dynamics for large point sources in the Bay Area and coastal areas

a. Program scope

Main elements: 1) field measurements of power plant plumes and their environs at a coastal location and a Bay Area location with subsequent interpretation and 2) application of a newly developed plume-in-grid (PiG) model to estimate plume impacts on downwind ozone levels before and after additional NO_x reductions.

A radar profiler with RASS would be stationed near each power plant during plume measurements to characterize the vertical wind and temperature structure – information essential to understanding and modeling plume dynamics. A slow-moving aircraft, preferably a helicopter, would make plume transects at various distances and times of day and night downwind of the stacks, measuring temperature, relative humidity, NO, NO₂, NO_y, HNO₃, O₃, CO, and speciated VOC from canister grab samples.

MAQSIP-SCICHEM is a modularized air quality model that emulates SAQM and incorporates a state-of-the-science reactive plume-puff module. It utilizes information on stack parameters, on-site and more distant meteorological measurements, and aircraft measurements to estimate plume rise, dispersion, “background” air quality and downwind plume impacts on air quality both for measured conditions and those extrapolated to the future. It would be considered for use in the planned project.

b. Justification

Plume studies in Tennessee (Ryerson et al., 1998. J. Chem. Phys. 103(D7) 22,569-22,584; Gillani et al., 1998, J. Chem. Phys. 103(D7) 22,593-22,616.) have indicated that the ozone production efficiency of NO_x emitted from large power plant plumes is less than that from more dispersed, less NO_x-dense plumes. This suggests that previous ozone assessments, based on modeling of overly dispersed power plant plumes (such as in earlier SIP modeling), may have overestimated both ozone production from power plant NO_x emissions and the reductions of ozone achievable through reductions in NO_x emissions from power plants. Because the background air composition, especially with respect to VOC, may differ substantially between coastal and inland locations, and this composition may strongly influence the ozone production efficiency of power plant NO_x, both coastal and inland power plant plumes must be studied.

A local study should provide a substantially more accurate assessment of the impact of power plant NO_x on ozone levels in Central California.

c. Analyses envisioned

An empirical (conceptual) model of power plant plume dispersion would be developed from the field measurements for coastal and inland locations. The PiG model would be evaluated using the observational data and, if found to be performing adequately, would be applied to improved ozone air quality assessments in conjunction with SAQM.

d. Rough cost estimate

Estimated budget range: \$1-1.5M.

e. Developmental needs

None. All measurement and modeling technologies have been developed under other auspices.

f. Anticipated concerns and their potential consequences

The primary concern is the availability of an appropriate slow-moving aircraft, preferably a helicopter. Faster moving aircraft will not be able to map the plume as effectively and provide as definitive a data base for plume characterization and model evaluation, given the response times of available instruments.

A secondary concern is the reconciliation of results from MAQSIP-SCICHEM with SAQM, which employs an earlier version of PiG treatment. One approach would be to correct SAQM results by scaling to MAQSIP-SCICHEM results in the vicinity (100 km) of elevated point source NO_x plumes. Another would be to incorporate SCICHEM directly into SAQM.

g. Deliverables

A monitoring and modeling plan, an archived and documented database, results of plume modeling efforts and their comparison with data, and a detailed report discussing the project – plan, approach, results, interpretation.

3. Study of the origin, transport and fate of pollutants along the central Bay/Livermore/Altamont/central SJV transport corridor

a. Program Scope

Monitoring of ambient ozone, NO_x, wind and temperature in a vertical plane extending from the central bay through the Livermore Valley and eastward through the Altamont Pass. Continuous monitoring of surface wind and pollutant levels at the passes through which air enters and exits the Livermore Valley. Use of radar profilers and/or acoustic sounders at key locations to measure meteorological conditions aloft. Finally, on selected episode days, mobile sampling at selected surface locations together with aircraft measurements of ozone (and possibly precursor) concentrations in an E-W vertical plane.

Meteorological modeling of air trajectories, together with analysis of vertical cross sections of pollutant concentrations, will be used to investigate transport, both within the Bay Area and beyond, and the probable role of mixing of ozone from aloft. This information will provide valuable insights into the relative contributions of local emissions, emissions from upwind urban areas, ozone transport between the Bay Area and the Central Valley, and mixing to the surface of ozone-rich air aloft.

b. Justification

Livermore experiences the Bay Area's highest ozone concentrations. Previous analyses suggest that morning emissions from upwind urban areas, and possibly from the major traffic arteries that enter the Livermore Valley, may play a major role in the ozone problem in areas such as Livermore that are downwind of urban sources. If this is true, then control strategies should focus on emissions from the large urban centers and the highway network rather than on local emissions.

Previous analyses, which used two dimensional trajectory calculations based on routine surface wind measurements, are highly uncertain, however, because surface wind measurements in complex coastal terrain are sparse and necessary pollutant and meteorological information aloft are unavailable. Further, although it is known that offshore flow aloft during ozone episodes is common and that ozone concentrations aloft are often relatively high, it is not known how important a role these processes play in determining ozone levels observed in downwind areas.

It is particularly important to understand the factors leading to high ozone concentrations at such sites as Livermore, Folsom and Edison - that are downwind of urban source areas - for two reasons. First, these sites experience the highest ozone levels in their respective air basins. Second, despite substantial precursor emission reductions in central California,

ozone levels at these sites have shown little or no improvement over the last decade.

c. Analyses Envisioned

Three-dimensional forward and backward trajectory calculations using meteorological models.

d. Rough cost estimate:

Estimated budget range: \$1M

e. Deliverables

Detailed analyses and interpretations presented in a final report.

4. Characterization of pollutant concentrations in upwind areas and aloft

a. Program scope

Measurement of ozone, precursors, and other key air pollutants in areas upwind of the Bay Area and the SJV. Mapping the spatial and temporal variability of concentration fields over a period of time that provides ample characterization of the variability in these fields.

These measurements would be conducted over an area that extends further upwind than was the case in the 1990 monitoring study; the upwind boundary of the region would be characterized by near-global background concentrations.

b. Justification

Boundary conditions (BCs) can contribute a significant fraction of the total pollutant loading in the western portion of central California. While central California may also be the source of a significant fraction of the pollutants upwind, conveyed there at an earlier time, this cloud nevertheless must be taken into account in any analysis of air pollution and attendant control strategies. In 1990 monitoring was conducted up to 40 miles offshore. This penetration over the Pacific Ocean proved to be insufficient; ozone concentrations were at times measured at 70 ppb, well above background. This elevated level indicates that the pollutant cloud persists further offshore; knowing how far and at what concentrations enables proper representation of the contribution of BCs to the pollutant mixture that produces ozone in central California.

c. Analyses envisioned

Characterization of BCs through analysis of observed data: spatial and temporal distributions of concentrations, conditions under which different patterns merge, persistence of patterns, and other characteristics.

d. Rough cost estimate

Estimated budget range: \$0.3-0.8 M.

e. Anticipated concerns and their potential consequences

Need for accurate and reliable measurement of NO₂ and NO. If these cannot be made in an airborne environment, characterization of nitrogen oxides will be uncertain, and the inadequacy of the information may hamper control strategy analysis.

f. Deliverables

A data base, a report on the data acquired, and a report on the analysis of the data.

V. [A POSTERIORI] APPRAISAL OF FINDINGS AND THE DEVELOPMENT OF AN UPDATED “CONCEPTUAL MODEL”

A number of technical efforts are suggested in this document. The purpose of this task is to bring together the results of these efforts in a coherent integration of findings and implications. A key component is to develop an approach to weighing the evidence in a manner that reflects fairly the relevance, utility, and reliability of individual results. Science is to be served by portraying the state of knowledge at the completion of this work through the formulation of an updated “conceptual model” that describes the dynamics of pollutant formation and the impacts of emissions controls.

A. Program scope

With the results of the various studies outlined “in hand” and interpretations of results completed, synthesize these various findings into an integrated whole.

Identify inconsistencies in results. Attempt to pinpoint assignable causes. Delineate work needed to resolve inconsistencies.

Develop an up-to-date conceptual model of the dynamics of processes that influence ozone formation in central California.

B. Justification

This task is a logical conclusion to the comprehensive effort outlined. It will provide the combined findings of the study as a whole.

C. Rough cost estimate

Estimated budget range: identification of inconsistencies - \$50K; resolution of problems, \$100-250K; final report, \$40K.

D. Deliverables

A report discussing inconsistencies and recommendations for their resolution; a report presenting work conducted to resolve issues; a final report synthesizing findings and presenting an updated conceptual model.

Closing Comments

Several administrative issues arise in considering a program that need to be addressed by interested agencies and potential sponsors:

- What will be the available budget?
- Given the budget, how should funds be allocated to make most effective use of them?
- If the budget is less than the estimated costs (as is likely to be the case), how should priorities be set?
- How will the overall program be managed? Who will manage it?
- What will be the management structure – policy oversight, technical committee, day-to-day administration, technical management?

As these questions are answered, the evolving information will be incorporated in this document.