EIGHT-HOUR OZONE ATTAINMENT PLAN FOR SAN DIEGO COUNTY

May 2007

SAN DIEGO COUNTY
AIR POLLUTION CONTROL DISTRICT
10124 OLD GROVE ROAD
SAN DIEGO, CA 92131

EIGHT-HOUR OZONE ATTAINMENT PLAN
FOR SAN DIEGO COUNTY

TABLE OF CONTENTS

ATTACHMENTS

1.0 INTRODUCTION AND OVERVIEW

Federal clean air standards have been established for common outdoor air pollutants, including ozone, to protect public health and the environment from the harmful effects of air pollution. These standards, called *National Ambient Air Quality Standards* (NAAQS), are established by the U.S. Environmental Protection Agency (EPA) pursuant to requirements of the federal Clean Air Act (CAA).[1] Each area of the nation with air pollution levels violating a NAAQS must be designated by EPA as a "nonattainment area" for that pollutant. Each nonattainment area must submit a "State Implementation Plan" (SIP) outlining the combination of local, State, and federal actions and emission control regulations necessary to bring the area into attainment as expeditiously as practicable.

San Diego County is currently designated a Nonattainment Area for the eight-hour ozone NAAQS. By June 15, 2007, the San Diego County Air Pollution Control District (APCD) must submit to EPA, through the California Air Resources Board (ARB), a SIP identifying control measures and associated emission reductions as necessary to demonstrate attainment by June 15, 2009. This Eight-Hour Ozone Attainment Plan addresses and complies with these requirements.

1.1 BACKGROUND

1.1.1 <u>What is Ozone?</u>

Ozone is a corrosive gas composed of three oxygen atoms linked together. Ozone exists in two layers of the atmosphere. It occurs naturally in the stratosphere (upper atmosphere) where it absorbs and provides a protective shield against the sun's damaging ultraviolet radiation. Ozone also exists in the troposphere (lower atmosphere), even near ground level, as a result of various human activities. "Ground level" ozone—the subject of this Attainment Plan—is an air pollutant that can damage living tissue and break down certain materials.

Ozone is not usually emitted directly into the air, but at ground level is formed by chemical reactions of "precursor" pollutants—oxides of nitrogen (NOx) and volatile organic compounds (VOC)—in the presence of ultraviolet radiation (strong sunlight). NOx and VOC emissions are mostly the result of various human activities such as fossil fuel combustion and solvent use. However, there are also natural sources of VOC emissions (such as trees) and NOx emissions (such as forest fires). Consequently, there are natural background levels of ozone, at levels shown to be well tolerated.

Ozone levels are usually higher during the spring and summer months. Abundant sunshine promotes ozone formation and warm weather increases VOC emissions (an ozone precursor) from fuel and solvent evaporation. Additionally, warm weather is often associated with stable atmospheric conditions and an inversion layer[2] in the lower atmosphere, reducing dispersion of ozone.

---

[1] Federal Clean Air Act requirements are codified, as amended, in the U.S. Code at 42 U.S.C. Sections 7401, et seq.

[2] An inversion layer is a stable layer of the atmosphere, which does not allow for upward air motion. An inversion often acts like a cap on the atmosphere, trapping air pollution below it.

Concentrations of ozone are not uniform; the amount of ozone in the lower atmosphere varies by hour, day, and place. Ozone molecules in urban areas persist for less than a day, with concentrations usually peaking in mid to late afternoon, after exhaust fumes from morning commutes have had time to react fully in the sunlight. By early evening, ozone production drops as the sunlight's intensity decreases and exhaust fumes from evening commutes react with and break down most of the remaining ozone. This entire cycle repeats itself the following day.

1.1.2 Health and Welfare Effects

A significant body of research has shown that exposure to unhealthful levels of ozone can cause lung and airway inflammation, significant decreases in lung function and capacity, and other respiratory symptoms such as cough and pain when taking a deep breath. Ozone exposure is a particular threat during the summer ozone season for people working, exercising, or playing outdoors or who already have respiratory problems. Long-term exposure to moderate levels of ozone may cause permanent changes in lung structure, leading to premature aging of the lungs and worsening of chronic lung disease.

Plants and crops are also impacted by ground level ozone, slowing plant growth and increasing susceptibility to disease, pests, and harsh weather. The reduced yield hurts the agricultural and forest industries.

Scientific and medical research continue to uncover new information on the effects of ozone air pollution. The California Air Resources Board has prepared a summary of recent research and findings, available on their website at www.arb.ca.gov/research/health/fs/PM-03fs.pdf.

1.1.3 Federal Ozone Air Quality Standards

Eight-Hour Ozone NAAQS. The eight-hour ozone NAAQS was established by EPA in 1997.[3] It is attained when the “three year average” of the “annual fourth highest daily maximum” eight-hour average ozone concentration—called the “design value”—is no greater than 0.084 parts per million (ppm) at each EPA-approved ozone air quality monitor in the region. The “three-year average” and “annual fourth highest daily maximum” are statistical values that provide stability to the standard, moderating the influence of extreme meteorological conditions (over which an area has no control) that could cause the region’s ozone compliance status to vacillate between attainment and nonattainment despite ongoing emission reductions.

One-Hour Ozone NAAQS. A one-hour ozone NAAQS (0.12 ppm) was established by EPA in 1979.[4] This ozone standard was attained in San Diego County in 2001,[5] the culmination of decades of emission reduction efforts. Attainment was achieved despite substantial growth in the region’s population and motor vehicle fleet, clearly demonstrating that emission control efforts in San Diego County are working. (Refer to Section 1.4 for additional information on emissions and regional growth trends.) One-hour ozone attainment was achieved by reducing emissions of ozone precursors NOx and VOC, setting the stage for continuing efforts to attain the more health-protective eight-hour ozone NAAQS.

---

[3] Federal Register, Volume 62, Page 38856 (62 FR 38856).

[4] 44 FR 8202.

[5] 67 FR 65043.

The one-hour ozone NAAQS was revoked by EPA, effective June 15, 2005.[6] Although the one-hour standard has been phased out, associated emission control requirements in place on the date of revocation continue to apply pursuant to anti-backsliding provisions of the CAA (Section 172(e)).

1.1.4 Ozone Designation Status

The region's air quality designations for the NAAQS (attainment, nonattainment, or unclassifiable) are listed in federal regulation.[7] San Diego County was designated a Nonattainment Area for the eight-hour ozone NAAQS, effective June 15, 2004, based on ozone air quality measurements over the 2001-2003 three-year period.[8] At that time, the region's nonattainment status was further categorized by EPA as "Basic," a category of eight-hour ozone nonattainment areas whose one-hour ozone design values meet the former one-hour ozone NAAQS.

Boundaries of Nonattainment Area. The outer boundaries of the San Diego Nonattainment Area are contiguous with the boundaries of San Diego County, as illustrated in Figure 1-1.

FIGURE 1-1
San Diego Nonattainment Area Boundaries
For the Eight-Hour Ozone NAAQS

<http://www.epa.gov/ozonedesignations/areamaps/SanDiego.pdf>

---

[6] 70 FR 44470.

[7] 40 CFR 81.305, "Designation of Areas for Air Quality Planning Purposes – California."

[8] 69 FR 23858.

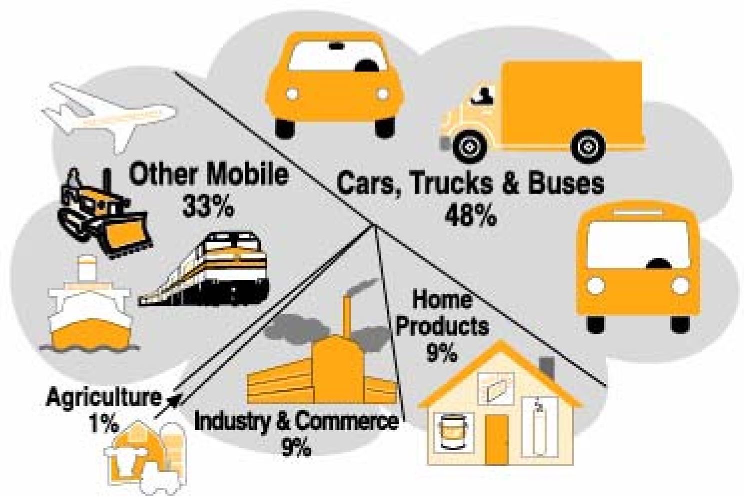
Tribal Nations. The Campo, Cuyapaipe, La Posta, and Manzanita Indian Reservations (near the southeast corner of the county) are excluded from San Diego's Nonattainment Area designation, and are designated as Attainment Areas. In fact, pursuant to federal requirements, none of the region's Tribal Nations are regulated by the District and their ozone status does not affect this Eight-Hour Ozone Attainment Plan, which applies to non-tribal land only.

1.2 EMISSION SOURCES

Ground level ozone is formed by complex chemical reactions of NOx and VOC emissions in the presence of sunlight. NOx is emitted mostly from sources of fossil fuel combustion, including motor vehicles, other mobile sources (such as ships, trains, and aircraft), power plants, and piston engines. VOC emissions are released from fuel combustion as well as fuel and solvent evaporation. Sources of VOC emissions include motor vehicles, gas stations, chemical plants, factories, landfills, and consumer and commercial products. (Natural sources of VOC and NOx emissions also exist, as indicated in Section 1.1.1.)

The percentage contribution of ozone-forming emissions by manmade source type in San Diego County is presented in Figure 1-2. Mobile sources, which are under State and federal jurisdiction, produce over three-quarters of ozone-forming emissions regionwide. Stationary industrial facilities and consumer and home products contribute to a lesser extent. A complete inventory of emission sources in San Diego County is presented in Section 2.0 (Emission Inventories and Trends) and Attachment A.

FIGURE 1-2
Manmade Sources of Ozone-Forming Emissions
(VOC+NOx)
San Diego County, 2002 Base Year



Based on ARB SIP emissions inventory.

1.3 EMISSION CONTROL EFFORTS

Air quality control in California is a shared responsibility among local, State, and federal agencies. Local air districts regulate emissions from non-mobile (stationary) sources, such as stationary industrial and commercial sources, and some area-wide sources such as coatings and industrial solvents. At the State level, ARB adopts measures to reduce emissions from on-road motor vehicles, off-road vehicles and equipment, fuels, and consumer products. At the national level, EPA regulates off-road equipment and inter-state sources such as ships, trains, aircraft, and out-of-state vehicles.

APCD—in collaboration with federal, State, and local agencies and the citizens, businesses, and civic groups of San Diego County—has worked hard to efficiently and cost-effectively reduce ozone precursor emissions from nearly every source to ensure cleaner air for all San Diegans. Summaries of State and federal control programs and associated regulations are presented in Section 3.2.1. The District has adopted dozens of emission control rules addressing all significant stationary source categories in San Diego County (see Section 3.2.2). These rules implemented previous local planning efforts to attain the NAAQS (such as for the former one-hour ozone standard), coupled with State requirements for adopting every feasible control measure for sources under District jurisdiction. As a result of shared efforts, San Diego's motor vehicles, power plants, factories, gas stations, engines, paints, and solvents are among the cleanest in the nation.

Total regionwide NOx and VOC emissions have been reduced 32% and 46% respectively over the 1990-2005 period (see Section 2.0, Emission Inventories and Trends).[9] Further, ongoing implementation of existing rules and regulations will continue reducing total regionwide ozone precursor emissions for the foreseeable future, as future-year requirements become effective and as new lower-emitting sources replace older, higher-emitting sources at the end of their useful lives. Because ozone-precursor control efforts in the region are working effectively and will continue to provide emission benefits, and because San Diego County's ozone air quality is now close to attaining the eight-hour ozone NAAQS (see Sections 1.4 and 4.4), the strategy to attain as expeditiously as practicable relies heavily on the existing District, State, and federal programs and regulations. The Emission Control Strategy is discussed in detail in Section 3.0.

1.4 OZONE AIR QUALITY IMPROVEMENT

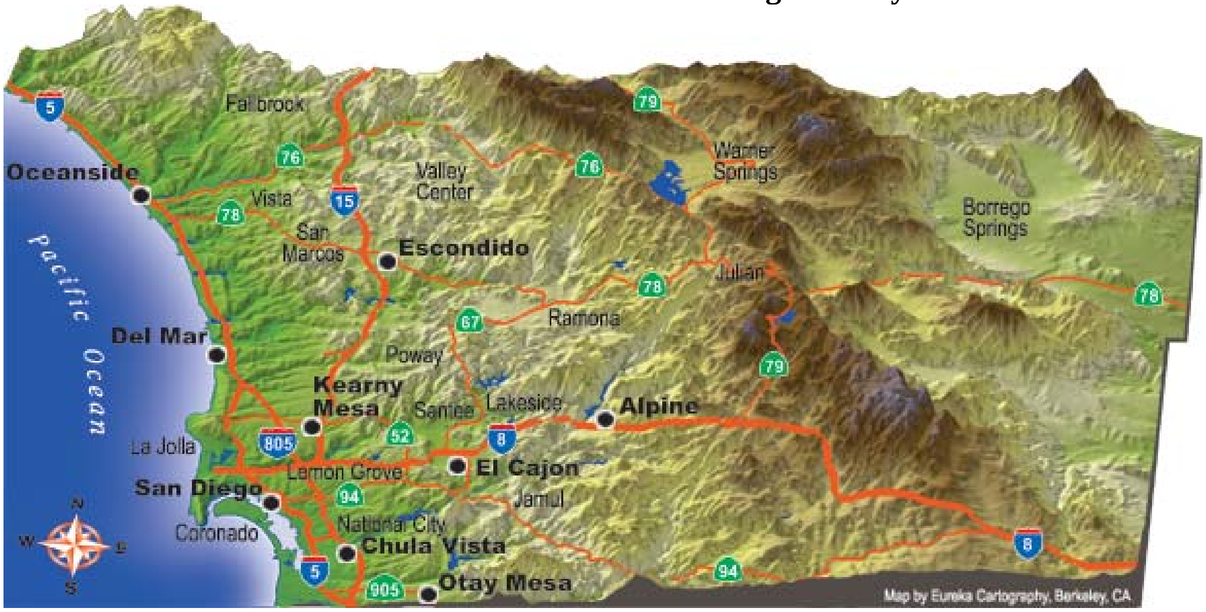
The District operates an extensive air monitoring network, continuously monitoring ambient levels of ozone (and many other air pollutants) at numerous sites throughout the region (Figure 1-3) in compliance with federal requirements.[10] Data generated at these monitors are used to define the nature and severity of ozone and to determine NAAQS attainment status in San Diego County.

---

[9] Based on ARB SIP emissions inventory, Version 1.06.

[10] 40 CFR Part 58, "Ambient Air Quality Surveillance."

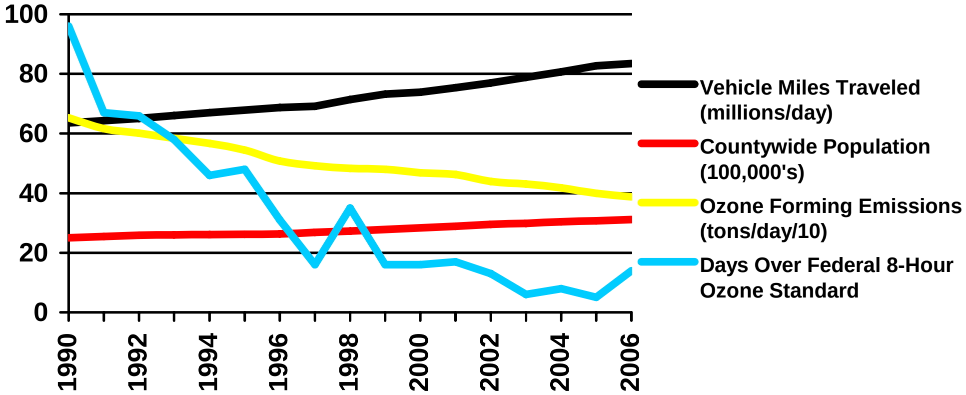
FIGURE 1-3
Ozone Monitor Locations in San Diego County



1.4.1 Most Improved in the Nation

Although the eight-hour ozone NAAQS was not established until 1997, monitoring data since 1990 show a long-term trend toward attainment even while the region experienced substantial growth in population and vehicle miles traveled, as illustrated in Figure 1-4. Improvements in ozone air quality generally track with reductions in ozone-forming emissions, providing more evidence that emission control programs are successful. In fact, in 2005 the region distinguished itself as the most improved metropolitan area in the nation for reduction in exceedances of the eight-hour ozone NAAQS between 1990 (96 exceedances) and 2004 (eight exceedances). Only one monitoring location (Alpine) has violated the eight-hour ozone standard since 1998.

FIGURE 1-4
Emissions and Growth Trends in San Diego County



1.4.2 Transported Pollution

San Diego's ozone air quality problem is complicated by transported air pollution from the South Coast Air Basin, located immediately north and upwind of San Diego County.[11] South Coast suffers the worst ozone problem in the nation, notwithstanding tremendous ozone air quality improvement over the past two decades. This transported air pollution, over which the District has no control, often increases ozone concentrations measured downwind at San Diego's monitoring sites. Since 2003, transport has played a significant role in all of the county's exceedances of the eight-hour ozone NAAQS, as determined by meteorological analyses of ozone exceedances.

Transported air pollution from South Coast to San Diego follows several different known routes:

1. **Transport Aloft**. Ozone is transported aloft from South Coast when winds from the north move ozone trapped aloft within the inversion layer southward into San Diego County. This transported ozone aloft most often impacts the Alpine monitoring site, in the inland foothills at an elevation of approximately 2,000 feet. The Alpine monitor is the only monitoring site in San Diego County with eight-hour ozone design values exceeding the NAAQS.

2. **Coastal Transport**. Coastal transport can occur when relatively mild Santa Ana winds blowing toward the southwest push South Coast's air pollution over the ocean, and the sea breeze transports air pollution onshore into San Diego County, impacting the coastal monitoring sites.

3. **Inland Transport**. Inland transport can occur when air pollution from South Coast's inland areas blows into San Diego County generally along the Interstate 15 freeway corridor.

Importantly, the South Coast Air Quality Management District (SCAQMD) has implemented an effective emissions control program resulting in a long-term trend of emission reductions and ozone air quality improvement in the South Coast region. In turn, this has led to a reduction in air pollution transported to San Diego.

Substantial emission reductions occurring in San Diego County coupled with a reduction in transported air pollution from South Coast provided for attainment of the former one-hour ozone NAAQS in San Diego County. Similarly, as previously illustrated in Figure 1-4, substantial progress has already been achieved in San Diego toward attaining the more stringent eight-hour ozone NAAQS. Nevertheless, transported air pollution will continue to play a substantial role in the region's ability to expeditiously attain and maintain the ozone NAAQS.

1.5 ATTAINMENT PLANNING REQUIREMENTS

EPA promulgated Phase 1 of its eight-hour ozone implementation rule in April 2004, establishing the nonattainment classification scheme and attainment dates for nonattainment areas.[12] EPA followed up its Phase 1 ozone implementation rule with a final (Phase 2) rule in November 2005,

---

[11] The South Coast Air Basin includes Orange County and the metropolitan portions of Los Angeles, Riverside, and San Bernardino Counties.

[12] 69 FR 23951.

specifying the planning and emission control requirements regions must address in their implementation plans.[13]

Pursuant to EPA's Phase 1 eight-hour ozone implementation rule, all Basic Nonattainment Areas—including San Diego County—are subject to the general planning and emission control requirements of Subpart 1 (of Part D of Title I) of the CAA. These Subpart 1 requirements are discussed in detail in Section 1.5.2 below. Basic Nonattainment Areas are not subject to the additional, more prescriptive requirements of Subpart 2, which were originally established for the former one-hour ozone NAAQS.

1.5.1 2006 Appeals Court Decision and Implications

Several parties have filed lawsuits challenging various elements of EPA's ozone implementation rules. During development of this Attainment Plan, a federal Appeals Court vacated (voided) EPA's Phase 1 ozone implementation rule.[14] The Appeals Court disagreed with EPA applying Subpart 1 to all eight-hour ozone nonattainment areas that have attained the former one-hour ozone NAAQS, and indicated that some such areas (possibly including San Diego County) must also be subject to Subpart 2 requirements. The Appeals Court remanded the matter back to EPA. However, the Department of Justice (on behalf of EPA) and other parties have appealed the Decision.

Implications. The Appeals Court Decision calls into question whether San Diego County will remain a Subpart 1/Basic Nonattainment Area or be classified in the future under Subpart 2. Regardless, most of the stringent Subpart 2 emission control requirements are already met in San Diego County pursuant to backsliding prohibitions for the former one-hour ozone NAAQS. These requirements, plus additional Subpart 2 requirements that would possibly apply, are discussed in Section 1.5.3.

Resolution of the legal issues associated with EPA's ozone implementation rules will take many months, if not years. In the meantime, the District is proceeding with this Eight-Hour Ozone Attainment Plan to ensure compliance with the June 15, 2007, submittal deadline (which was not vacated by the Appeals Court) and continued ozone air quality improvement in the San Diego region. However, additional or revised ozone planning efforts may be required in the future upon resolution of the legal issues associated with EPA's ozone implementation rules.

1.5.2 Subpart 1/Basic Nonattainment Area Requirements

Subpart 1, Basic Nonattainment Area requirements are fully addressed in this Attainment Plan, pursuant to CAA Section 172 and EPA's previously issued Phase 1 and Phase 2 ozone implementation rules. Major requirements are summarized below.

An **Emission Inventory** (Section 2.0) is a comprehensive tabulation of pollutants emitted into the air as a result of various activities, organized by emission source category. This Eight-Hour Ozone Attainment Plan includes updated inventories of ozone precursor emissions, VOC and NOx, for the

---

[13] 70 FR 71612.

[14] U.S. Court of Appeals for the District of Columbia Circuit, Case No. 04-1200, South Coast Air Quality Management District v. Environmental Protection Agency; decided December 22, 2006.

2002 base year (the year from which future-year inventories are projected)[15] and the 2008 attainment year, representative of a typical summer weekday. Section 2.0 also identifies **Emission Budgets** for transportation and general conformity purposes.

The **Emission Control Strategy** (Section 3.0) identifies a comprehensive group of stationary and mobile source control measures to lead the region into eight-hour ozone attainment as expeditiously as practicable. The Emission Control Strategy provides for a demonstration of attainment within five years (June 15, 2009) of the nonattainment designation (June 15, 2004). Therefore, pursuant to EPA's Phase 2 implementation rule, Basic Nonattainment Area requirements for Reasonably Available Control Technology (RACT) are fulfilled by the control measures relied on in the Attainment Demonstration.[16] Similarly, the requirement for Reasonable Further Progress (RFP) is fulfilled because all necessary emission reductions will be achieved by the beginning of the 2008 attainment year.[17] Therefore, no separate discussions are needed in this Eight-Hour Ozone Attainment Plan to address RACT and RFP requirements. However, additional RACT and RFP requirements would apply if the region is subsequently classified as a Subpart 2 Nonattainment Area under any rule revisions EPA may be required to issue responding to the court order (see Section 1.5.3).

An analysis of **Reasonably Available Control Measures** (RACM, Section 3.4) is presented pursuant to federal requirements to determine whether additional technologically and economically feasible control measures could advance the ozone attainment date by one or more years. The stringency and comprehensiveness of currently adopted control requirements on emission sources in San Diego County significantly reduces the availability of potential new measures that could provide additional emission reductions to advance the attainment year. The RACM analysis demonstrates there are no additional economically and technologically feasible control measures (alone or in conjunction with others) that could advance the attainment year from 2008 to 2007.

An **Attainment Demonstration** (Section 4.0) was developed pursuant to federal requirements, using photochemical air quality simulation modeling and other approved analytical techniques (collectively called "Weight of Evidence") to demonstrate the ability of the Emission Control Strategy (Section 3.0) to provide for eight-hour ozone attainment as expeditiously as practicable. Ozone nonattainment areas are required to model attainment in the ozone season[18] prior to the area's attainment date.[19] For San Diego County, the demonstrated "attainment year" is 2008, representing the first full ozone season prior to the June 15, 2009, attainment date.

Contingency Measures (Section 5.0) are required, pursuant to CAA Section 172(c)(9), to be implemented in the event of failure to achieve RFP milestones or failure to attain the NAAQS by

---

[15] EPA established 2002 as the emission inventory base year for eight-hour ozone planning purposes. See "2002 Base Year Emission Inventory SIP Planning: 8-hr Ozone, PM2.5 and Regional Haze Programs," Lydia Wegman, Director, Air Quality Standards and Strategy Division, November 18, 2002 (www.epa.gov/ttnchie1/eidocs/2002baseinven_102502new.pdf).

[16] 40 CFR 51.912(c)(1).

[17] 40 CFR 51.910(b)(2)(i).

[18] San Diego's ozone season (when eight-hour ozone exceedances can be expected) has long been specified in federal regulation (40 CFR Part 58, Appendix D, section 2.5) as January through December. However, based on eight-hour ozone levels in recent years, the region's ozone season is more likely May through September (see Section 4.4.5). Regardless, for purposes herein, the full ozone season remains January through December.

[19] 40 CFR 51.908(d).

the attainment deadline. The Contingency Measures requirement is intended to ensure emission reduction progress continues while the failure is being corrected.

Typically, contingency measures are held in reserve and implemented only if required. However, California's stringent emissions control program and on-going emissions reduction trend create a unique situation, allowing this Attainment Plan to identify several mobile source control regulations as contingency measures that will be implemented regardless of contingency measure requirements. These measures provide additional emission reductions, beyond those relied on in the Attainment Demonstration.

New Source Review (NSR) rules are required by the CAA. For purposes of implementing the eight-hour ozone NAAQS, the NSR rules must have applicability thresholds and offset ratios at least as stringent as mandated in the CAA for the nonattainment area's classification. Since San Diego County was designated under Subpart 1 as a Basic Nonattainment Area, the mandated applicability threshold for VOC and NOx emissions is 100 tons per year, and the mandated offset ratio is at least 1-to-1. If in the future the area were classified Moderate under Subpart 2 (see Section 1.5.3), the same 100 tons per year threshold would apply, but the mandated offset ratio would be 1.15-to-1.

The District's current NSR rules (Rules 20.1 – 20.4) were adopted in 1998 when San Diego County was classified as a Serious Nonattainment Area for the one-hour ozone NAAQS, but they have not yet been approved into the SIP. The offset applicability threshold in the current NSR rules is 50 tons per year and the offset ratio is 1.2-to-1. In the District's EPA-approved NSR rules (adopted in 1979) that are included in the federally enforceable SIP, the offset applicability threshold is 100 tons per year and the offset ratio is 1.2-to-1. The District's NSR rules (both versions) also require Lowest Achievable Control Technology and other requirements mandated for nonattainment areas. Thus, both versions of the District's NSR rules fulfill the eight-hour ozone requirements, whether San Diego County remains under Subpart 1 or is classified Moderate under Subpart 2.

1.5.3 Subpart 2/Moderate Nonattainment Area Requirements

Current Subpart 2 requirements are also addressed in this Attainment Plan, in the event the region would be classified as a Subpart 2 nonattainment area under an EPA rule revision. Based on the region's 2003 eight-hour ozone design value (0.093 ppm), Moderate Nonattainment Area requirements would likely apply under this scenario.

Importantly, Subpart 2 requirements have long been implemented in San Diego County pursuant to the region's former status as Subpart 2/Serious Nonattainment Area for the one-hour ozone NAAQS.[20] These requirements continue to be implemented in the region and are required under federal anti-backsliding provisions, and include the following:

1. Enhanced vehicle inspection and maintenance program [CAA Section 182(c)(3)];
2. Stage II gasoline vapor recovery [CAA Section 182(b)(3)];

---

[20] Subpart 2/Serious Nonattainment provisions were fully satisfied in San Diego County pursuant to the 1994 One-Hour Ozone Attainment Plan, approved by EPA (62 FR 1150). Compliance with Subpart 2 was reaffirmed by EPA when redesignating the region to a Maintenance Area for one-hour ozone (68 FR 13653).

3. Reformulated gasoline [CAA Section 211(k)];

4. New Source Review regulations for new or modified major stationary sources of VOC or NOX, including an offset ratio of 1.2:1 [CAA Section 182(c)(10)];

5. Reasonably Available Control Technology for existing major stationary sources of NOx [CAA Section 182(f)];

6. Periodic emissions inventory and source emission statement regulations [CAA Section 182(a)(3)]; and

7. Enhanced ambient monitoring [Photochemical Assessment Monitoring Stations (PAMS), CAA Section 182(c)(1)].

Limited Further Requirements Under Subpart 2. If in the future San Diego County were to be classified by EPA as a Subpart 2/Moderate Nonattainment Area, at least two additional SIP submittal requirements could apply in addition to those already implemented in the region.

1. <u>Reasonably Available Control Technology [CAA Section 182(b)(2)]</u>: In a separate SIP submittal, a Subpart 2 region must newly reevaluate and assure RACT requirements are met for each applicable category of stationary sources of VOC and NOx.[21]

2. <u>Reasonable Further Progress [CAA Section 182(c)(2)(b)]</u>: Newly classified Moderate areas may be required to submit new RFP demonstrations.

These detailed RACT and RFP requirements do not apply to this Attainment Plan because it is prepared pursuant to Subpart 1 requirements. If EPA subsequently classifies San Diego County under Subpart 2, then reasonable deadlines for compliance with additional requirements will be specified by EPA.

1.5.4 Attainment Finding Versus Attainment Demonstration

The Attainment Demonstration required to be included in this Attainment Plan differs from an "attainment finding" that EPA must issue after an area has actually attained the NAAQS. This Attainment Demonstration is a prediction of clean air quality in the forecasted attainment year (2008). An attainment finding is an after-the-fact determination that the NAAQS has been attained.

An actual attainment finding must be based on three consecutive years of ambient ozone monitoring data. An actual attainment finding in 2008 for San Diego County, based on the 2006-2008 three-year period, is not anticipated due to higher eight-hour ozone levels that occurred during a record-breaking heat wave in 2006.[22]. Nevertheless, pursuant to federal requirements, an

---

[21] RACT compliance options for Subpart 2 areas include (1) certifying that ongoing RACT rules for one-hour ozone implementation represent RACT for eight-hour ozone purposes; or (2) making a new RACT determination and any associated rule revisions.

[22] See Attachment G for a discussion of unusual meteorological conditions in 2006 that led to higher eight-hour ozone levels.

Attainment Demonstration for 2008 is not required to present three years of ambient ozone data (2006–2008) that provide for attainment in the attainment year (2008).[23] Rather, areas must demonstrate that the attainment year itself (2008) is anticipated to be a "clean" year with respect to eight-hour ozone levels, with a prediction of three or fewer exceedances of the NAAQS at each monitor in that year.[24]

The air quality simulation modeling runs predict 2008 ozone concentrations of 0.086 ppm, just slightly higher than the 0.085 ppm level representing the standard. However, statistical air quality trends analyses included in the Weight of Evidence demonstration indicate that historical eight-hour ozone design values at the Alpine monitoring site have been decreasing at a rate that would lead to attainment years ranging from 2006 to 2008. Thus, the Weight of Evidence predicts 2008 to be a clean year.

If, as predicted, 2008 proves to be a "clean year" for eight-hour ozone levels in San Diego County (as occurred in 2004, with just two exceedances measured at Alpine), then the region will qualify for a one-year attainment date extension provided under CAA Section 172(a)(2)(C), extending the three-year attainment period to 2007-2009. Further, if high ozone concentrations were to occur in 2007 that prevent actual attainment in the 2007-2009 timeframe, but 2009 itself is a "clean year," then a second one-year extension would be available, and attainment must then be achieved based on the 2008-2010 three-year period. Thus, a "2008 attainment demonstration" corresponds to a forecast of clean years in 2008 and 2009 and actual attainment based on either the 2007-2009 or 2008-2010 three-year period.

---

[23] 66 FR 57163; 71 FR 52678-79.

[24] The Attainment Demonstration's focus on a single attainment year, rather than on a three-year attainment period, is consistent with federal requirements to achieve all necessary emission reductions by the beginning of the attainment year, not three years prior to the area's attainment date. This approach is also a function of how the photochemical air quality simulation model operates, predicting air quality for one year.

2.0 EMISSION INVENTORIES AND TRENDS

2.1 INVENTORY DEVELOPMENT PROCESS

Emission inventories, projections, and trends in this Eight-Hour Ozone Attainment Plan are based on the latest Ozone SIP Planning Emission Projections compiled and maintained by ARB.[1] Supporting data were developed jointly by stakeholder agencies, including ARB, the District, SCAQMD, the Southern California Association of Governments (SCAG), and the San Diego Association of Governments (SANDAG). Each agency plays a role in collecting and reviewing data as necessary to generate comprehensive emission inventories. The supporting data include socio-economic projections, industrial and travel activity levels, emission factors, and emission speciation profiles.

ARB compiles annual statewide emission inventories in its emission-related information database, the California Emission Inventory Development and Reporting System (CEIDARS). Emission projections for past and future years were generated using the California Emission Forecasting System (CEFS), developed by ARB to project emission trends and track progress towards meeting emission reduction goals and mandates. CEFS utilizes the most current growth and emissions control data available and agreed upon by the stakeholder agencies to provide comprehensive projections of anthropogenic (human activity-related) emissions for any year from 1975 through 2030.

Local air districts are responsible for compiling emissions data for all point sources and many stationary area-wide sources. For mobile sources, CEFS integrates emission estimates from ARB's EMFAC2007 and OFFROAD models. SCAG and SANDAG incorporate data regarding highway and transit projects into their Travel Demand Models for estimating and projecting vehicle miles traveled (VMT) and speed. ARB's on-road emissions inventory in EMFAC2007 relies on these VMT and speed estimates. To complete the inventory, estimates of biogenic (naturally occurring) emissions are developed by ARB using the Biogenic Emissions Inventory Geographic Information System (BEIGIS) model.

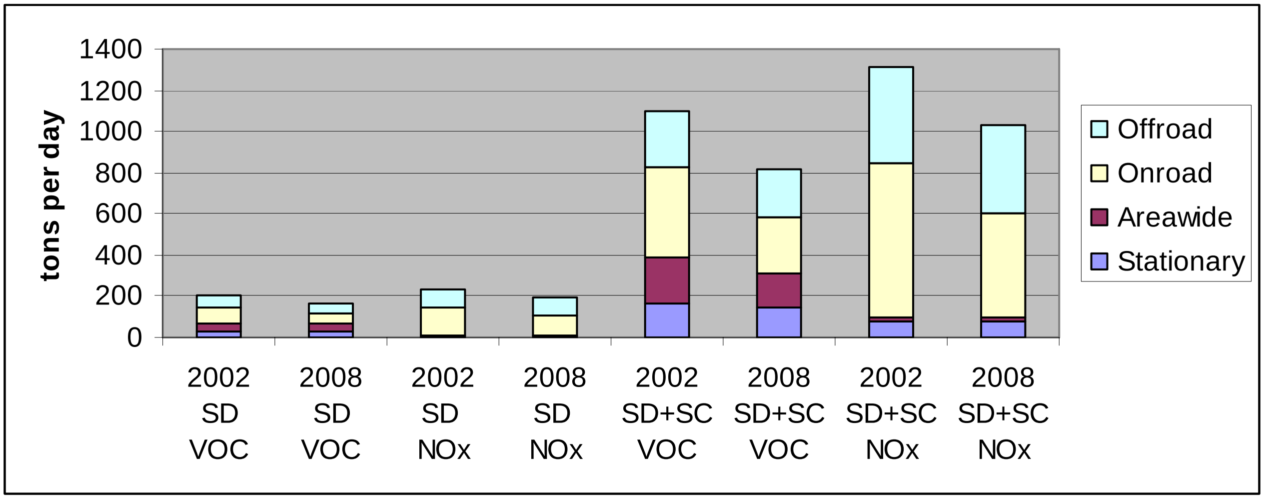
2.2 INVENTORIES FOR 2002 BASE YEAR AND 2008 ATTAINMENT YEAR

Detailed inventories (by source category) of ozone-precursor emissions (VOC and NOx) for the 2002 base year and 2008 attainment year are presented in Attachment A and illustrated in Figure 2-1. Because San Diego's ozone air quality is often affected by emissions from the South Coast Air Basin (see Section 1.4.2), both an inventory of San Diego-only emissions and an inventory of combined San Diego plus South Coast emissions are presented. The latter scenario is a general indicator of progress for the South Coast-San Diego transport couple.

---

[1] Version 1.06 Rf#980.

FIGURE 2-1
Ozone Precursors Emissions in San Diego County and South Coast Air Basin



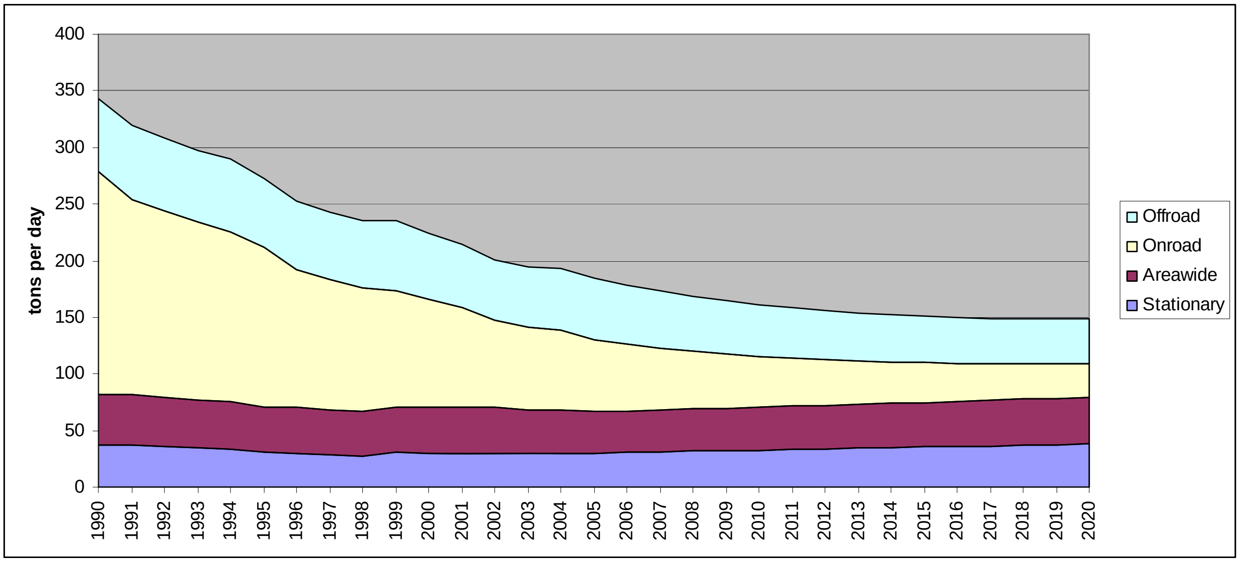
SD = San Diego Air Basin; SC = South Coast Air Basin
Source: ARB SIP emissions inventory.

2.3 LONG-TERM EMISSION TRENDS

Projected emission reduction trends in San Diego County for VOC and NOx are illustrated in Figures 2-2 and 2-3, respectively. A 30-year time period, looking back to 1990 and forward to 2020, is presented. Only currently adopted emission control regulations are reflected in future year projections. The resulting data are disaggregated for onroad, offroad, areawide, and stationary source emissions.

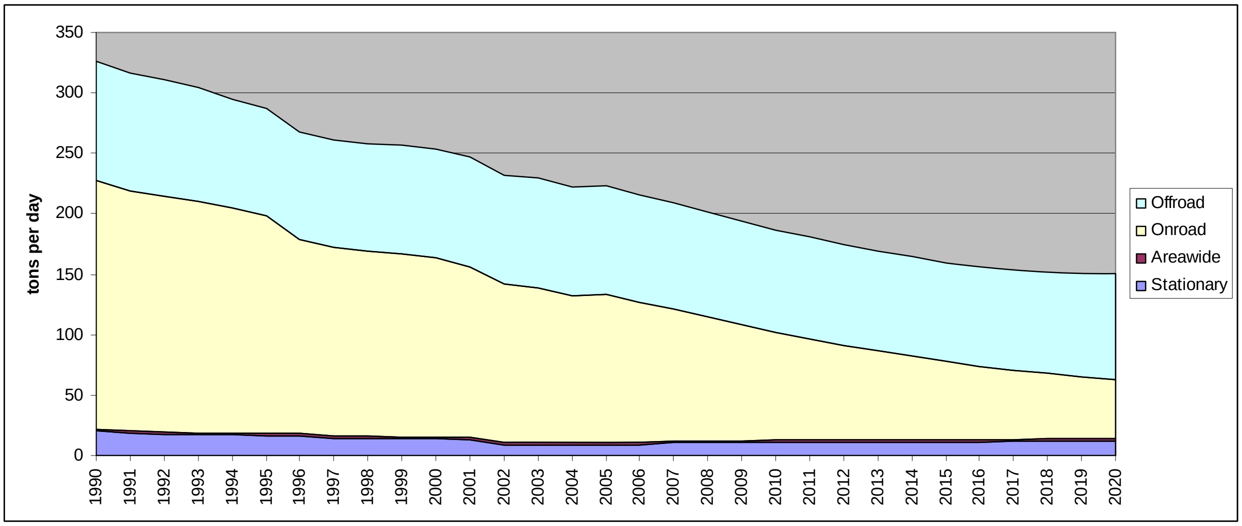
As new lower-emitting motor vehicles (required by State regulations) gradually replace used, higher-emitting vehicles, the share of VOC and NOx emissions from motor vehicles is projected to drop. Stationary source control measures continue to hold stationary source emissions relatively constant despite economic growth. Nevertheless, although not reflected in the figures, future ongoing implementation of the every-feasible-control-measure requirement of State law will likely provide further reductions in emissions as additional cost-effective control technologies become available.

FIGURE 2-2
Volatile Organic Compounds Emissions Trend in San Diego County



Source: ARB SIP emissions inventory.

FIGURE 2-3
Oxides of Nitrogen Emissions Trend in San Diego County



Source: ARB SIP emissions inventory.

2.4 EMISSION BUDGETS

2.4.1 On-Road Motor Vehicle Emission Budgets For Transportation Conformity

The federal transportation conformity regulation[2] requires the Eight-Hour Ozone Attainment Plan to specify on-road motor vehicle emission budgets for the 2008 Attainment Year.[3] The 2008 Attainment Year emission budgets will also apply to all post-2008 future transportation conformity analysis years, as authorized in the federal transportation conformity rule.[4]

TABLE 2-3
On-Road Motor Vehicle Emission Budgets in San Diego County
For 2008 and Subsequent Years
(tons per day)

Pollutant	2008 and Subsequent Years
VOC	53
NOx	98

Note: Emission budgets are based on ARB's EMFAC2007 model with ARB off-model adjustments and reflect "summer day."

The emission budgets presented in Table 2-3 represent the on-road motor vehicle emission levels projected for 2008, as determined by ARB using ARB's EMFAC2007 on-road motor vehicle emissions estimation model and adjusted by ARB to reflect recently adopted emission control programs not reflected in EMFAC2007 and other corrections.

Minor budget adjustments were made to account for imprecision in the on-road motor vehicle emissions modeling process.[5] The emission budgets are expressed as whole numbers, and therefore on-road motor vehicle emission estimates should be rounded to whole numbers (in tons per day) using standard rounding conventions (.49 rounds down; .50 rounds up) prior to being compared to emission budgets for transportation conformity determinations.

---

[2] 40 CFR 93 ("Determining Conformity of Federal Actions to State or Federal Implementation Plans").

[3] 40 CFR 93.118 ("Criteria and Procedures: Motor Vehicle Emissions Budget").

[4] 40 CFR 93.118(b)(2).

[5] To establish the emission budgets, the 2008 on-road motor vehicle emissions estimates were adjusted by rounding up to the next whole number (tons per day), and adding one. This same adjustment procedure was previously used in the approved One-Hour Ozone Maintenance Plan.

2.4.2 Military Growth Increment for General Conformity

The federal general conformity regulation[6] and corresponding District Rule 1501[7] require federal agencies proposing major federal actions to make a determination that proposed actions will conform to the applicable SIP. Specifically, proposed federal actions may not cause or contribute to a NAAQS violation or interfere with the purposes of an applicable SIP. A method for demonstrating conformity is forecasting and accounting for reasonably anticipated emissions from future actions by federal agencies in the applicable SIP (attainment or maintenance plan).[8]

The Department of the Navy (DoN) previously developed, for inclusion in the One-Hour Ozone NAAQS Maintenance Plan (2002), a projection of future mobile source emissions from anticipated military actions that may occur during the twenty-year maintenance period.[9] The NOx emission projections for the Maintenance Plan included a Military Growth Increment of 11.4 tons per day. The ongoing reduction in total regionwide NOx emissions outweighs projected growth in NOx emissions from military activity. Consequently, the Military Growth Increment of NOx emissions in the Maintenance Plan did not jeopardize ongoing maintenance of the one-hour ozone standard. Further, no growth is anticipated in mobile source VOC emissions from future military activities. Rather, VOC reductions from the proposed actions are anticipated.

However, in recognition of the need for further reductions in ozone-precursor emissions to provide for expeditious attainment of the more stringent eight-hour ozone NAAQS, the District has reevaluated whether and what size of a military-growth NOx emissions increment can be accommodated in this Eight-Hour Ozone Attainment Plan. DoN has requested a reduced increment of 2.3 tons per day of NOx emissions (see Attachment B) be included in this Attainment Plan to account for those projects that DoN has planned for implementation during the period in which this Attainment Plan is the applicable SIP (prior to attainment and subsequent replacement of this SIP by a new maintenance plan). The 2.3 tons per day of NOx emissions would result from plans to replace older aircraft at Miramar and Camp Pendleton with new advanced-technology aircraft that produce higher NOx emissions but lower VOC emissions, as well as plans for home-porting a new shallow-water combat ship at Naval Station San Diego. For perspective, military aircraft and ship activities over and offshore of San Diego County currently emit approximately 10 tons per day of NOx.

Attachment B presents preliminary schedules for implementation of the planned military projects through 2015. For purposes of analyzing the potential impact of these projects on 2008 ozone attainment, total emissions from full implementation of these projects were assumed to occur in 2008. The analysis indicates that the emissions growth allowance requested by the military can be accommodated without jeopardizing the demonstration of eight-hour ozone attainment by the 2008 deadline.[10] Consequently, a growth allowance of 2.3 tons per day of NOx emissions is incorporated in this Eight-Hour Ozone Attainment Plan.

---

[6] 40 CFR 51, subpart W ("Determining Conformity of General Federal Actions to State or Federal Implementation Plans).

[7] APCD Rule 1501, "Conformity of General Federal Actions," fully approved by EPA on April 23, 1999 (64 FR 19916).

[8] 40 CFR 51.858(a)(1).

[9] "Navy/Marine Corps Mobile Source Emissions Growth Projection and SIP Planning," Department of the Navy, San Diego County, California, June 6, 2002.

[10] Comparison of modeling 2008 with and without the planned military projects indicates the combination of NOx emission increases and VOC decreases associated with the projects would result in slightly lower ozone concentrations by a small fraction of a part per billion.

2.5 PRE-BASELINE BANKED EMISSION CREDITS

The District's federally mandated New Source Review Rules require new and modified major stationary sources that increase emissions in amounts exceeding specified thresholds to provide emission reduction offsets to mitigate the emissions growth. Emission reduction offsets represent either on-site emission reductions or the use of banked emission reduction credits (ERCs), which are voluntary, surplus emission reductions previously achieved and registered with the District for future use as offsets. As a result of offset requirements, there should be no net effect on emission inventories from future construction or modification of major sources; in other words, associated emission increases that otherwise would be added to the inventory are effectively canceled out by reductions of other emissions that are in the inventory. The "no net effect on the inventory" result from new or modified major sources holds true only if the emissions that are reduced to provide offsets remain in the inventory.

To ensure construction or modification of major sources has no net effect on emission inventories used for demonstrating eight-hour ozone attainment, banked ERCs derived from pre-2002 emission reductions—which otherwise would not be included as emissions in the baseline and subsequent inventories—must be added back into the inventories as if these emission were still in the air, pursuant to federal requirements.[11] Accordingly, Attachment C presents the pre-baseline ERCs currently in the District's credit bank that have been added to the 2008 Attainment Year Emissions Inventory.

---

[11] FR 70 71676.

3.0 EMISSION CONTROL STRATEGY

3.1. SUMMARY

Over the past two decades, ozone air quality in San Diego County has improved significantly (see Sections 1.4 and 4.4) due to comprehensive control strategies implemented to reduce pollution from mobile and stationary emission sources. Those controls were primarily designed to address the former one-hour ozone NAAQS. However, ongoing controls and reductions in peak ozone levels have also substantially reduced eight-hour average ozone such that the region is now close to attaining the eight-hour ozone NAAQS. Further, existing District, State, and federal regulations will provide additional reductions in ozone precursors for the foreseeable future (see Sections 2.3 and 4.4.4 for emission trends). Given the success of the existing comprehensive regulatory program, the Emission Control Strategy for this Eight-Hour Ozone Attainment Plan relies primarily on ongoing implementation of existing District, State, and federal regulations to attain the eight-hour ozone NAAQS as expeditiously as practicable. These currently adopted regulations are referred to as the “Existing Control Strategy,” which is described in Section 3.2

This Attainment Plan also reflects two additional stationary source control rules being submitted into the SIP, collectively providing an estimated 2.4 tons per day of VOC reduction between 2002 and 2008. First, the newest version of Rule 67.0 (Architectural Coatings) is being submitted into the SIP along with this Attainment Plan (see Section 3.2.2). Second, a new additional control measure (Low VOC Solvent Cleaning) is planned to be implemented in 2008 (see Section 3.3).

3.2 EXISTING CONTROL STRATEGY

3.2.1 State and Federal Control Programs

The California ARB is responsible for controlling emissions from mobile sources (except where federal law preempts ARB’s authority) and consumer products, developing fuel specifications, adopting statewide control measures for air toxics, and establishing gasoline vapor recovery standards and certifying vapor recovery systems. ARB has regulated mobile sources since the 1960s and consumer products since the early 1990s, and has added to and significantly tightened those regulations many times over the years.

The State Department of Pesticide Regulation (DPR) is responsible for control of agricultural, commercial and structural pesticides. The State Bureau of Automotive Repair (BAR) runs the State’s Smog Check programs to identify and repair higher polluting cars.

EPA is authorized to control emissions from mobile sources, including sources under exclusive federal jurisdiction (such as interstate trucks, some farm and construction equipment, locomotives, aircraft, and marine vessels based in the U.S.). International organizations develop standards for aircraft and marine vessels that operate outside the U.S. Federal agencies have the lead role in representing the U.S. in the process of developing international standards.

Control measures implemented by State and federal agencies pursuant to California’s 1994 Ozone SIP (addressing the former one-hour ozone NAAQS) are presented in Table 3-1. In 2003, ARB identified another series of new statewide mobile and area source control measures to achieve further progress in ozone air quality. These measures are listed in Table 3-2.

The existing State and federal emission control regulations will continue providing significant emission reductions through the coming decade as the regulations are fully implemented. From 2002 to 2008, these regulations will reduce daily ozone precursor emissions in San Diego County by more than 70 tons, as presented in Table 3-3.

TABLE 3-1
State and Federal Control Measures Adopted Since 1994 Ozone SIP

	Responsible Agency	Adopted
Defined Measures in 1994 Ozone SIP		
M1: Light-duty vehicle scrappage	ARB	1998
M2: Low Emission Vehicle II program	ARB	1998
M3: Medium-duty vehicles	ARB	1995
M4: Incentives for clean engines (Moyer Program)	ARB	1999
M5: California heavy-duty diesel vehicle standards	ARB	1998
M6: National heavy-duty diesel vehicle standards	U.S. EPA	1998
M7: Heavy-duty vehicle scrappage	ARB	Replaced with M17
M17: In-use reductions from heavy-duty vehicles	ARB	No
M8: Heavy-duty gasoline vehicle standards	ARB	1995
M9: CA heavy-duty off-road diesel engine standards	ARB	2000
M10: National heavy-duty off-road diesel engine stds	U.S. EPA	1998
M11: CA large off-road gas/LPG engine standards	ARB	1998
M12: National large off-road gas/LPG engine stds	U.S. EPA	2002
M13: Marine vessel standards	U.S. EPA	1999
M14: Locomotive engine standards	U.S. EPA	1997
M15: Aircraft standards	U.S. EPA	No
M16: Marine pleasurecraft standards	U.S. EPA	1996
CP2: Consumer products mid-term measures	ARB	1997/1999
CP3: Aerosol paint standards	ARB	1995/1998
Enhanced I/M (Smog Check II)	BAR	1995
DPR-1: Emission reductions from pesticides	DPR	Voluntary
Adopted measures not originally included in 1994 Ozone SIP		
Clean fuels measures	ARB	Multiple
Marine pleasurecraft (reductions beyond M16)	ARB	1998/2001
Motorcycle standards	ARB	1998
Urban transit buses	ARB	2000
Enhanced vapor recovery program	ARB	2000
Medium/heavy-duty gasoline standards (beyond M8)	ARB	2000
2007 heavy-duty diesel truck standards (beyond M5 and M6)	ARB/U.S. EPA	2001
Small off-road engine standard revisions	ARB	1998

Source: “2003 State and Federal Strategy for the California State Implementation Plan,” ARB, September 2003.

TABLE 3-2
State Measures Identified in the 2003 Ozone SIP

Strategy (Agency)	Name	Adoption Years	Implementation Years
LT/MED-DUTY-1 (ARB)	Replace or Upgrade Emission Control Systems on Existing Passenger Vehicles – Pilot Program	2005	2007-2008
LT/MED-DUTY-2 (BAR)	Improve Smog Check to Reduce Emissions from Existing Passenger and Cargo Vehicles	2002-2005	2002-2006
ON-RD HVY-DUTY-1 (ARB)	Augment Truck and Bus Highway Inspections with Community-Based Inspections	2003	2005
ON-RD HVY-DUTY-2 (ARB)	Capture and Control Vapors from Gasoline Cargo Tankers	2005	2006-2007
ON-RD HVY-DUTY-3 (ARB)	Pursue Approaches to Clean Up the Existing and New Truck/Bus Fleet	2003-2006	2004-2010
OFF-RD CI-1 (ARB)	Pursue Approaches to Clean Up the Existing Heavy-Duty Off-Road Equipment Fleet (Compression Ignition Engines) – Retrofit Controls	2004-2008	2006-2010
OFF-RD CI-2 (ARB)	Implement Registration and Inspection Program for Existing Heavy-Duty Off-Road Equipment to Detect Excess Emissions (Compression Ignition Engines)	2006-2009	2010
OFF-RD LSI-1 (ARB)	Set Lower Emission Standards for New Off-Road Gas Engines (Spark Ignited Engines 25 hp and Greater)	2004-2005	2007
OFF-RD LSI-2 (ARB)	Clean Up Off-Road Gas Equipment Through Retrofit Controls and New Emission Standards (Spark-Ignition Engines 25 hp and Greater)	2004	2006-2012
SMALL OFF-RD-1 (ARB)	Set Lower Emission Standards for New Handheld Small Engines and Equipment (Spark Ignited Engines Under 25 hp such as Weed Trimmers, Leaf Blowers, and Chainsaws)	2003	2005
SMALL OFF-RD-2 (ARB)	Set Lower Emission Standards for New Non-Handheld Small Engines and Equipment (Spark Ignited Engines Under 25 hp such as Lawnmowers)	2003	2007
MARINE-1 (ARB)	Pursue Approaches to Clean Up the Existing Harbor Craft Fleet – Cleaner Engines and Fuels	2003-2005	2005
MARINE-2 (ARB)	Pursue Approaches to Reduce Land-Based Port Emissions – Alternative Fuels, Cleaner Engines, Retrofit Controls, Electrification, Education Programs, Operational Controls	2003-2005	2003-2010

Strategy (Agency)	Name	Adoption Years	Implementation Years
FUEL-1 (ARB)	Set Additives Standards for Diesel Fuel to Control Engine Deposits	2006-2009	2006-2010
FUEL-2 (ARB)	Set Low-Sulfur Standards for Diesel Fuel for Trucks/Buses, Off-Road Equipment, and Stationary Engines	2003	2006
CONS-1 (ARB)	Set New Consumer Products Limits for 2006	2003-2004	2006
CONS-2 (ARB)	Set New Consumer Products Limits for 2008-2010	2006-2008	2008-2010
FVR-1 (ARB)	Increase Recovery of Fuel Vapors from Aboveground Storage Tanks	2003	2007
FVR-2 (ARB)	Recover Fuel Vapors from Gasoline Dispensing at Marinas	2006-2009	2006-2010
FVR-3 (ARB)	Reduce Fuel Permeation Through Gasoline Dispenser Hoses	2004	2007
PEST-1 (DPR)	Implement Existing Pesticide Strategy	---	1996-2010
Potential Range for Defined Near-Term State Measures			
Minimum Commitment via Adoption 2003-2006			
LONG-TERM STRATEGY (ARB)	Lead Multi-Agency Effort (State, federal and local) and Public Process Beginning in 2004 to Identify and Adopt Long-Term Measures	2007-2009	2010

Source: "2003 State and Federal Strategy for the California State Implementation Plan," ARB, Sept 2003.

TABLE 3-3
2002-2008 San Diego County Emissions Reductions from Existing State and Federal Control Programs
(tons per day)

Source Category	VOC Reductions	NOx Reductions
Consumer Products	2	--
Onroad Motor Vehicles	26	28
Commercial Boats	<1	2
Recreational Boats	1	0
Res/Ind/Const Equipment	2	7
Farm Equipment	<1	1
Gasoline Cans	2	--
Pesticides	<1	--
TOTAL	**34**	**38**

Source: ARB SIP emissions inventory, Version 1.06.

3.2.2 Local Control Measures

The District is primarily responsible for controlling emissions from stationary and areawide sources (with the exception of consumer products and pesticides) through rules and permitting programs. Examples of stationary and areawide sources include industrial sources such as factories, power plants, and chemical plants; commercial sources such as gas stations, dry cleaners, and paint spray booth operations; and residential sources such as water heaters, furnaces, and house paints. The District implements these control measures through adoption of rules, permits, inspections and testing of a wide variety of stationary sources. In addition, local transportation agencies are responsible for developing and implementing transportation control measures aimed at reducing vehicle activity and associated emissions.

Existing District Rules. The District has already adopted rules to control almost all stationary source categories in San Diego County, as presented in Table 3-4 for NOx rules and Table 3-5 for VOC rules. Most of these rules were fully implemented and achieved their emission reductions before the 2002 base year for this Eight-Hour Ozone Attainment Plan. Enforcement of these rules continues, but they can not be considered as “control measures” for this Attainment Plan because they will not provide new additional emission reductions.[1]

TABLE 3-4
Existing District Rules to Control NOx Emissions

Rule Number	Title	SIP Approval Date
68	Fuel-Burning Equipment-Oxides of Nitrogen	04/09/1996
69	Electrical Generating Steam Boilers, Replacement Units and New Units	Not In SIP*
69.2	Industrial & Commercial Boilers Process Heaters & Steam Generators	02/09/1996
69.3	Stationary Gas Turbine Engines	06/17/1997
69.3.1	Stationary Gas Turbine Engines – Best Available Retrofit Control Technology	Not In SIP*
69.4	Stationary Reciprocating Internal Combustion Engines	01/04/2006
69.4.1	Stationary Reciprocating Internal Combustion Engines– Best Available Retrofit Control Technology	Not In SIP*
69.5	Natural Gas-Fired Water Heaters	Not In SIP*
69.6	Natural Gas-Fired Fan-Type Central Furnaces	Not In SIP*

* The District has adopted and implemented additional rules pursuant to California’s stringent requirements for Best Available Retrofit Control Technology (BARCT). The District’s BARCT rules have not been submitted into the SIP because they are not required by federal law and are not credited as control measures in this Eight-Hour Ozone Attainment Plan.

---

[1] For purposes of this Emission Control Strategy section, the term “control measure” refers to new rules and regulations that are submitted into the SIP and provide new additional emission reductions (not previously accounted for) beyond the 2002 base year.

TABLE 3-5
Existing District Rules to Control VOC Emissions

Rule Number	Title	SIP Approval Date
61.0	Definitions Pertaining to the Storage and Handling of Organic Compounds	09/13/1993
61.1	Receiving and Storing Volatile Organic Compounds at Bulk Plants and Bulk Terminals	08/08/1995
61.2	Transfer of Organic Compounds Into Mobile Transport Tanks	08/26/2003
61.3	Transfer of Volatile Organic Compounds Into Stationary Storage Tanks	06/30/1993
61.3.1	Transfer of Gasoline Into Stationary Underground Storage Tanks	Not In SIP*
61.4	Transfer of Volatile Organic Compounds Into Vehicle Fuel Tanks	05/13/1993
61.4.1	Transfer of Gasoline From Stationary Underground Storage Tanks Into Vehicle Fuel Tanks	Not In SIP*
61.5	Visible Emission Standards for Vapor Control Systems	04/14/1981
61.7	Spillage of Volatile Organic Compounds	03/11/1998
61.8	Certification Requirements for Vapor Control Equipment	03/11/1998
66	Organic Solvents	08/11/1998
67.0	Architectural Coatings	03/27/1997
67.1	Alternative Emission Control Plans	03/27/1997
67.2	Dry Cleaning Equipment Using Petroleum-Based Solvent	03/27/1997
67.3	Metal Parts and Products Coating Operations	11/14/2003
67.4	Metal Container, Metal Closure and Metal Coil Coating Operations	11/03/1997
67.5	Cutback and Emulsified Asphalt	03/27/1997
67.6	Solvent Cleaning Operations	12/13/1994
67.7	Cutback and Emulsified Asphalts	03/27/1997
67.9	Aerospace Coating Operations	08/17/1998
67.10	Kelp Processing and Bio-Polymer Manufacturing	06/22/1998
67.11	Wood Products Coating Operations	Not In SIP*
67.11.1	Large Wood Products Coating Operations	06/05/2003
67.12	Polyester Resin Operations	03/27/1997
67.15	Pharmaceutical & Cosmetic	03/27/1997
67.16	Graphic Arts Operations	03/27/1997
67.17	Storage of Materials Containing Volatile Compounds	03/27/1997
67.18	Marine Coating Operations	03/27/1997
67.19	Coatings and Printing Inks Manufacturing Operations	05/26/2000
67.20	Motor Vehicle and Mobile Equipment Refinishing Operations	Not In SIP*
67.21	Adhesive Materials Application Operations	Not In SIP*
67.22	Expandable Polystyrene Foam Products Manufacturing Operations	Not In SIP*
67.24	Bakery Ovens	03/27/1997

* The District has adopted and implemented additional California BARCT rules that have not been submitted into the SIP because they are not required by federal law and are not credited as control measures in this Eight-Hour Ozone Attainment Plan.

Existing District Control Measure - Architectural Coatings. The District adopted the current version of Rule 67.0 (Architectural Coatings) in December 2001. It requires phased implementation of more stringent VOC content limits for certain coating categories that were implemented in 2003 and 2004. The rule provides an estimated 1.4 tons per day of additional VOC emission reductions.

Since the recently implemented provisions of the Architectural Coatings Rule provided emission reductions after the 2002 baseline, the rule is considered a control measure for this Eight-Hour Ozone Attainment Plan. This version of the rule has not yet been submitted into the SIP. Consequently, it is being submitted into the SIP along with this Eight-Hour Ozone Attainment Plan.

3.3 ADDITIONAL NEW CONTROL MEASURE – LOW VOC SOLVENT CLEANING

The District is adopting a new control measure, as reflected in this Eight-Hour Ozone Attainment Plan, to reduce the VOC content of solvents used in cold solvent cleaning operations, effective in 2008. The control measure will replace current District Rule 67.6 (Solvent Cleaning Operations) with two new rules, Rule 67.6.1 (Cold Solvent Cleaning and Stripping Operations) and Rule 67.6.2 (Vapor Degreasing Operations), which are being adopted simultaneously with this Eight-Hour Ozone Attainment Plan. Proposed new Rule 67.6.1 will require that each solvent utilized in a cold solvent cleaning operation must have a VOC content of 50 grams per liter of material or less, in addition to other requirements. Proposed new Rule 67.6.2 will apply to vapor degreasing operations, with requirements that are generally identical to those in current Rule 67.6.

When new Rule 67.6.1 is implemented in Spring 2008, San Diego County cold solvent cleaning-related VOC emissions are projected to drop by approximately 1 ton per day relative to the 2002 baseline. Because these emission reductions are not fully achieved before January 2008 (the beginning of the first full ozone season prior to the June 15, 2009, attainment deadline), they are not reflected in the Attainment Demonstration (Section 4.0), which shows attainment with the Existing Control Strategy. Nevertheless, the rule is identified as an additional control measure in this Attainment Plan to assist in reducing ozone concentrations in 2008 to below the level of the eight-hour ozone NAAQS.

3.4. REASONABLY AVAILABLE CONTROL MEASURES (RACM)

3.4.1. RACM Requirements

An analysis of Reasonably Available Control Measures (RACM) must demonstrate that the SIP provides for attainment as expeditiously as practicable.[2] Demonstrating attainment as expeditiously as practicable is a two-step process. First, an initial control strategy is developed that can demonstrate attainment by the earliest year that is preliminarily considered to be feasible within the statutory maximum attainment deadline.[3] The RACM analysis is then conducted as a second step, in which additional technologically and economically feasible potential control measures (that were not included in the initial control strategy) must be considered to determine if there is any

---

[2] CAA Section 172(c)(1).

[3] As a Subpart 1/Basic Nonattainment Area for eight-hour ozone, San Diego's maximum attainment deadline is June 15, 2009, plus up to five additional years, if necessary.

combination of additional control measures that could provide sufficient additional emission reductions in time to advance the attainment date by one or more years. The additional feasible control measures are determined to be "reasonably available" and must be included in the SIP only if implementing the measures can advance the attainment year.

To be able to advance the attainment year, potential control measures must meet two pre-requisites. First, each control measure must be implemented in time to provide the intended emission reductions by the beginning of the ozone season of the earlier—i.e., advanced—attainment year. Second, the cumulative emission reduction potential (in that advanced attainment year) of all the candidate measures together would need to be sufficient to advance the attainment year. As discussed below, the stringency and comprehensiveness of the Existing Control Strategy, and the already early year forecast to reach attainment (2008), limits or eliminates the feasibility of additional measures that can satisfy these criteria. Specifically, such measures would have to advance attainment to 2007, the current year.

3.4.2 Identifying Potential RACM for Stationary Sources

Identifying additional control measures for consideration as potential RACM is challenging in San Diego County because, in response to stringent requirements of State law, the District is already required to adopt every feasible control measure as expeditiously as practicable. Consequently, as previously presented in Table 3-4 for NOx and Table 3-5 for VOC, the District has already adopted rules to control almost all significant stationary source categories in the county. Most rules have been submitted into the SIP to fulfill federal requirements for Reasonably Available Control Technology (RACT). However, because California State law requires Best Available Retrofit Control Technology (BARCT) which is more stringent than RACT, the District has also adopted additional BARCT rules that have not been submitted into the SIP because they are not required by federal law or regulation. The District's existing BARCT rules can not be considered as potential RACM because they have already been implemented and would not provide new additional emission reductions that could advance the attainment year. Nevertheless, those additional BARCT rules have already achieved emission reductions that contribute to the forecast of an early attainment year.

The District has relied on an ongoing control measure evaluation process required under State law to identify potential RACM. Specifically, California local air districts must triennially update their air quality plans to achieve State ozone standards to include "every feasible control measure." Each district is required to consider, for each emission source category, whether adopting some or all of the requirements of the most stringent adopted rule in the State for that source category would be feasible within that district.

The District's current review of the most stringent rules identified 17 source categories (listed in Table 3-6) for which the most stringent rules in the State contain more stringent requirements than San Diego APCD rules. Table 3-6 also indicates the implementation period, in years, that would be necessary to fully realize the emission reductions if the rules were locally adopted. The one- to three-year implementation periods indicated for the VOC control measures, and the two- to 25-year implementation periods for the NOx control measures, represent the time necessary to obtain lower emitting materials, install control equipment, or replace existing units at the end of their useful lives. Thus, even if all measures were adopted concurrent with this Attainment Plan in 2007 (which is not feasible due to the lead time necessary for rule development and adoption), the reductions could not be fully realized before the beginning of 2007. Consequently, those measures are not available for advancing the attainment year to 2007.

An analysis of each of the potential control measures identified in Table 3-6 is presented in Attachment D.

TABLE 3-6
Stationary Source Categories for Which More Stringent Control Requirements Have Been Adopted by Another District

Control Measure	Other District Rule Number*	San Diego Rule Number	Estimated Emission Reduction Potential (Tons/Day)	Implementation Period (Years)	Pollutant
Low VOC Solvent Cleaning	SC 1122	67.6	1	1	VOC
Architectural Coatings	SC 1113	67.0	5	1	VOC
Automotive Refinishing	ARB SCM	67.20	1	2	VOC
Adhesive and Sealant Applications	SC 1168	67.21	1.4	1	VOC
Solvent Wipe Cleaning Operations	SC 1171	Various Rules	0.57	1	VOC
Wood Products Coating Operations	SC 1136	67.11-67.11.1	0.25	2	VOC
Graphic Arts	SC 1130	67.16	0.23	1	VOC
High Emitting Spray Booth Facilities	SC 1132	Various Coating Rules	0.15	2	VOC
Petroleum Storage Tanks	SC 1178	61.1	0.03	3	VOC
Mobile Transport Tanks Loading	SJV 4621	61.2	0.02	1	VOC
Food Products Manufacturing/Processing	SC 1131	No comparable rule	0.02	2	VOC
Polyester Resins Operations	SC 1162	67.12	0.02	1	VOC
Equipment Leaks	BA 8-18	Various Rules	<0.02	1	VOC
Aerospace Manufacturing Operations	SC 1124	67.9	<0.01	1	VOC
Industrial, Commercial, and Institutional Boilers	SJV 4306	69.2	0.1	2	NOx
Small Boilers and Large Commercial Water Heaters	SC 1146.1 & 1146.2	No comparable rule	0.3	25**	NOx
Residential Water Heaters	SC 1121	69.5	1.5	10**	NOx

*SC = South Coast air district; ARB = Air Resources Board; BA = Bay Area district; SJV = San Joaquin Valley district; SCM = Suggested Control Measure

**Emissions reductions would occur gradually, as new low-emitting units replace existing higher-emitting units at the end of their useful lives.

3.4.3 Identifying Potential RACM for Transportation Sources

Potential RACM also include Transportation Control Measures (TCMs), which are strategies to reduce motor vehicle trips, vehicle miles traveled, or vehicle idling and associated air pollution. Table 3-7 lists the 16 TCMs identified in CAA Section 108(f) and their implementation status in San Diego County. A discussion of each TCM, further describing the status of implementation, follows Table 3-7.

As indicated, 13 of the 16 TCMs have been implemented, including transit and traffic flow improvements, ridesharing, high occupancy vehicle (HOV) lanes, pedestrian-only streets, control of extended idling, and 7 other measures. The agencies responsible for developing and implementing these TCMs include the San Diego Association of Governments (SANDAG, the transportation planning agency for the San Diego region) and other State and local agencies as appropriate.

Five of the implemented TCMs—TCMs 1, 3, 5, 8, and 10—were included in the 1982 SIP Revision for San Diego County.[4] Descriptions herein of any ongoing implementation beyond 1982 SIP commitments does not constitute submittal of additional implementation commitments into the SIP. Submittal of additional TCM commitments into the SIP would be required only if the TCMs meet the RACM qualifications specified in Section 3.4.1. TCMs that have already been implemented can not provide new additional emissions reductions in 2007 that could advance the attainment year from 2008 to 2007. Therefore, they can not be considered RACM and consequently are not required to be submitted into the SIP.

Table 3-7 and the subsequent discussion also address the three TCMs that have not been implemented in San Diego County and the reasons for non-implementation. These measures address trip-reduction ordinances, peak-period vehicle restrictions, and vehicle emissions in extremely cold environments.

---

[4] In the 1982 SIP, TCMs 3 and 8 (see Table 3-7) were combined into one comprehensive TCM, the "Ridesharing" TCM.

TABLE 3-7
Transportation Control Measures listed in Clean Air Act Section 108(f) Implementation Status in San Diego County

Transportation Control Measures	**Implemented**	**In 1982 SIP**
1. Programs for improved public transit	Yes	Yes
2. Restriction of certain roads or lanes to, or construction of such roads or lanes for use by, passenger buses or high occupancy vehicles	Yes	
3. Employer-based transportation management plans, including incentives	Yes	Yes
4. Trip-reduction ordinances *Adopted in 1994, but rescinded in 1995 when federal and State laws were amended eliminating the mandate for such measures	No*	
5. Traffic flow improvement programs that achieve emission reductions	Yes	Yes
6. Fringe and transportation corridor parking facilities serving multiple occupancy vehicle programs or transit service	Yes	
7. Programs to limit or restrict vehicle use in downtown areas or other areas of emission concentration particularly during periods of peak use	No	
8. Programs for the provision of all forms of high-occupancy, shared-ride services	Yes	Yes
9. Programs to limit portions of road surfaces or certain sections of the metropolitan area to the use of non-motorized vehicles or pedestrian use, both as to time and place	Yes	
10. Programs for secure bicycle storage facilities and other facilities, including bicycle lanes, for the convenience and protection of bicyclists, in both public and private areas	Yes	Yes
11. Programs to control extended idling of vehicles	Yes	
12. Programs to reduce motor vehicle emissions, consistent with Title II, which are caused by extreme cold start conditions	Not Applicable	
13. Employer-sponsored programs to permit flexible work schedules	Yes	
14. Programs and ordinances to facilitate non-automobile travel, provision and utilization of mass transit, and to generally reduce the need for single-occupant vehicle travel, as part of transportation planning and development efforts of a locality, including programs and ordinances applicable to new shopping centers, special events, and other centers of vehicle activity	Yes	
15. Programs for new construction and major reconstructions of paths, tracks or areas solely for the use by pedestrian or other non-motorized means of transportation when economically feasible and in the public interest	Yes	
16. Program to encourage the voluntary removal from use and the marketplace of pre-1980 model year light duty vehicles and pre-1980 model light duty trucks	Yes	

3.4.3.1 Implementation Status of Transportation Control Measures (TCM)

TCM 1 – Improved Public Transit

The Transit measure commitments included in the 1982 SIP were fully implemented by 1995. Transit improvements have continued since that time, as follows. Bus revenue miles[5] in San Diego County increased 7% from 1995 to 2005, totaling nearly 28 million miles. In the last five years, the County's two largest transit providers have redirected service from low-ridership to high-ridership routes. Further, rail transit services, including the San Diego Trolley[6] and the Coaster[7] commuter rail service, have grown by nearly 42% since 1997, reaching over 8.2 million revenue car miles by 2005. The six-mile extension of the San Diego Trolley, from Qualcomm Stadium in Mission Valley to San Diego State University and La Mesa, opened in 2006. Additionally, construction began in 2004 on the 22-mile Sprinter Rail Line, connecting Oceanside to Escondido, and it is scheduled to begin revenue service in December 2007.

Notwithstanding these important improvements, it should be understood that the region's generally low-density land use pattern currently does not support extensive deployment of fixed-rail rapid transit modes that could provide faster travel times that are more comparable to the personal automobile. The San Diego region's existing transit network, although extensive, is mostly composed of lower-speed transit modes (such as conventional transit buses) that are appropriate for the lower-density land use levels that exist. The region's transit strategy, articulated in SANDAG's Regional Comprehensive Plan, is to increase land use densities and transit ridership in town centers and particular corridors. In most parts of the region, this system will take several decades to mature.

SANDAG's Regional Transportation Plan (RTP), MOBILITY 2030, envisions adding a new transit mode called Bus Rapid Transit (BRT). BRT would utilize a new class of coaches to provide shorter travel times and more convenience than current conventional buses, offering service more similar to light rail, but using the streets. Improved travel times will be accomplished by utilizing High Occupancy Vehicle lanes and transit prioritizing schemes for traffic signals.

TCM 2 – High Occupancy Vehicle (HOV) Lanes

Currently, three freeways (I-5, I-15, and SR 54) in the San Diego region have HOV lane segments. HOVs are also provided with preferential lanes at 62% of the 276 metered on-ramps, and there is a buses-only lane at the SR-163 on-ramp from downtown San Diego. The RTP calls for the development of a more robust HOV/Managed Lanes network, as follows:

- Managed lane facilities on:
  - I-5 from I-805 to Vandegrift Blvd;
  - I-15 from SR 163 to SR 78;
  - I-805 from SR 905 to I-5;
  - SR 52 from I-15 to SR 125.

---

[5] Revenue (car) miles are the total distance that a fleet travels while available for passenger service.

[6] The San Diego Trolley is a 54-mile light rail transit system serving southern San Diego County.

[7] The Coaster is a 42-mile passenger rail line between Oceanside and Downtown San Diego that began service in 1996.

- One HOV lane in each direction on:
  - I-5 from SR 905 to I-805;
  - I-8 from SR 125 to 2nd Street;
  - SR 52 from I-805 to I-15;
  - SR 54/SR 125 from I-5 to SR 94;
  - SR 56 from I-5 to I-15;
  - SR 78 from I-5 to I-15;
  - SR 94/125 from I-5 to I-8.

- Direct HOV to HOV connectors are included at the following freeway interchanges:
  - I-5 to I-805: North to North & South to South;
  - I-15 to SR 78: East to South & North to West;
  - I-15 to SR 94: South to West & East to North;
  - I-805 to SR 52: West to North & South to East.

Managed lanes will provide priority to HOVs such as carpools and vanpools, regular transit services, and a BRT system. Excess capacity in these lanes will be "sold" to solo drivers for a fee, similar to the current FasTrak program on I-15. The managed lanes will be separated from the general purpose lanes by a barrier with access provided at several locations through openings in the barrier.

TCM 3 – Employer-Based Transportation Management Plans

In the 1982 SIP, the Employer-Based Transportation Management Plans measure (TCM 3) was combined with the Shared-Ride Services measure (TCM 8) to form a more comprehensive measure, the “Ridesharing” TCM. The Ridesharing TCM commitments included in the 1982 SIP were fully implemented by 1988.

Traffic Abatement Plan requirements of APCD Rule 132 were included as part of the Ridesharing TCM. Pursuant to federal requirements for abating air pollution emergency episodes,[8] employer-based Traffic Abatement Plan measures are triggered by ozone levels exceeding 0.35 ppm. No ozone concentrations of this level or higher have been recorded in San Diego County since 1979.

TCM 4 – Trip-Reduction Ordinances

A regional trip-reduction ordinance was adopted by APCD as part of the 1994 Ozone SIP, but was rescinded in 1995 when federal and State laws were amended eliminating the mandate for such measures based on public opposition. (It should be noted that this TCM focuses on addressing weekday commute trips, whereas San Diego’s exceedances of the eight-hour ozone NAAQS occur disproportionately more frequently on weekends (see Section 4.3.1).

TCM 5 – Traffic Flow Improvements to Reduce Emissions

Traffic Flow Improvements mostly consist of traffic signal improvements to reduce idling and associated emissions. The Traffic Flow Improvements TCM commitments included in the 1982 SIP were fully implemented by 1990.

---

[8] 40 CFR 51.150 et seq.

Further implementation of the Traffic Flow Improvements TCM continues. All federally funded traffic signal projects selected with the federal transportation funding program (TEA-21) have been implemented (117 projects). SANDAG's 2006 Regional Transportation Improvement Program (RTIP) contains $19.7 million in traffic flow improvements, including eight traffic signal projects (two highway, six local).

TCM 6 – Park-and-Ride Facilities

Currently, there are 66 park-and-ride lots in the San Diego region, with 4,049 spaces available. More lots are anticipated as funding becomes available. In addition, transit parking at commuter rail stations has been developed and is currently available at six stations, with 6,300 spaces available. The San Diego Trolley also provides parking at over half (28) of its stations, with 9,700 confirmed spaces and an undetermined amount of shared-use parking. The future Sprinter rail line will offer parking at 13 stations accommodating 1,500 parking spaces.

TCM 7 – Peak-Period Vehicle Restrictions in Downtown Areas

This measure is feasible only in high-density portions of compact metropolitan areas with an extensive transit system. Given the San Diego region's historically low-density land use pattern, and therefore longer transit travel times, this measure is not yet feasible. However, SANDAG's Smart Growth Incentive Program provides funding to cities for infrastructure projects which enhance alternatives to driving in higher density areas. (It should be noted that this TCM focuses on addressing peak-period (weekday) trips, whereas San Diego's exceedances of the eight-hour ozone NAAQS occur disproportionately more frequently on weekends (see Section 4.3.1)).

TCM 8 – Shared-Ride Services

As mentioned above, in the 1982 SIP, TCM 8 was combined with TCM 3 in a "Ridesharing" TCM. The Ridesharing TCM commitments included in the 1982 SIP were fully implemented by 1988.

Further implementation of Shared-Ride Services TCM continues. SANDAG and APCD are partners in the support of RideLink (www.ridelink.org), the regional transportation assistance program, charged with providing shared ride services and education to employers and individuals on all ridesharing and biking options. Example services include:

- Carpool Ride Matching Service – computerized ride-matching.
- Guaranteed Ride Home Service – qualifying ride sharers are provided with three vouchers per year for $3 taxi fares or 24-hour rental cars to travel home to address a personal unscheduled event.
- Promotion of Teleworking and Alternative Work Schedules (see TCM 13) – RideLink works with employers and employees to create programs for offering alternative work arrangements (such as flex time and teleworking) to reduce commute trips and peak hour traffic congestion.
- Park and Ride Programs (see TCM 6) – Caltrans and other agencies provide park and ride facilities, which are promoted by RideLink.
- Vanpool Program – SANDAG operates a Regional Vanpool Program, funded in part by The District's Vehicle Registration Fund. As of November 1, 2006, 537 vanpools were operating in the San Diego region carrying more than 4,600 passengers daily, a 19%

increase over 2005 levels. Vanpools are anticipated to grow at 6 net vanpools per month. Additional vanpools are anticipated as additional funding becomes available.

TCM 9 – Road Surface Restrictions for Motor Vehicles in Metro Areas

Numerous examples of road surface restrictions exist in the San Diego region. In downtown San Diego, C Street is limited to the Trolley and pedestrian use, and a block of B Street was closed and transformed into the Civic Center Concourse. In Old Town San Diego State Historical Park, portions of San Diego Avenue, Calhoun Street, and Mason Street have been restricted to pedestrian-only use. In Balboa Park, the eastern end of El Prado is also restricted to pedestrian-only use. North of Sorrento Valley, a segment of Sorrento Valley Road is closed to traffic and reserved for bicycle and pedestrian uses. This measure is also implemented on a limited or recurring temporary basis for certain recreational areas, weekly farmer's markets, and yearly festivals/street fairs.

TCM 10 – Bicycle Facilities

The Bicycling TCM commitments included in the 1982 SIP were fully implemented by 1995. However, further implementation of the Bicycling TCM continues. The bikeway system currently includes 1,136 miles of bikeways in the San Diego region, consisting of Class I (exclusive bicycle path separated from roadway), Class II (striped on-street bicycle lane), and Class III (shared with motor vehicles) facilities. Additionally, front-mounted bike racks are available on nearly all transit buses. SANDAG maintains a system of 580 bicycle lockers throughout the region available for commuters at transit centers and park-and-ride facilities.

TCM 11 – Idling Controls

ARB has adopted diesel-fueled vehicle idling limitation programs focusing on school buses (www.arb.ca.gov/toxics/sbidling/sbidling.htm), trucks (www.arb.ca.gov/msprog/truck-idling/truck-idling.htm), and locomotives (www.arb.ca.gov/railyard/ryagreement/ryagreement.htm). More information is available on ARB's website at the specified web addresses.

TCM 12 – Vehicle Cold Start Emissions in Extreme Cold Conditions

This measure is not applicable due to the mild climate in the San Diego region.

TCM 13 – Flexible Work Schedules

This measure has been implemented by the RideLink program, as previously identified under TCM 8. (See www.ridelink.org/Employer_Services/Alternative_Schedules.asp) RideLink staff work with employers and employees to create programs for offering alternative work arrangements (such as flex time and teleworking) to reduce commute trips and peak hour traffic congestion.

TCM 14 – Programs and Ordinances Facilitating Non-Automotive Travel

This measure has been implemented in San Diego via the Regional Comprehensive Plan (RCP), adopted by SANDAG, which emphasizes greater reliance on non-automotive travel through increased development densities, more mass transit usage, and increased bicycling and walking for transportation. Pursuant to the RCP, SANDAG has designated existing and potential Smart Growth Areas, and provides funding incentives for local jurisdictions to increase densities and provide for mixed uses and additional transit, bicycling and walking facilities in these areas. The largest city in the region, the City of San Diego, is in the final stages of adopting a general plan revision consistent with this approach. Developers in the region have responded to these policies, and to market forces, by initiating a number of large-scale smart growth developments ultimately representing over

40,000 new housing units. Additionally, thousands of new units have been added to existing communities well-served by transit and amenable to non-motorized travel.

Additionally, in 2004, voters extended the region's half-cent sales tax ordinance for transportation ("TransNet"), and added additional funding categories, including the Smart Growth Incentive Program, and transit, bicycling, and pedestrian improvements. The ordinance requires routine accommodation of these modes for all TransNet-funded local roadway projects.

TCM 15 – Paths or Areas Encouraging Non-Motorized Travel

The San Diego region has implemented an extensive network of bicycling facilities, many of which also serve pedestrians. Additionally, three regional, multi-use trails are still under development—the Bayshore Bikeway (26 miles around the San Diego Bay), the Inland Rail Trail (22 miles from the Escondido Transit Center to the Oceanside Transit Center), and the Coastal Rail Trail (44 miles from northern Oceanside to downtown San Diego). These three trails are expected to be used by commuters as well as recreational users. Additionally, due to land use plans, regional transportation funding formulas, and the nature of the housing market, a number of new smart growth developments have been built which include paths and trails that encourage non-motorized travel (see TCM 14).

TCM 16 – Removal of Older, Higher-Polluting Light Duty Vehicles

Under a program administered by the District using Vehicle Registration Fee funds, a total of 4,277 older vehicles were permanently retired through 2005, resulting in an estimated reduction of 470 tons of ozone-precursor emissions. Further, a State-run vehicle retirement program continues, administered by the California Department of Consumer Affairs' Bureau of Automotive Repair (www.smogcheck.ca.gov/stdpage.asp?Body=/Consumer/cap_program.htm).

3.4.3.2 Emission Reduction Potential of Transportation Control Measures

Trip Reduction Ordinances alone (TCM 4) have been estimated to reduce on-road vehicle emissions by less than 2%.[9] That analysis also estimated that all other TCMs combined would not be more effective than Trip Reduction Ordinances (i.e., would not provide combined emission reductions exceeding 2%).

Consequently, it is assumed that the maximum emission reduction potential of implementing all unimplemented TCMs (TCMs 4, 7, and 12) would be 2% of on-road vehicle emissions. Projected on-road motor vehicle emissions in San Diego County in 2008 are 51 tons per day of VOC and 102 tons per day of NOx (see Table A-1 in Attachment A). Therefore, the maximum emissions reduction potential of implementing all unimplemented TCMs, assuming a 2% reduction in on-road emissions, is an estimated 1 ton per day reduction of VOC emissions and 2 tons per day reduction of NOx emissions.

3.4.4 RACM Analysis

To determine whether additional control measures could advance the attainment year, the additional emission reduction increment that would be necessary to advance the attainment year must be

---

[9] "Transportation Control Measures for the Air Quality Plan," San Diego Association of Governments, 1992.

estimated. The potential total emission reductions that could be provided by the additional control measures can then be compared to the necessary emission reduction increment to determine whether implementing the additional control measures could advance the attainment year.

Pollutant transport from the South Coast Air Basin contributes significantly to ozone exceedances in the San Diego nonattainment area (see Section 1.4.2). Due to the effects of the transport contribution, the emission reduction increment that would be necessary from sources within San Diego County to advance the attainment year will be greater (to compensate for transport emissions) than if ozone exceedances were caused solely by local emissions. Thus, for purposes of this RACM analysis, emissions contributing to San Diego's eight-hour ozone nonattainment are assumed to be the total of emissions from San Diego County and South Coast combined.

The increment of additional emission reductions that would be necessary in 2007 to advance the attainment year from 2008 to 2007 is the amount by which total contributing emissions projected for 2007 are greater than projected emissions for 2008 (preliminarily considered to be the earliest attainment year). For San Diego and South Coast combined, projected 2007 emissions are greater than 2008 emissions by 44 tons per day of VOC and 58 tons per day of NOx (see Table 3-8). Thus, 44 tons per day of additional VOC reductions and 58 tons per day of additional NOx reductions would be necessary in 2007 to advance the attainment year from 2008 to 2007.

As shown in Table 3-8, San Diego County-only emissions in 2007 are projected to be higher than 2008 by about 5 tons per day of VOC and 6 tons per day of NOx. Consequently, in the rarer circumstances where exceedances of the eight-hour ozone NAAQS are caused solely by local San Diego County emissions, 5 tons per day of additional VOC reductions and 6 tons per day of additional NOx reductions would be necessary in 2007 to advance the attainment year from 2008 to 2007.

TABLE 3-8
Projected Total Daily Emissions in 2007 versus 2008

	VOC Emissions (tons per day)			NOx Emissions (tons per day)		
Region*	2007	2008	Difference	2007	2008	Difference
SD plus SC	862	818	44	1090	1032	58
SD Only	173	168	5	201	195	6

*SD = San Diego Air Basin; SC = South Coast Air Basin
Source: ARB SIP emissions inventory.

Due to the long lead time required for rule or program development, adoption, and implementation, none of the control measures listed in Tables 3-6 (stationary source measures) and 3-7 (transportation source measures) could be implemented by the beginning of 2007. Consequently, none of those measures are considered "reasonably available" to advance the attainment year from 2008 to 2007. Furthermore, even if the measures in Tables 3-6 and 3-7 could be implemented in time, these measures would cumulatively provide less than 11 tons per day of VOC reductions and less than 4 tons per day of NOx reductions.[10] This is less than the additional emission reduction

---

[10] The indicated maximum emission reduction potential is derived by summing the reductions listed in Table 3-6 and the values presented in Section 3.4.3.2. The calculations are presented in Attachment E.

increments that would be necessary to advance the attainment year for both the San Diego-only and South Coast plus San Diego scenarios. Consequently, those measures would not be considered reasonably available and are not required to be included in the SIP.

Nevertheless, as discussed in Section 3.3, the District is currently planning to adopt the Low VOC Solvent Cleaning control measure, to be implemented in 2008, to satisfy State requirements for every feasible control measure and to assist in reducing ozone concentrations in 2008 to below the level of the eight-hour ozone NAAQS.

4.0 ATTAINMENT DEMONSTRATION

4.1 BACKGROUND

The Attainment Demonstration summarizes the results of photochemical air quality simulation modeling and supplemental Weight of Evidence analyses to demonstrate that the Emission Control Strategy (Section 3.0) to reduce ozone-precursor emissions is sufficient to provide for attainment of the eight-hour ozone NAAQS in San Diego County as expeditiously as practicable, pursuant to CAA requirements. The Attainment Demonstration was developed pursuant to EPA's *Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the eight-hour Ozone NAAQS* (October 2005).

Ozone formation in the atmosphere is a complex photochemical process, and sophisticated photochemical air quality simulation modeling is a valuable tool to help predict the amount of precursor emission reductions needed to provide for attainment of the eight-hour ozone NAAQS. The air quality model is computer-driven and simulates weather patterns, emissions, and photochemical processes in the atmosphere to predict future ozone levels in the region.

As with other predictive tools, photochemical air quality simulation modeling has inherent uncertainties and can not be expected to produce absolutely accurate results. Such models require detailed three-dimensional and time-varying inputs of emissions and meteorological data for the days being considered. Limitations in these inputs, as well as limitations in the model's formulations for simulating photochemical reactions, pollutant dispersion, and deposition lead to uncertainties in model predictions.[1]

To address the inherent modeling uncertainties, EPA Guidance established comprehensive procedures for demonstrating attainment of the eight-hour ozone NAAQS. These procedures differ in two major ways from past attainment demonstrations for the former one-hour ozone NAAQS.

1. The new Modeled Attainment Test is based on relative, rather than absolute, use of the modeling results. That is, the test relies on the ability of the photochemical modeling system to simulate the *change* in ozone due to emission reductions, rather than considering the modeling results to represent exact values for future-year ozone concentrations. Specifically, the model is run for both the 2002 baseline conditions and future 2008 scenario. The results of the baseline and future scenario model runs are compared to derive "Relative Response Factors," which predict the relative reduction in ozone concentrations between 2002 and 2008 resulting from control strategy implementation in the future year. The Relative Response Factors are then applied to monitored base-year (2002) design values to produce predicted future-year (2008) design values. The Modeled Attainment Test is "passed" if the predicted future-year design values at each site are below 85 parts per billion (ppb).[2] The future-year design value represents the fourth highest eight-hour average ozone concentration in the forecast attainment year.

---

[1] According to EPA's Guidance document, past modeling analyses have shown that future ozone design value uncertainties of 2 to 4 parts per billion can result from use of alternate, yet equally appropriate, emissions inputs, chemical mechanisms, and meteorological inputs.

[2] Equivalent to 0.085 parts per million. Eight-hour ozone levels are usually identified in terms of parts per million (ppm), as reflected in Sections 1 through 3. However, EPA guidance uses parts per billion (ppb) for purposes of discussing photochemical air quality simulation modeling. Accordingly, ozone concentrations are identified in ppb for purposes of this Section 4.0.

2. In recognition of the inherent uncertainties (described above) in the Modeled Attainment Test, the Attainment Demonstration must also include a Weight of Evidence Demonstration incorporating a variety of statistical and other analyses—such as monitored air quality and emissions trends and meteorological analyses—that provide additional persuasive support to a conclusion that the Control Strategy is sufficient to provide for timely attainment. Further, as specified in EPA Guidance, in areas where the Modeled Attainment Test is narrowly failed—that is, showing future-year design values above 85 but below 88 ppb—the Weight of Evidence Demonstration can be used to demonstrate timely attainment.

4.2 RESULTS

As discussed in detail below, the Modeled Attainment Test predicts a 2008 Design Value in San Diego County of 86 ppb, which narrowly exceeds the attainment threshold of less than 85 ppb, but is well within the allowable range (less than 88 ppb) for demonstrating expeditious attainment with supplemental Weight of Evidence analyses. Pursuant to EPA Guidance, this Attainment Demonstration incorporates a supplementary Weight of Evidence Demonstration. The resulting evidence indicates that the Emission Control Strategy is adequate to reduce ozone concentrations to below the level of the eight-hour ozone NAAQS by the statutory attainment deadline of June 15, 2009.

4.3 MODELED ATTAINMENT TEST

The Modeled Attainment Test predicts whether or not estimated ozone design values in the air basin in 2008 (the first full ozone season prior to the June 15, 2009, attainment deadline), under meteorological conditions similar to those simulated in the model, will be less than or equal to the concentration level specified in the ozone NAAQS. Specifically, if estimates of 2008 future-year ozone concentrations are predicted to be below 85 ppb, then the Modeled Attainment Test is satisfied.

The Modeled Attainment Test is site-specific and, therefore, must be performed for each monitoring site in the nonattainment area. In San Diego County, only the Alpine monitoring site violates the eight-hour ozone NAAQS. The Alpine monitoring site is located in the inland foothills at an elevation of approximately 2,000 feet. Other monitoring sites in the county have occasionally recorded exceedances of the eight-hour ozone NAAQS, but not frequently enough to violate the standard.

The 2002 baseline ozone design value used in the Modeled Attainment Test is the average of the design values for 2002 (based on 2000-2002 data), 2003 (2001-2003 data), and 2004 (2002-2004). EPA recommends averaging the three design values to smooth the impact of weather-related variability and provide a more representative air quality baseline. For the Alpine monitoring site, the 2002 baseline ozone design value equates to 92.3 ppb.

4.3.1 <u>Episodes</u>

The Modeled Attainment Test itself must also account for day-to-day variability of meteorology. Several different "episode" days, with representative high eight-hour ozone concentrations, must be modeled to incorporate a variety of meteorological conditions that are conducive to producing high ozone concentrations in the area. EPA Guidance recommends modeling ten or more episode days if possible, but at least five episode days must be modeled.

As discussed below, six days from two different episodes are reflected in the Modeled Attainment Test for this Attainment Demonstration. The selected episodes were drawn from the 1997 Southern California Ozone Study (SCOS97). SCOS97 was an intensive comprehensive air quality and meteorological data gathering effort, which involved supplemental monitoring sites for ozone and its precursors and meteorological parameters, as well as aircraft-based monitoring. The episodes were selected from the SCOS97 period because the richer database from SCOS97 provides the more detailed three-dimensional time-varying data needed for developing and evaluating adequate air quality simulation modeling applications.

San Diego County experienced a substantial drop in ozone exceedances in the year of the field study, 1997. Nevertheless, the District was able to derive two relatively high-ozone episodes from the SCOS97 database, as described below. These two episodes provide a sufficient number of episode days (six) for modeling purposes.

August 4-7, 1997 (Local Plus Transport), is an ozone episode where both local contributions and transport from the South Coast Air Basin (to the north) contributed to ozone exceedances in San Diego County. The highest eight-hour averaged ozone concentration measured at an EPA-approved official monitor was 87 ppb at Alpine on August 5.

September 27-28, 1997 (Weekend), is a weekend episode. Exceedances of the ozone standard on weekends are important in San Diego County. In 2006, 57% of the days with exceedances of the eight-hour ozone NAAQS were on Saturday or Sunday. Both local sources and transport contributed to the exceedances during this episode. Eight-hour average ozone levels did not reach 85 ppb at EPA-approved monitors during this episode. The highest eight-hour average ozone concentration at Alpine during this episode was 83 ppb on September 28.

Ramp-Up Days. Pursuant to EPA Guidance, additional “ramp-up” days (August 3, September 25-26) just prior to the selected episodes were included in the modeling to allow the modeling system to fully initialize and stabilize before simulating the episode days of concern. As specified by EPA, the modeled results for ramp-up days were excluded from the calculation of relative response factors.

EPA further recommends that the episode days have 2002 model-predicted concentrations of 85 ppb or more, although including episode days with lower concentrations of at least 70 ppb is acceptable. Due to 1997 being such a clean year, only three of the episode days have 2002 model-predicted concentrations greater than 85 ppb. However, all six episode days have 2002 model-predicted concentrations of at least 70 ppb.

Detailed documentation of the photochemical modeling performance evaluation and the 2002 base-year and 2008 attainment-year simulation modeling are presented in Attachment H. The modeling protocols are in Attachment I.

4.3.2 Model-Predicted 2008 Design Value

EPA Guidance specifies the following steps for calculating the Relative Response Factor.

1. Identify the model-predicted daily maximum eight-hour ozone concentration representing the monitoring site for each episode day for 2002 and 2008.
2. Calculate the average of the model-predicted eight-hour ozone concentrations over all the episode days for 2002 and 2008.
3. Calculate the 2002-to-2008 Relative Response Factor by dividing the 2008 averaged model-predicted eight-hour ozone concentration by the 2002 averaged model-predicted eight-hour ozone concentration.

The Model-Predicted 2008 Design Value is then calculated by multiplying the 2002-to-2008 Relative Response Factor by the actual monitored 2002 baseline design value, which is 92.3 ppb at the Alpine site. EPA Guidance specifies that the Model-Predicted 2008 Design Value is truncated to the whole ppb value prior to being compared to the eight-hour ozone NAAQS. Calculations of the Model-Predicted 2008 Design Value at the Alpine Monitoring Site are presented in Table 4-1.

TABLE 4-1
Calculation of Model-Predicted 2008 Design Value at Alpine Monitoring Site
(parts per billion)

Date	2002	2008	RRF*	Baseline	2008 Predicted
August 4	75.1	71.4	0.951	92.3	87
August 5	92.5	87.1	0.942	92.3	86
August 6	106.7	100.4	0.941	92.3	86
August 7	91.8	86.2	0.939	92.3	86
September 27	72.8	68.1	0.935	92.3	86
September 28	73.7	68.3	0.927	92.3	85
6-Day Average of Aug 4,5,6,7,Sep 27,28	85.4	80.3	0.940	92.3	**86**

*RRF = Relative Response Factor

The Modeled Attainment Test predicts a 2008 Design Value of 86 ppb, which is narrowly higher than the attainment threshold of below 85 ppb. However, due to inherent modeling uncertainties as described above, this Attainment Demonstration incorporates a supplementary Weight of Evidence Demonstration that persuasively demonstrates, based on a preponderance of all available evidence, that the Existing Control Strategy is sufficient to reduce ozone concentrations in the area to below the level of the eight-hour ozone NAAQS by the 2008 attainment year.

4.4 WEIGHT OF EVIDENCE DEMONSTRATION

Pursuant to EPA Guidance, a Weight of Evidence Demonstration includes a variety of statistical and other analyses that provide additional persuasive support to a conclusion that the Control Strategy is sufficient to provide for timely attainment. This Weight of Evidence Demonstration includes additional modeling results, statistical air quality trends analyses, graphical air quality trends analyses, and meteorological analyses of both a recent "clean year" (2004, with eight-hour ozone levels below the level of the NAAQS) and the unusually hot and high ozone season in 2006. Results of each analysis have been considered in concert, along with results of the Modeled Attainment Test, to determine that the Existing Control Strategy is sufficient to reduce ozone concentrations throughout the county to below the level of the eight-hour ozone NAAQS by 2008, thus providing a demonstration of attainment by the June 15, 2009, statutory deadline.

4.4.1 Weight-of-Evidence Analyses Involving Modeling Results

Pursuant to EPA Guidance, this Weight of Evidence Demonstration incorporates several analyses involving modeling results beyond those considered in the Modeled Attainment Test. The supplemental modeling analyses include:

1. Consideration of model-predicted future ozone concentrations in areas not near a monitor.
2. Modeled Ozone Exposure Reduction Metric.

4.4.1.1 Unmonitored Area Analysis

The Modeled Attainment Test is designed to focus on monitoring sites and thus does not consider future ozone concentrations in areas that are not near a monitor. To address this possible discrepancy, EPA Guidance recommends a procedure for predicting future ozone concentrations in areas that are not near a monitor. The focus of the recommended procedure is to identify areas where the model predicts ozone concentrations significantly higher than those predicted near a monitor.

As can be seen in Table 4-2, the maximum 2008 eight-hour ozone concentration predicted within San Diego County was near the Alpine monitoring site on four of the six episode days. On the other two episode days, the maximum 2008 eight-hour concentration in the county is only about 2 ppb greater than the concentration predicted for the Alpine monitoring site. Consequently, the modeling indicates that Alpine adequately represents the maximum eight-hour ozone concentrations predicted within San Diego County. Therefore, no additional analyses are needed to address areas away from a monitor.

TABLE 4-2
Comparison of Maximum Predicted 2008 Ozone Concentration in San Diego County to Concentration Predicted Near Alpine Monitoring Site
(parts per billion)

Episode Day	Countywide Maximum	Near Alpine Monitoring Site
August 4	73.7	71.4
August 5	88.6	87.1
August 6	100.4	100.4
August 7	86.2	86.2
September 27	68.1	68.1
September 28	68.3	68.3

4.4.1.2 Modeled Ozone Exposure Reduction Metric

EPA Guidance identifies various optional metrics that can be considered as part of a Weight of Evidence Demonstration. One such metric—percent change in total amount of ozone ≥ 85 ppb within the nonattainment area—addresses both the frequency and magnitude of eight-hour ozone nonattainment and was evaluated. This metric is defined as the change between 2002 and 2008 in the sum total (in ppb), over all grid cells[3] within the nonattainment area and for all hours of the episode days, of the amount by which the modeled ozone concentration in each grid cell exceeds 85 ppb. Three of the six episode days (August 4, September 27-28) modeled for San Diego County do not have 2002 base-year modeled ozone levels exceeding 85 ppb, and therefore a modified metric using a 70 ppb minimum threshold (in lieu of 85 ppb) was applied to assess the modeled reductions in unhealthful ozone exposure on those three episode days.[4]

The final EPA Guidance does not specify a minimum percent reduction in the metric to support a Weight of Evidence Demonstration of attainment. An early draft version of the Guidance (1999) indicates "[a]n 80% reduction in this measure may be regarded as an example of a 'large' reduction." Since the final EPA Guidance does not specify a suggested benchmark level, this Weight of Evidence Demonstration does not strictly rely on an 80% reduction level as a threshold for evaluating the modeling, but does indicate how many of the modeling days exceed an 80% reduction level.

As shown in Tables 4-3 and 4-4, more than 80% reduction in the ozone exposure metric was predicted on five of the six modeled episode days, with a greater than 50% reduction on the remaining day, reflecting substantial reductions in ozone exposure and supporting this Weight of Evidence demonstration.

---

[3] For modeling purposes, San Diego County was divided into 5-kilometer squares, called grid cells.

[4] 70 ppb is consistent with the minimum level for selecting episode days (see Section 4.3.1), and is also the level of the California State eight-hour ozone standard.

TABLE 4-3
Total Eight-Hour Averaged Ozone Above 85 ppb Aggregated Over All Grid Cells in San Diego County For the August 5-7 Ozone Episode Days

Date	2002 Simulation (ppb)	2008 Simulation (ppb)	Change in Metric (ppb)	Percent Change
August 5	2383	104	-2279	-96%
August 6	3698	1764	-1934	-52%
August 7	328	5	-323	-98%

TABLE 4-4
Total Eight-Hour Averaged Ozone Above 70 ppb Aggregated Over All Grid Cells in San Diego County For the August 4 and September 27-28 Ozone Episode Days

Date	2002 Simulation (ppb)	2008 Simulation (ppb)	Change in Metric (ppb)	Percent Change
August 4	1068	75	-993	-93%
Sept 27	65	0	-65	-100%
Sept 28	468	60	-408	-87%

4.4.2 Air Quality Trends Data

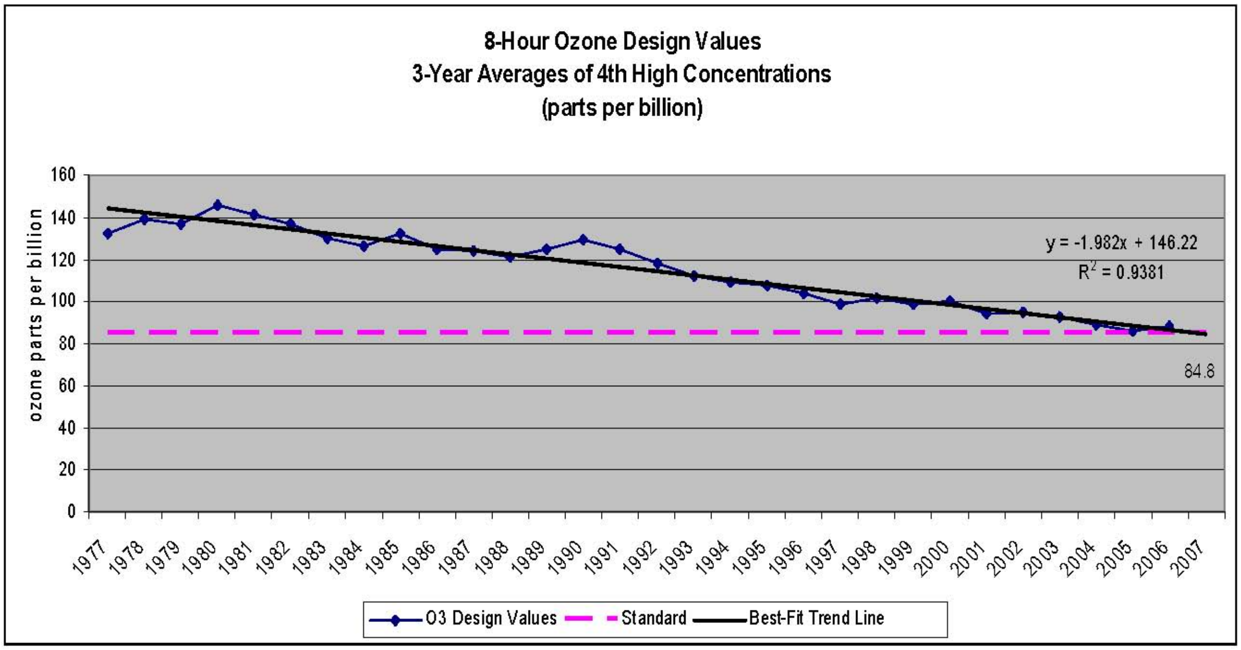
This element of the Weight of Evidence Demonstration includes five statistical analyses of Eight-Hour Ozone Design Values, which indicate ozone levels can be expected to be reduced to below 85 ppb by 2008. Numerous graphical analyses illustrating the continuing downward trends in ozone and precursor concentrations are also presented.

4.4.2.1 Eight-Hour Ozone Design Values Trends Statistical Analyses

The District performed several air quality trends statistical analyses of the monitored eight-hour ozone design values at the Alpine monitoring site (the only site at which violations of the eight-hour ozone NAAQS have been observed), using a variety of ozone data samples reflecting different groups of years. The best-fit trend line through each data sample was calculated, and the formula for that trend line was used to extrapolate the trend line to determine a projected attainment year based on that sample.

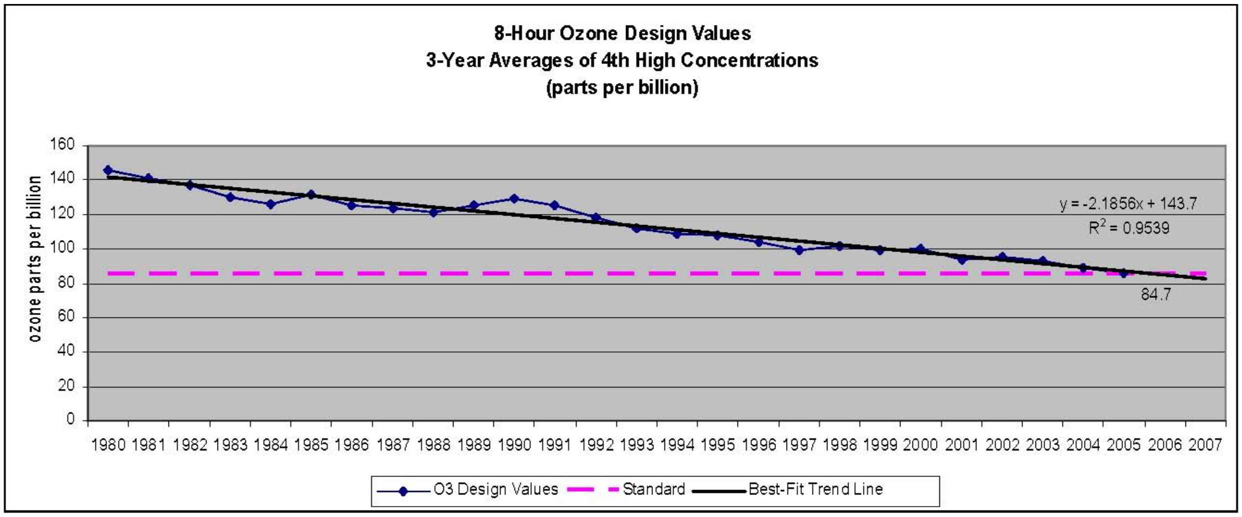
The first sample reflects all years in ARB's monitored air quality database, 1977-2006. (See Figure 4-1 below.) Based on this sample, attainment would be projected to occur in 2007 with an extrapolated ozone design value of 84.8 ppb.

FIGURE 4-1



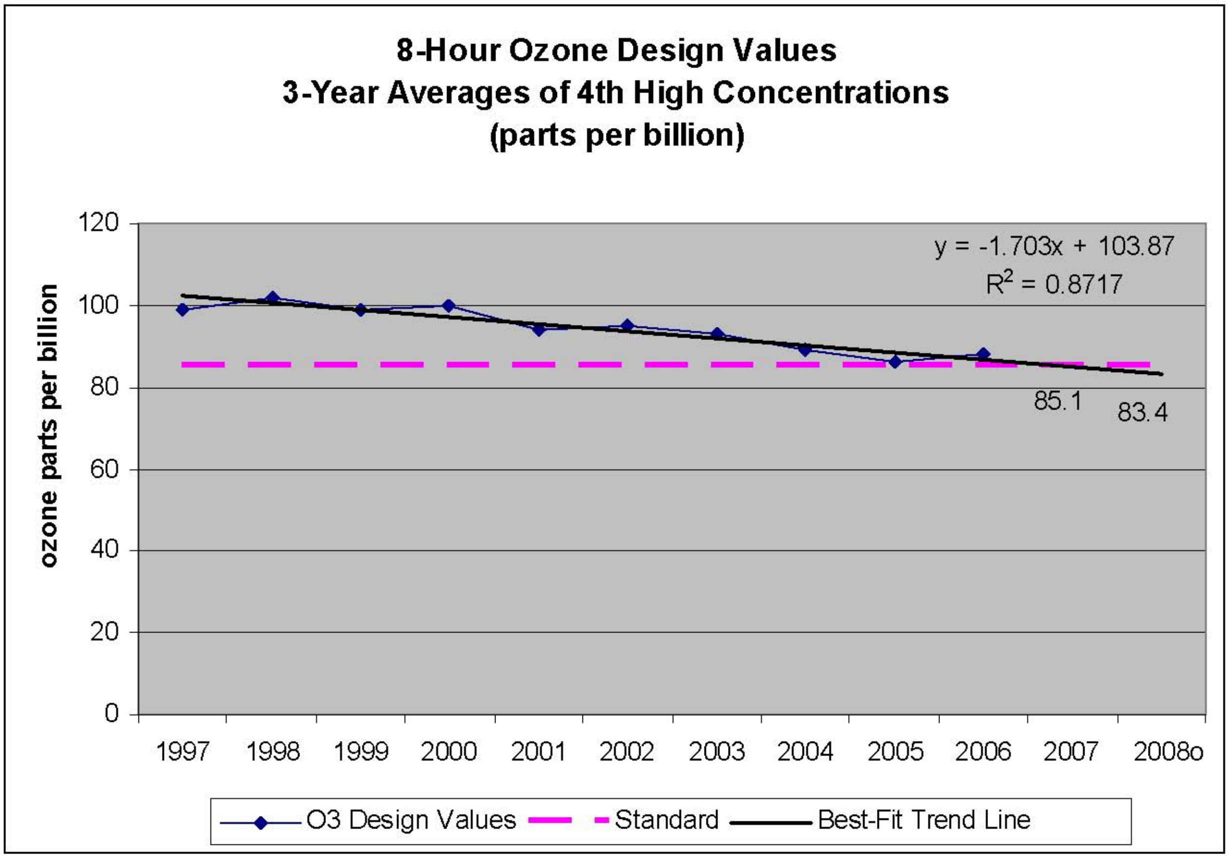
A more optimistic sample providing a slightly steeper trend line, starting with the 1980 peak and ending with the 2005 low value (Figure 4-2), projects attainment in 2006 with an extrapolated ozone design value of 84.7 ppb.

FIGURE 4-2



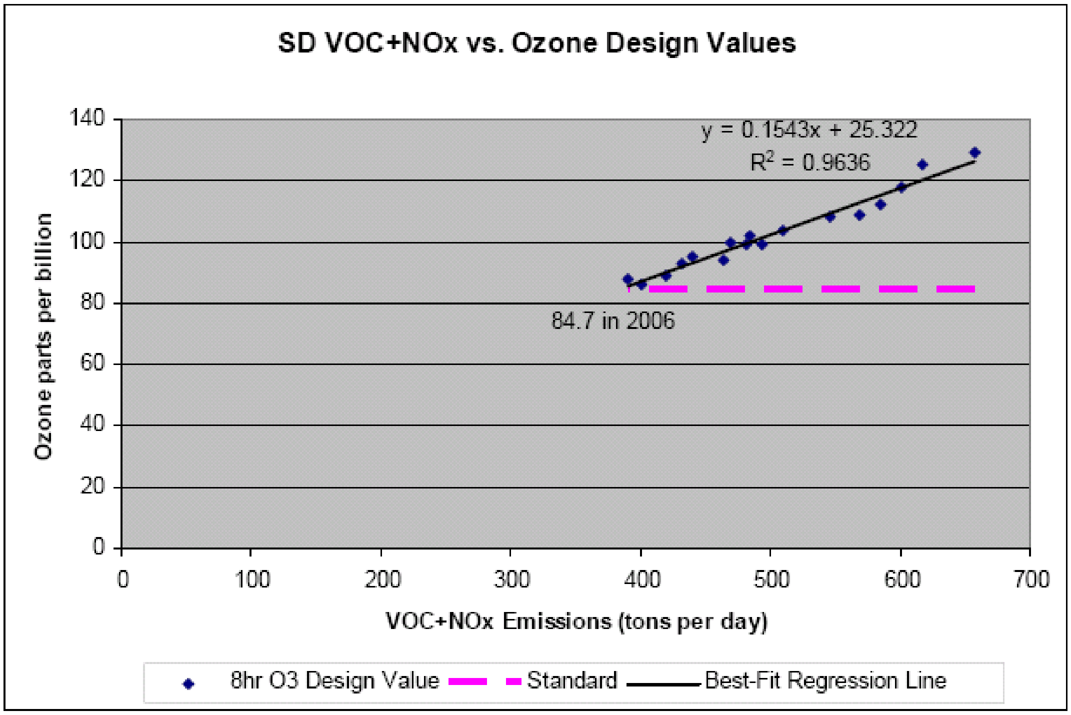
A more conservative sample providing a flatter trend line (Figure 4-3), starting in 1997 and ending in 2006, projects attainment in 2008 with an extrapolated ozone design value of 83.4 ppb.

FIGURE 4-3



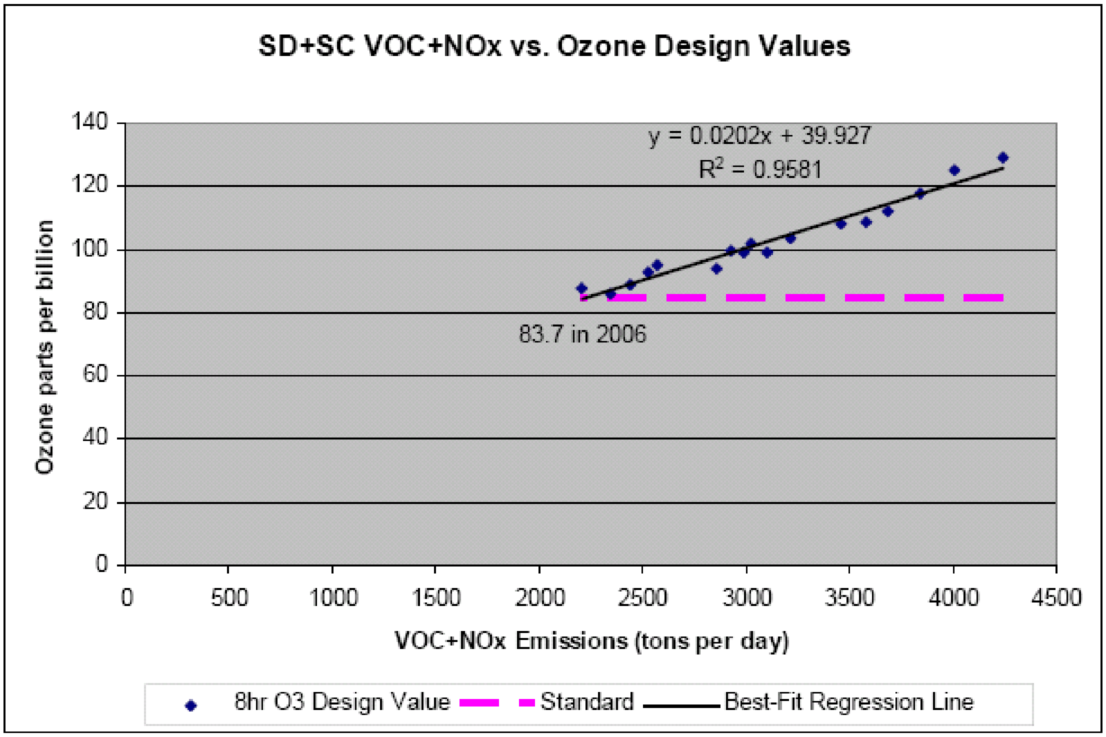
To obtain another perspective on ozone air quality trends, regression analyses were performed relating the eight-hour ozone design values to their associated ozone precursor emissions (VOC + NOx) for 1990 through 2006. Figures 4-4 and 4-5 illustrate that precursor emissions correlate highly with measured ozone design values. In Figure 4-4, considering precursor emissions from within San Diego County only, the best-fit regression line projects attainment in 2006 with a regression-projected ozone design value of 84.7 ppb.

FIGURE 4-4



Lastly, using the combined emissions from both the San Diego and upwind South Coast air districts (Figure 4-5) yields a similar but more optimistic result, with a regression-projected 2006 ozone design value of 83.7 ppb.

FIGURE 4-5



The high R^2 values (0.87 to 0.96) identified in Figures 4-1 through 4-5 indicate the data within each graph are well correlated and each air quality trend line has excellent predictive value. These statistical analyses provide strong evidence that the Existing Control Strategy will reduce ozone levels to below the level of the eight-hour ozone NAAQS by the 2008 attainment year.

4.4.2.2 Graphical Air Quality Trends Analyses

A discussion of 20 additional figures, providing a more in-depth review of long-term trends of monitoring data for ozone and ambient concentrations of ozone precursors, is presented in Attachment F.

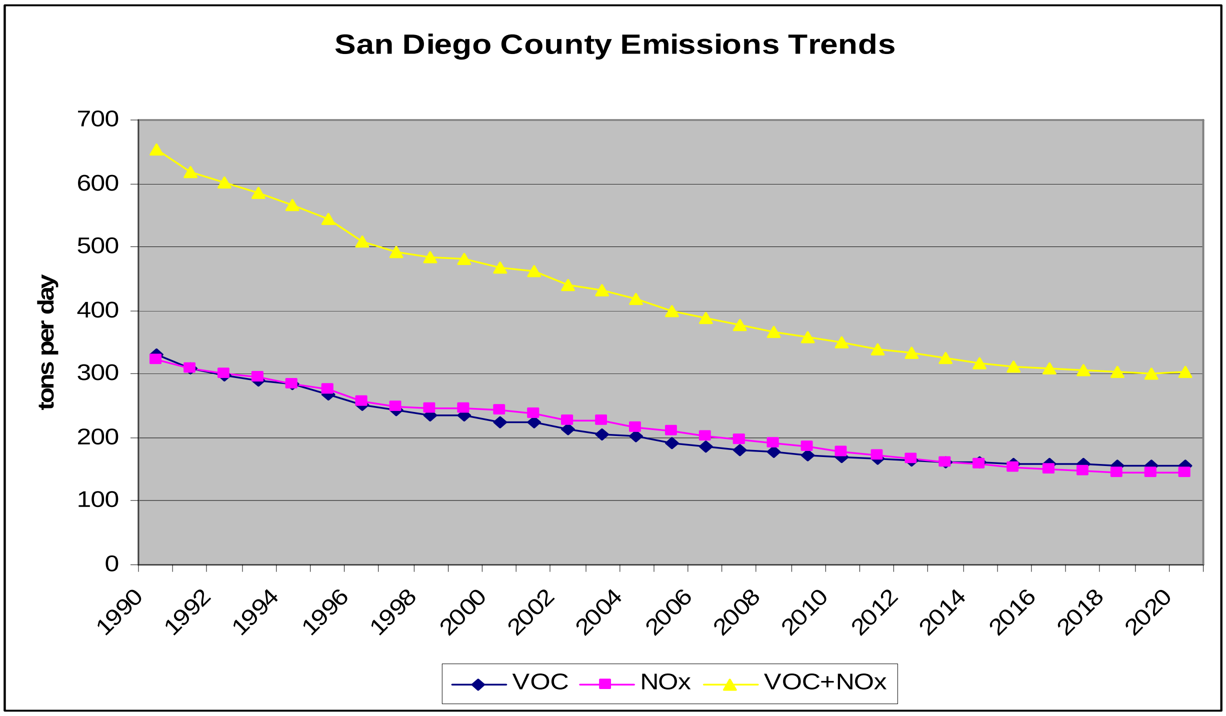
4.4.3. Meteorological Representativeness of Recent Years

In 2004, the Alpine monitor recorded only two exceedances of the eight-hour ozone NAAQS, and the fourth highest eight-hour concentration was 0.083 ppm, below the level of the standard. In 2005, the standard was exceeded five times and the fourth highest eight-hour concentration was 0.087 ppm, just slightly exceeding the level of the standard. However, due to a record-breaking heat wave, in 2006 the standard was exceeded 14 times and the fourth highest eight-hour concentration was 0.094 ppm. Attachment G presents a detailed meteorological analysis of those three years (2004, 2005, and 2006), and concludes that the "clean" year 2004 had typical meteorology similar to 2005, and thus could be expected to recur during the attainment period. Conversely, 2006 was quite anomalous and similar conditions are unlikely to recur in the near future.

4.4.4 Emission Trends

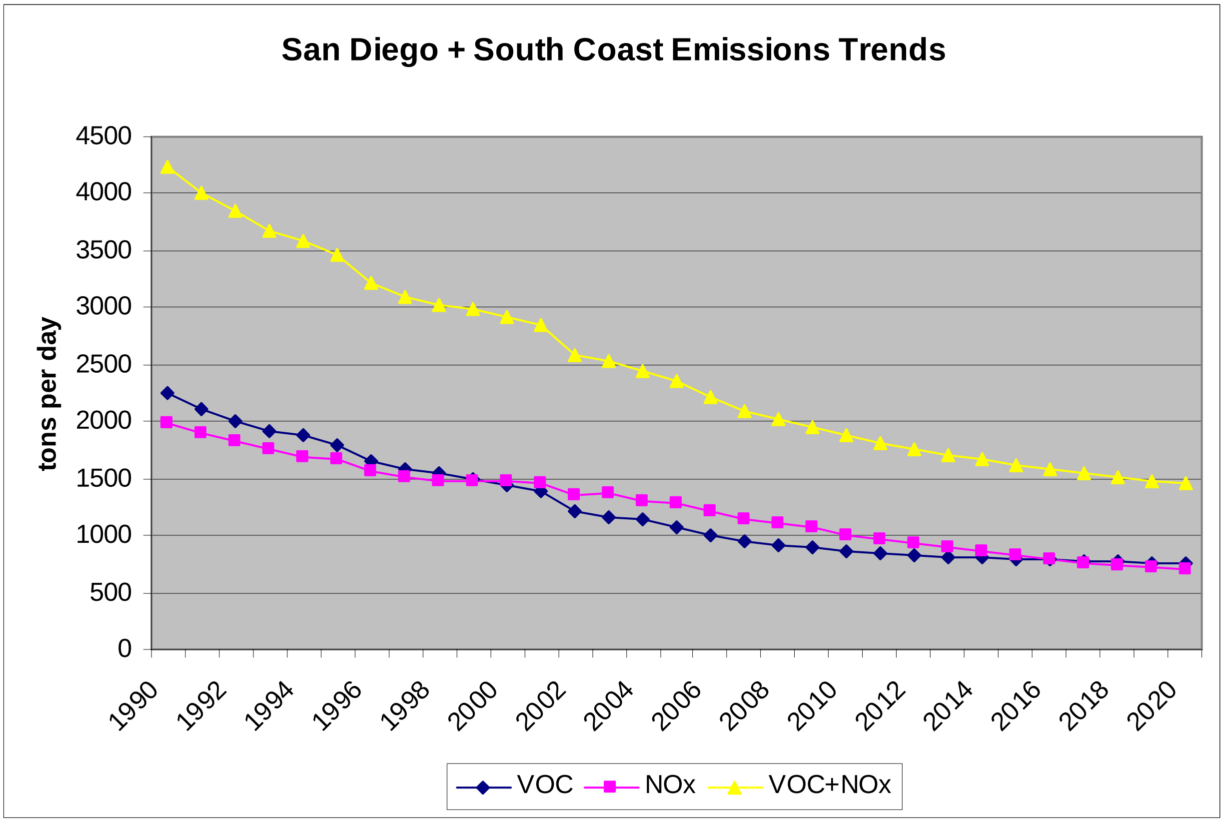
Ozone precursor emissions are projected to continuously reduce through 2020 due to existing, ongoing emission control regulations. Figure 4-6 presents San Diego County emission trends for the ozone precursors VOC plus NOx, based on currently adopted emission control regulations. Figure 4-7 presents combined emission trends for both San Diego County and the South Coast air districts to reflect all emissions contributing to San Diego County's ozone concentrations. These continuous improvement trends provide corroborative evidence of the adequacy of the Emission Control Strategy to provide for timely attainment (and maintenance) of the eight-hour ozone NAAQS in San Diego County.

Figure 4-6



Source: ARB SIP emissions inventory, Version 1.06.

Figure 4-7

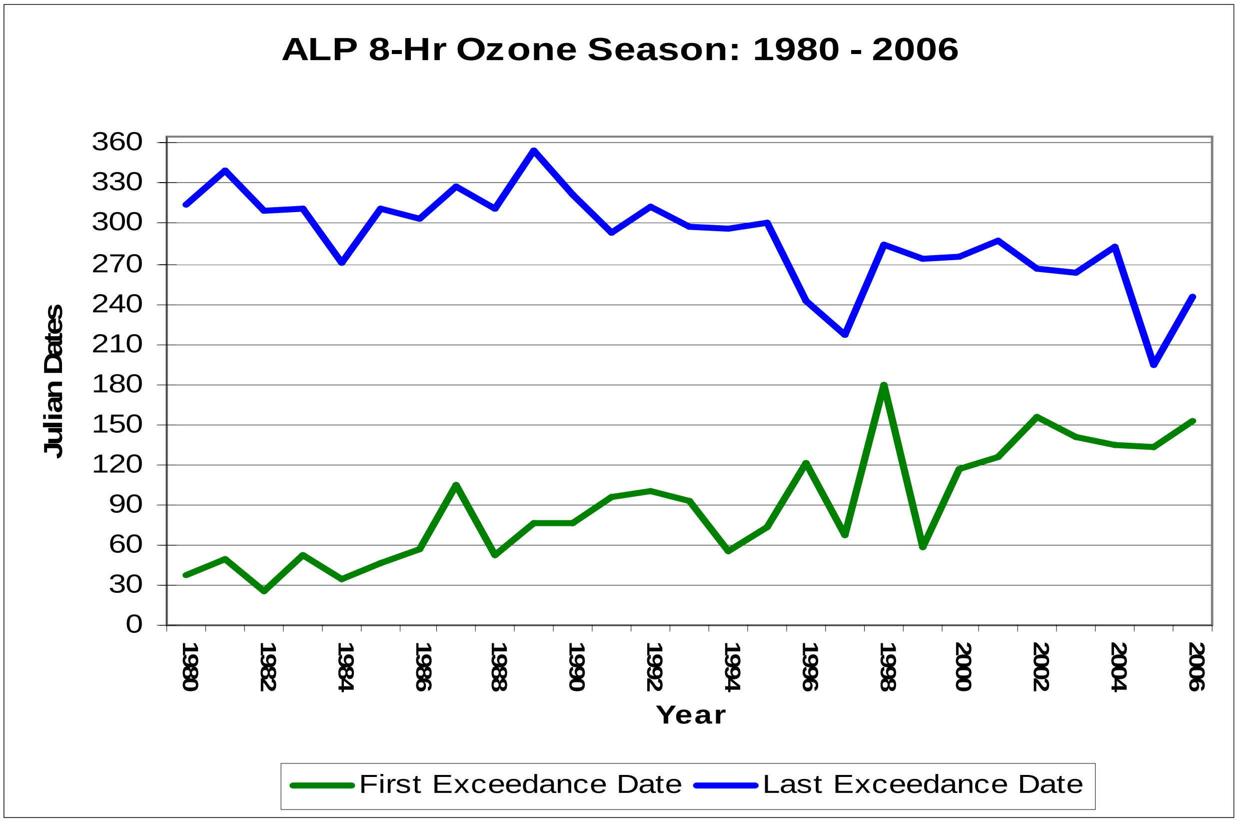


Source: ARB SIP emissions inventory, Version 1.06.

4.4.5 Shortened Ozone Season

EPA has identified San Diego County (and all of California) as having a 12-month ozone season, meaning that ozone levels at any time of year have been capable of exceeding the eight-hour ozone NAAQS. However, as presented in Figure 4-8, over the years the length of the ozone season (number of days) has been shortening, beginning later and ending earlier. Since 2001, there have been no exceedances of the eight-hour ozone NAAQS at the Alpine monitoring site before May or after October. The shortening of the ozone season provides additional positive evidence of the adequacy of the Emission Control Strategy to provide for timely attainment.

Figure 4-8



4.5 CONCLUSION

Pursuant to Clean Air Act requirements and EPA Guidance, the District has conducted numerous and diverse analyses—including the Modeled Attainment Test, the Unmonitored Area Analysis, and several analyses of air quality, emissions, and meteorological data—to judge whether timely attainment of the eight-hour ozone NAAQS in San Diego County is likely. The results of the Weight-of-Evidence analyses, on balance, provide persuasive support to a conclusion that the Existing Control Strategy is sufficient to reduce ozone concentrations throughout San Diego County to below the level of the eight-hour ozone NAAQS by the 2008 ozone season. Accordingly, attainment by the statutory deadline of June 15, 2009, has been demonstrated.

5.0 CONTINGENCY MEASURES

Contingency Measure requirements are not included by EPA in the Code of Federal Regulations, but are discussed in section IV.F. of the preamble of the *Final Rule to Implement the 8-Hour Ozone National Ambient Air Quality Standard.* Areas are required to adopt contingency measures to be implemented in the event of failure to meet a RFP milestone or to attain the eight-hour ozone NAAQS. It should be noted that the CAA requires States to identify contingency measures that will go into effect without further action on the part of the State or EPA.

Since existing mobile source control measures are projected to continue providing additional significant emission reductions for many years beyond the 2008 attainment date as newer vehicles enter the fleet, this Eight-Hour Ozone Attainment Plan relies on the continuing emission reductions from those existing mobile source control measures to fulfill the Contingency Measures requirement. These measures will continue to be implemented regardless of the air basin's attainment status in 2009.

As indicated in Table 5-1, existing mobile source control regulations will continue reducing San Diego County total VOC emissions between 2008 and 2012 by about 2% per year and NOx emissions by about 3% per year. Such continuing emission reductions are ample to ensure reasonable further progress will continue to be achieved in the event that the area would fail to attain the eight-hour ozone NAAQS by the attainment deadline.

TABLE 5-1
Projected VOC and NOx Emissions 2008-2012
(tons per day)

	VOC					NOx				
	2008	**2009**	**2010**	**2011**	**2012**	**2008**	**2009**	**2010**	**2011**	**2012**
Stationary Sources	31.7	32.2	32.8	33.3	33.9	10.4	10.5	11.0	11.0	11.0
Areawide Sources	36.3	36.6	36.9	37.2	37.6	1.8	1.8	1.8	1.8	1.8
Onroad Mobile Sources	51.1	47.9	44.9	42.5	40.2	96.8	92.0	87.0	81.5	75.6
Offroad Mobile Sources	48.5	46.9	45.6	44.3	43.2	85.8	84.3	82.7	82.1	81.4
Total	167.6	163.7	160.2	157.4	154.8	194.8	188.6	182.4	176.4	169.9
Reduction		4.0	3.4	2.8	2.6		6.1	6.2	6.0	6.6
Percent Reduction		2.4%	2.1%	1.8%	1.6%		3.1%	3.3%	3.3%	3.7%

Columns may not sum exactly to totals due to rounding.
Source: ARB SIP emissions inventory.

ATTACHMENT A
EMISSION INVENTORIES FOR 2002 AND 2008

Table A-1
Emission Inventory of Ozone Precursors in San Diego County
(tons per day)

	VOC	VOC	NOx	NOx
SOURCE CATEGORY	**2002**	**2008**	**2002**	**2008**
Electric Utilities	0.43	0.70	2.42	3.58
Cogeneration	1.75	1.84	2.70	2.83
Manufacturing And Industrial	0.07	0.07	1.05	1.11
Food And Agricultural Processing	0.02	0.01	0.12	0.10
Service And Commercial	0.16	0.17	0.99	1.01
Other (Fuel Combustion)	0.18	0.14	1.44	1.25
Sewage Treatment	0.04	0.05	0.06	0.07
Landfills	1.66	1.83	0.17	0.19
Incinerators	0.00	0.00	0.00	0.00
Soil Remediation	0.00	0.00	0.00	0.00
Other (Waste Disposal)	0.23	0.25	0.00	0.00
Laundering	0.07	0.09	0.00	0.00
Degreasing	1.64	1.72	0.00	0.00
Coatings And Related Process Solvents	6.20	6.97	0.00	0.00
Printing	3.76	4.08	0.00	0.00
Adhesives And Sealants	3.06	2.64	0.00	0.00
Other (Cleaning And Surface Coatings)	0.10	0.11	0.00	0.00
Petroleum Marketing	8.07	8.50	0.01	0.01
Other (Petroleum Production And Marketing)	0.00	0.00	0.00	0.00
Chemical	1.32	1.61	0.00	0.00
Food And Agriculture	0.09	0.09	0.00	0.00
Mineral Processes	0.14	0.17	0.13	0.15
Metal Processes	0.00	0.00	0.00	0.00
Electronics	0.00	0.00	0.00	0.00
Other (Industrial Processes)	0.56	0.66	0.08	0.08
Stationary Subtotal	**29.56**	**31.70**	**9.19**	**10.38**
Consumer Products	21.94	19.12	0.00	0.00
Architectural Coatings And Related Process Solvents	11.98	10.54	0.00	0.00
Pesticides/Fertilizers	1.17	0.85	0.00	0.00
Asphalt Paving / Roofing	1.78	1.81	0.00	0.00
Residential Fuel Combustion	0.32	0.33	1.64	1.70
Farming Operations	1.37	1.37	0.00	0.00
Fires	0.05	0.05	0.02	0.02
Managed Burning And Disposal	0.28	0.26	0.09	0.08
Cooking	1.82	2.00	0.00	0.00
Areawide Subtotal	**40.71**	**36.34**	**1.75**	**1.80**

Table A-1 (continued)
Emission Inventory of Ozone Precursors in San Diego County
(tons per day)

SOURCE CATEGORY	VOC 2002	VOC 2008	NOx 2002	NOx 2008
Light Duty Passenger	37.93	21.43	33.41	18.17
Light Duty Trucks - 1	6.70	4.18	7.15	4.14
Light Duty Trucks - 2	13.81	9.54	24.44	14.45
Medium Duty Trucks	5.86	4.19	10.91	7.35
Light Heavy Duty Gas Trucks - 1	4.03	2.50	4.14	3.20
Light Heavy Duty Gas Trucks - 2	0.60	0.45	0.56	0.54
Medium Heavy Duty Gas Trucks	1.38	0.85	1.37	1.12
Heavy Heavy Duty Gas Trucks	0.66	0.46	1.62	1.19
Light Heavy Duty Diesel Trucks - 1	0.01	0.10	0.11	2.54
Light Heavy Duty Diesel Trucks - 2	0.06	0.08	1.27	1.62
Medium Heavy Duty Diesel Trucks	0.22	0.27	11.58	10.92
Heavy Heavy Duty Diesel Trucks	2.15	1.96	27.45	25.01
Motorcycles	2.97	4.41	0.61	1.16
Heavy Duty Diesel Urban Buses	0.09	0.09	2.31	2.09
Heavy Duty Gas Urban Buses	0.04	0.04	0.06	0.07
School Buses	0.11	0.10	1.16	1.23
Other Buses	0.18	0.14	0.95	0.85
Motor Homes	0.56	0.31	1.49	1.10
Onroad Subtotal	**77.35**	**51.10**	**130.60**	**96.77**
Aircraft	3.19	3.24	5.01	5.54
Trains	0.07	0.08	1.38	1.26
Ships And Commercial Boats	1.94	1.82	29.34	31.52
Recreational Boats	19.16	17.89	4.80	6.79
Off-Road Recreational Vehicles	2.45	3.02	0.08	0.07
Off-Road Equipment	21.09	18.65	44.51	36.64
Farm Equipment	1.09	0.83	5.32	3.98
Fuel Storage And Handling	4.52	2.96	0.00	0.00
Offroad Subtotal	**53.51**	**48.49**	**90.44**	**85.81**
Pre-Baseline Emission Reduction Credits Subtotal		**0.63**		**0.22**
Military Growth Increment				**2.33**
TOTAL	**201.13**	**168.25**	**231.96**	**197.30**

Source: ARB SIP emissions inventory.

Table A-2
Emission Inventory of Ozone Precursors in San Diego County and South Coast Air Basin Combined
(tons per day)

	VOC	VOC	NOx	NOx
SOURCE CATEGORY	**2002**	**2008**	**2002**	**2008**
Electric Utilities	2.18	2.41	7.54	11.41
Cogeneration	1.88	1.96	3.28	3.31
Oil And Gas Production (Combustion)	0.24	0.24	1.23	0.79
Petroleum Refining (Combustion)	1.31	1.31	7.07	6.11
Manufacturing And Industrial	1.76	1.96	18.44	17.18
Food And Agricultural Processing	0.18	0.11	2.03	1.08
Service And Commercial	1.47	1.57	18.31	16.35
Other (Fuel Combustion)	1.06	0.82	9.46	7.61
Sewage Treatment	0.34	0.38	0.06	0.07
Landfills	1.75	1.93	0.80	0.86
Incinerators	0.09	0.10	1.53	1.63
Soil Remediation	0.00	0.00	0.00	0.00
Other (Waste Disposal)	7.38	7.35	0.00	0.00
Laundering	0.25	0.28	0.00	0.00
Degreasing	21.18	10.72	0.00	0.00
Coatings And Related Process Solvents	35.02	30.16	0.06	0.07
Printing	10.05	8.64	0.00	0.00
Adhesives And Sealants	6.51	6.25	0.00	0.00
Other (Cleaning And Surface Coatings)	1.49	0.79	0.14	0.17
Oil And Gas Production	2.50	0.85	0.05	0.33
Petroleum Refining	4.69	3.75	4.86	4.52
Petroleum Marketing	35.88	35.55	0.06	0.03
Other (Petroleum Production And Marketing)	0.01	0.01	0.00	0.00
Chemical	13.74	12.44	0.09	0.09
Food And Agriculture	2.86	2.93	0.00	0.01
Mineral Processes	0.52	0.55	1.34	0.93
Metal Processes	0.06	0.06	0.36	0.18
Wood And Paper	0.10	0.10	0.00	0.00
Glass And Related Products	0.01	0.01	0.03	0.01
Electronics	0.06	0.09	0.00	0.00
Other (Industrial Processes)	8.38	8.69	0.79	0.92
Stationary Subtotal	**162.96**	**142.04**	**77.57**	**73.68**
Consumer Products	132.34	116.67	0.00	0.00
Architectural Coatings And Related Process Solvents	69.28	37.25	0.00	0.00
Pesticides/Fertilizers	4.05	3.05	0.00	0.00
Asphalt Paving / Roofing	2.67	2.90	0.00	0.00
Residential Fuel Combustion	1.79	1.84	22.11	19.72
Farming Operations	11.24	7.01	0.00	0.00
Fires	0.28	0.29	0.09	0.09
Managed Burning And Disposal	0.53	0.51	0.20	0.19
Cooking	3.61	3.94	0.00	0.00
Areawide Subtotal	**225.80**	**173.46**	**22.40**	**20.00**

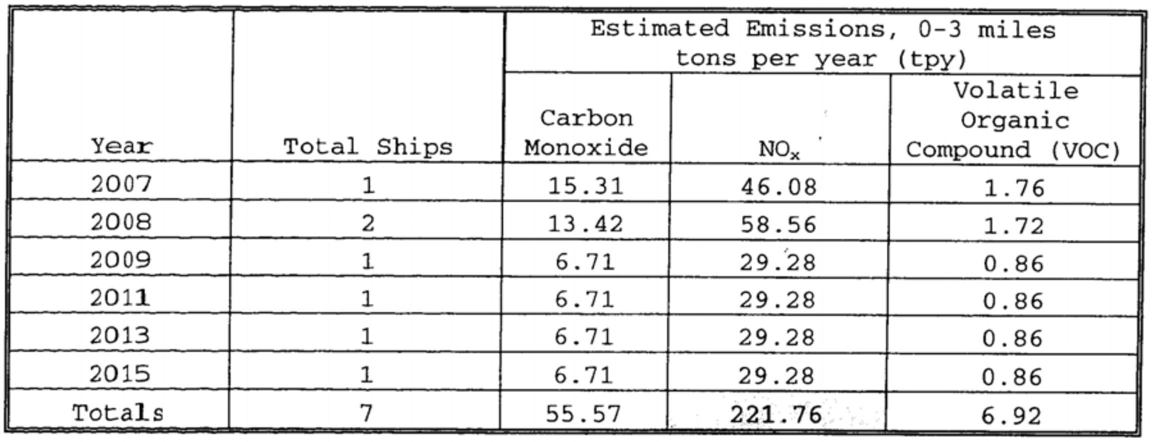
Table A-2 (continued)
Emission Inventory of Ozone Precursors in San Diego County and South Coast Air Basin Combined
(tons per day)

	VOC	VOC	NOx	NOx
SOURCE CATEGORY	**2002**	**2008**	**2002**	**2008**
Light Duty Passenger	216.68	110.71	173.63	84.02
Light Duty Trucks - 1	36.98	21.49	34.80	18.64
Light Duty Trucks - 2	74.25	48.79	118.13	66.97
Medium Duty Trucks	36.72	25.05	60.22	38.38
Light Heavy Duty Gas Trucks - 1	22.51	12.37	29.96	18.61
Light Heavy Duty Gas Trucks - 2	3.49	2.27	4.42	3.49
Medium Heavy Duty Gas Trucks	8.91	4.55	8.98	6.18
Heavy Heavy Duty Gas Trucks	5.00	3.20	10.71	7.29
Light Heavy Duty Diesel Trucks - 1	0.02	0.30	0.75	11.71
Light Heavy Duty Diesel Trucks - 2	0.25	0.28	9.66	9.25
Medium Heavy Duty Diesel Trucks	1.35	1.28	82.44	62.81
Heavy Heavy Duty Diesel Trucks	14.71	13.46	174.68	152.12
Motorcycles	12.57	17.28	2.27	4.23
Heavy Duty Diesel Urban Buses	0.53	0.48	15.14	13.10
Heavy Duty Gas Urban Buses	0.59	0.54	0.95	0.84
School Buses	0.46	0.39	5.38	5.35
Other Buses	0.82	0.61	4.50	4.16
Motor Homes	1.82	1.00	5.29	3.99
Onroad Subtotal	**437.64**	**264.04**	**741.89**	**511.13**
Aircraft	9.61	11.41	18.28	23.02
Trains	2.58	2.55	39.29	30.21
Ships And Commercial Boats	5.54	5.44	93.11	108.04
Recreational Boats	87.05	78.51	16.41	23.75
Off-Road Recreational Vehicles	9.83	11.98	0.30	0.24
Off-Road Equipment	127.08	107.71	285.41	229.89
Farm Equipment	3.25	2.52	15.75	12.09
Fuel Storage And Handling	27.96	18.30	0.00	0.00
Offroad Subtotal	**272.89**	**238.42**	**468.56**	**427.26**
Pre-Baseline Emission Reduction Credits Subtotal		**0.63**		**0.22**
Military Growth Increment				**2.33**
TOTAL	**1099.29**	**817.96**	**1310.41**	**1032.07**

Source: ARB SIP emissions inventory.

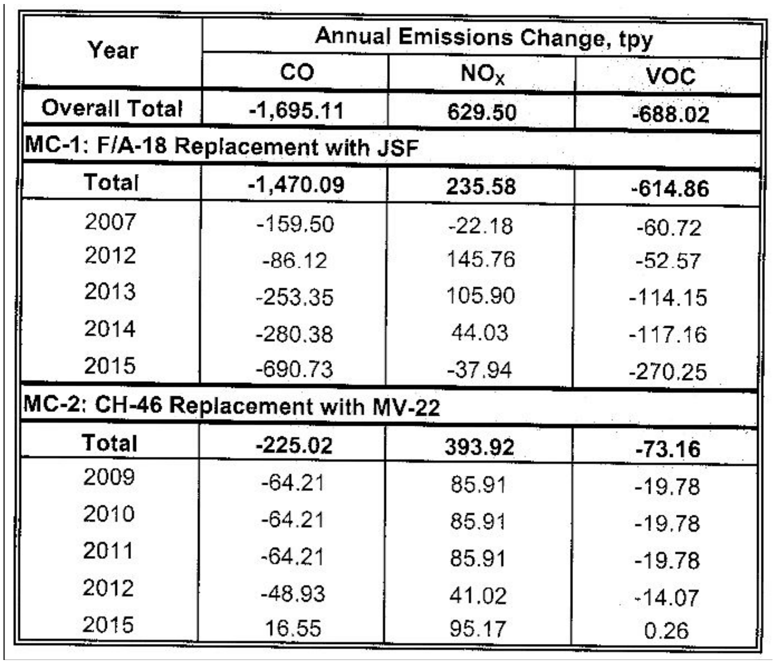
ATTACHMENT B
PLANNED MILITARY PROJECTS SUBJECT TO GENERAL CONFORMITY

Table 1. Projected Emissions and Preliminary Schedule for Placement of Littoral Combat Ships



Year	Total Ships	Estimated Emissions, 0-3 miles tons per year (tpy)		
		Carbon Monoxide	NO_x	Volatile Organic Compound (VOC)
2007	1	15.31	46.08	1.76
2008	2	13.42	58.56	1.72
2009	1	6.71	29.28	0.86
2011	1	6.71	29.28	0.86
2013	1	6.71	29.28	0.86
2015	1	6.71	29.28	0.86
Totals	7	55.57	221.76	6.92

Table 2. Projected Emissions and Preliminary Schedule for Marine Corps Projects through 2015



Year	Annual Emissions Change, tpy		
	CO	NO_x	VOC
Overall Total	**-1,695.11**	**629.50**	**-688.02**
MC-1: F/A-18 Replacement with JSF			
Total	**-1,470.09**	**235.58**	**-614.86**
2007	-159.50	-22.18	-60.72
2012	-86.12	145.76	-52.57
2013	-253.35	105.90	-114.15
2014	-280.38	44.03	-117.16
2015	-690.73	-37.94	-270.25
MC-2: CH-46 Replacement with MV-22			
Total	**-225.02**	**393.92**	**-73.16**
2009	-64.21	85.91	-19.78
2010	-64.21	85.91	-19.78
2011	-64.21	85.91	-19.78
2012	-48.93	41.02	-14.07
2015	16.55	95.17	0.26

Source: Letters to Air Pollution Control District from the Department of the Navy and from the Marine Corps, dated January 4 and January 5, 2007, respectively.

ATTACHMENT C
PRE-BASELINE BANKED EMISSION CREDITS

Table C-1
San Diego APCD ERC Banking Registry Summary
Emission Reduction Credits Issued in 2002 and Earlier

	Certificate	NOx	VOC	Cumulative	Totals
Company Name	**Number**	**(TPY)**	**(TPY)**	**NOx**	**VOC**
Carpenter Special Products Corporation	973125-01		7.2	0.00	7.20
Caspian, Inc.	890712-07		16.90	0.00	24.10
City of San Diego, Metropolitan Wastewater Dept.	950766-06		0.38	0.00	24.48
	970821-02		22.76	0.00	47.24
General Dynamics Properties, Inc.	970809-02	1.26		1.26	47.24
	970809-05		0.23	1.26	47.47
Hughes-Aircraft Co., Electro-Opti Cal Systems	940261-01		1.06	1.26	48.53
	940261-02		0.22	1.26	48.75
Muht-Hei, Inc.	981002-01		0.18	1.26	48.93
	981002-02		0.18	1.26	49.11
	981002-03		0.18	1.26	49.29
	981002-04		0.18	1.26	49.47
	981002-05		0.57	1.26	50.04
	981002-06		0.19	1.26	50.23
	981002-07		2.23	1.26	52.46
	981002-08		1.28	1.26	53.74
	981002-09		0.18	1.26	53.92
	981002-10		2.07	1.26	55.99
	981002-11		1.28	1.26	57.27
	981002-12		0.57	1.26	57.84
National Steel & Shipbuilding	40995-02	0.18		1.44	57.84
	40995-03		0.60	1.44	58.44
	40996-02	0.04		1.48	58.44
	40997-02	0.32		1.80	58.44
	40997-03		0.02	1.80	58.46
Naval Air Station, North Island	991014-01	8.00		9.80	58.46
	991015-01	3.30		13.10	58.46
	991016-01	18.70		31.80	58.46
Naval Station, San Diego	950949-01	4.83		36.63	58.46
	940206-01	0.67		37.30	58.46
	940206-03		0.05	37.30	58.51
Navy Region Southwest	990223-01	12.02		49.32	58.51
Northrop-Grumman Ryan Aeronautical Center	975000-01		1.20	49.32	59.71
Otay Mesa Generating Co., LLC	990902-01	1.21		50.53	59.71
	991123-01		17.05	50.53	76.76
	000128-01		25.00	50.53	101.76
	000427-01	1.30		51.83	101.76
	000427-02		30.10	51.83	131.86
	000918-01		10.30	51.83	142.16
	000224-01	4.40		56.23	142.16
	010629-01	0.32		56.55	142.16
	010629-02	2.39		58.94	142.16

Table C-1 continued
San Diego APCD ERC Banking Registry Summary
Emission Reduction Credits Issued in 2002 and Earlier

	Certificate	NOx	VOC	Cumulative	Totals
Company Name	**Number**	**(TPY)**	**(TPY)**	**NOx**	**VOC**
PGET	020906-01		20.70	58.94	162.86
Rohr, Inc., a subsidiary of BFGoodrich Co.	972754-01		5.30	58.94	168.16
Sempra Energy Resources	020620-02		0.40	58.94	168.56
Solar Turbines	970123-04	10.00		68.94	168.56
	950562-01		0.60	68.94	169.16
Sony Electronics, Inc.	940652-01		0.54	68.94	169.70
	977590-01		2.90	68.94	172.60
Sony Electronics, Inc.	977589-08		0.30	68.94	172.90
	977589-09	2.20		71.14	172.90
	977589-02	1.90		73.04	172.90
	977589-04		0.10	73.04	173.00
Southern California Edison Company	950171-01	0.51		73.55	173.00
	950171-03		0.02	73.55	173.02
Surface Technologies	990325-01		1.48	73.55	174.50
United States Marine Corps	030507-01	3.00		76.55	174.50
US Foam	974375-03		0.10	76.55	174.60
SW Division, Naval Facilities Engineering Cmd.	954185-01		2.00	76.55	176.60
	960709-01		9.00	76.55	185.60
	970311-01		13.00	76.55	198.60
	980511-03		3.15	76.55	201.75
	980521-02		13.25	76.55	215.00
	980529-02		7.40	76.55	222.40
Unisys Corporation	901238-01		3.66	76.55	226.06
	921410-01		1.25	76.55	227.31
	940577-01		2.95	76.55	230.26
USN Communications Station	940560-01	2.40		78.95	230.26
	940560-04		0.05	78.95	230.31
	940561-01	0.12		79.07	230.31
	940561-03		0.00	79.07	230.31
	940562-01	0.12		79.19	230.31
	940562-03		0.00	79.19	230.31
TOTALS (tons/year) =				**79.19**	**230.31**

ATTACHMENT D
ANALYSES OF POTENTIAL ADDITIONAL STATIONARY SOURCE CONTROL MEASURES

D.1 Low VOC Solvent Cleaning

Existing Rule 67.6 (Solvent Cleaning Operations) addresses VOC emissions generated by the application of solvents (held in a tank or reservoir) to remove unwanted materials, such as dirt and oils, from a surface. SCAQMD Rule 1122 is more stringent and contains the following requirements that are not in District Rule 67.6:

- Solvent VOC limit of 25 grams per liter for cold cleaners, including remote reservoirs and open-top dip tanks; or airless or air-tight cleaning systems for cold cleaners using high-VOC solvents;
- freeboard ratio of 0.75 for all open-top dip tanks;
- requirement for a superheated vapor system or secondary freeboard chiller for open-top vapor degreasers;
- freeboard ratio of 1.0 for all open-top vapor degreasers; and
- automated parts handler.

Several other air districts have adopted and implemented similar control measures, but with a VOC content limit of 50 grams per liter. These and other potential control requirements were evaluated to determine their technological feasibility, potential VOC reductions, and cost-effectiveness for San Diego County sources.

The cost-effectiveness of water-based or low-VOC cleaning systems is primarily affected by the VOC emission rate of the unit being replaced and the increased electricity needed to heat and pump aqueous solvents in the new replacement unit. Over 86% of the approximately 5,100 degreasing units in San Diego are small remote reservoirs with VOC emissions of less than 0.324 pounds per day, or 118 pounds per year, each. The lowest and average cost-effectiveness values calculated for these units were $4.36 and $5.26, respectively, per pound of VOC reduced.

The Low VOC Solvent Cleaning control measure has taken longer to develop than other control measures. Rule 67.6, which was initially adopted in 1979, needed to be substantially rewritten and was split into two rules, one addressing cold solvent cleaners and the other addressing vapor degreasers. Most importantly, due to the large number of small businesses affected by the rule, the public input process for this rule development needed to be extensive. The new replacement Rules 67.6.1 (Cold Solvent Cleaning and Stripping Operations) and 67.6.2 (Vapor Degreasing Operations), are being adopted simultaneously with this 8-Hour Ozone Attainment Plan.

New Rule 67.6.1 will require that each solvent utilized in a cold solvent cleaning operation must have a VOC content of 50 grams per liter of material or less, in addition to other requirements. New Rule 67.6.2 will apply to vapor degreasing operations, and the requirements are generally identical to those in current Rule 67.6, because more stringent requirements on vapor degreasers would have only negligible emissions reductions. When new Rule 67.6.1 is implemented in 2008, San Diego County cold solvent cleaning VOC emissions are projected to be reduced by about 1 ton per day, relative to the 2002 baseline. Although these emissions reductions are not available in time to advance the attainment year to 2007, they will assist in reducing ozone concentrations in 2008 to the level of the national 8-hour ozone standard.

D.2 Further Control of Architectural Coatings

Following the District adoption of the existing version of the Architectural Coatings Rule 67.0 (discussed in Section 3.2.2), the South Coast Air Quality Management District (SCAQMD) amended its Rule 1113 in 2006 to further tighten VOC content limits for Architectural Coatings in years 2007 and 2008. Adopting similar limits in San Diego County could potentially reduce VOC emissions from Architectural Coatings by an estimated 50% or approximately 5 tons per day, based on very preliminary ARB estimates.

ARB is updating its estimates of Architectural Coatings emissions based on a new 2005 survey of architectural coating products sold in California during 2004. Further, ARB is developing a statewide Suggested Control Measure (SCM)[1] that will be similar, but not necessarily identical, to SCAQMD Rule 1113. ARB intends to adopt the Architectural Coatings SCM in September 2007, with local rule adoption and compliance anticipated in 2009. Consequently, the anticipated additional emission reductions are not available in time to advance San Diego County's eight-hour ozone attainment year to 2007.

D.3 Automotive Refinishing

This source category is regulated by District Rule 67.20 (Motor Vehicle and Mobile Equipment Refinishing Operations). Total VOC emissions from the more than 400 facilities in this source category are an estimated 275 tons per year, based on the 1996 rule development emission inventory and projected emission reductions from rule adoption.

ARB adopted an SCM for Automotive Coatings on October 20, 2005. This measure has more stringent future VOC limits in several coating categories than Rule 67.20. These more stringent limits will likely result in the use of waterborne coatings for many topcoats, which have additional equipment surface preparation and application requirements compared to existing solvent-borne topcoats used in this industry, which is comprised mostly of small businesses.

This SCM has since been adopted by at least two California air districts. If adopted by the District, this control measure could potentially result in an estimated VOC emission reduction of an 0.6 ton per day. However, based on evaluation of the future availability of compliant coatings in California as a whole, and considering the equipment upgrades and training necessary to use these compliant coatings, the recommended compliance date in the SCM is not until January 1, 2009, or 2010 for some coating categories. The most recently adopted California air district rule based on the SCM—San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) Rule 4612 Motor Vehicle And Mobile Equipment Coating Operations, Phase II (September 2006)—retains these 2009 and 2010 compliance dates. SCAQMD Rule 1151–Motor Vehicle and Mobile Equipment Nonassembly Line Coating Operations, which was adopted very shortly after the SCM, has a slightly earlier compliance date of July 1, 2008. Regardless, because of the limited availability of compliant coatings and the necessary equipment upgrades and operator training, adoption of this measure would result in little if any emission reductions before 2008.

---

[1] A Suggested Control Measure (SCM)is a "model rule", developed by ARB for source categories where statewide consistency in control requirements is particularly desirable, that local air districts can copy for their rules for the covered source category. .

For existing rules with VOC limits already in place, the District compared Rule 67.20 to SJVUAPCD Rule 4602 (Motor Vehicle and Mobile Equipment Refinishing Operations). SJVUAPCD Rule 4602 has lower VOC limits than Rule 67.20 for this source category in the following coating categories: Group I Vehicle primers and primer surfacers, Group II Vehicle primers and primer surfacers, and Group II Vehicle primer sealers. Estimated emissions in San Diego County from these coating categories comprise a small fraction of total emissions from the source category (estimated emissions are less than 11 tons per year from the affected coating categories). If SJVUAPCD 4602 limits were incorporated in Rule 67.20 the estimated emission reduction potential would be about 6.1 tons per year, or 0.02 tons per day. However, SJVUAPCD Rule 4602 allows a higher ratio of high VOC precoat to primer usage than Rule 67.20 (1 gallon of precoat to 1 gallon of primer as compared to 1 gallon of precoat to 4 gallons of primer for Rule 67.20) and higher allowable usage of high VOC specialty coatings (1 gallon per day compared to 3 gallons per month for Rule 67.20). Therefore the overall emission reductions achieved by Rule 67.20 may be equivalent or greater than SJVUAPCD Rule 4602.

D.4 Adhesive and Sealant Applications

This source category is regulated by District Rule 67.21 (Adhesive Material Application Operations). Potential emission reductions were estimated by comparison with South Coast Rule 1168 (Adhesive and Sealant Applications), which has more stringent VOC content limits than Rule 67.21 in several adhesive categories. Total VOC emissions in San Diego County from this category are estimated at approximately 1302 tons per year, based on the 1998 Rule 67.21 rule development emission inventory and projected emission reductions from adoption of Rule 67.21 in 1998. Nearly all of the emissions (1249 tons per year) and potential emission reductions (512 tons per year, or 1.4 tons per day) that would be affected by adoption of Rule 1168 requirements are from nonpermitted sources such as construction operations. Although the estimated emission reductions are relatively large, the estimate does not account for penetration of the current San Diego market by low VOC adhesives sold in South Coast. Information from adhesive suppliers indicates that they typically provide all of Southern California with the same products. Emission reductions from permitted sources are not anticipated to be significant (total estimated emissions are only 53 tons per year). This category will be given a high priority for evaluation for future rule development, especially with regards to refining the emission inventory and assessing availability of low VOC adhesives.

D.5 Solvent Wipe Cleaning Operations

Solvent wipe cleaning (also called surface preparation or solvent cleaning) is defined in Rule 67.6 (Solvent Cleaning Operations) and similar rules in other California air districts as a method of cleaning a surface by physically rubbing it with a material such as a rag wetted with a solvent. This source category does not include the cleaning of coating application equipment, which has separate standards. It also does not include cleaning of parts in tanks or basins regulated by Rule 67.6. Further VOC reductions under Rule 67.6 are currently being evaluated.

Presently there are a variety of solvents used in San Diego County for cleaning and preparing surfaces for painting or for general maintenance cleaning. These solvents include isopropyl alcohol (IPA), methyl ethyl ketone (MEK), mineral spirits, xylene, lacquer thinner, etc. The VOC content of surface preparation and cleaning solvents are regulated under the District's source-specific coating Rules 67.3 (metal parts and products), 67.4 (can and coil), 67.5 (paper, film, and fabric), 67.9 (aerospace), 67.11 (wood), 67.12 (polyester resin), 67.18 (marine coating), 67.20 (automotive refinishing) and 67.21 (adhesives). These rules limit either the VOC content or vapor pressure (or boiling point) of solvents used for wipe cleaning operations. Those wipe cleaning operations that are not covered by source-specific rules are regulated by Rule 66 (organic solvents). Rule 66 does not limit the VOC content of solvents. Instead it requires the use of add-on control equipment for sources emitting certain quantities of specified organic solvents.

Based on available emission inventory data and, in some cases, engineering permit files, the estimated VOC emissions from wipe cleaning operations subject to Rule 66 are about 48 tons per year. The estimated VOC emissions from wipe cleaning operations subject to the source-specific coating rules are approximately 128 tons per year. The bulk of the emissions from operations subject to source-specific coating rules (about 65%) are from marine coating operations (67.18). Some coating operations such as can and coil coating (Rule 67.4), paper, fabric and film coating (Rule 67.5), and adhesive material application operations (Rule 67.21) do not use significant amounts of cleaning solvents containing VOCs. In addition, emissions from aerospace coating operations (Rule 67.9) are not included in the total. Aerospace coating operations are specifically exempt from general wipe cleaning solvent limits in the rules of other districts and the standards for wipe-cleaning in District Rule 67.9 are consistent with the limits in South Coast Rule 1124 (Aerospace Assembly and Component Manufacturing Operations) for aerospace coating operations.

The total estimated VOC emissions from wipe cleaning operations are about 177 tons per year. The estimated potential emission reductions for this source category are about 142 tons per year, or 0.57 tons per day, based on requiring use of wipe cleaning solvents with a VOC content of 50 grams per liter or less. This would be consistent with the standards for this source category in rules of several other air districts. This category will be given a high priority to be investigated for future rule development.

D.6 Wood Products Coating Operations

This source category is regulated by District Rules 67.11 (Wood Products Coating Operations) and 67.11.1 (Large Coating Operations For Wood Products). Rule 67.11 applies to all sources while Rule 67.11.1 only applies to sources emitting more than 25 tons per year of VOCs. Rule 67.11 contains technology forcing VOC content limits for wood coatings. Although the District is currently reviewing their feasibility, these limits were scheduled to be implemented July 1, 2005. Based on emission inventory information, total estimated VOC emissions from this source category are about 335 tons per year of which 12 tons per year are from sources exempt from Rule 67.11. If successful, the projected emission reductions from implementation of the 2005 VOC limits are about 112 tons per year from current emission levels.

South Coast Rule 1136 (Wood Products Coatings) regulates this source category and has lower technology forcing VOC content limits than those in Rule 67.11 in several coating categories. These technology forcing limits were to be implemented on July 1, 2005, and affect the following coating categories: conversion varnishes, fillers, high-solid stains, sealers and low-solids stains, toners or washcoats. If the lower limits in South Coast Rule 1136 were incorporated in Rule 67.11, the potential emission reductions are estimated to be about 57 tons per year, over and above the projected emission reductions from the technology forcing 2005 limits already in Rule 67.11.

In addition, South Coast Rule 1136 limits rule applicability to those sources using more than one gallon per day of wood coating while Rule 67.11 limits rule applicability to those sources using 500 gallons per year or more of wood coatings. If the applicability limit in Rule 67.11 were reduced to the South Coast Rule 1136 limit, which was assumed to be equivalent to an annual limit of 125 gallons per year, the estimated potential emission reductions would be 5.6 tons per year. Thus, the total estimated potential emission reductions would be 63 tons per year, or 0.25 tons per day.

The District anticipates that an evaluation of the effect of the mid-2005 limits can be made in 2007. This allows for the use of coatings complying with the mid-2005 standards in Rule 67.11 and South Coast Rule 1136 for one full calendar year.

D.7 Graphic Arts

This source category is regulated by District Rule 67.16 (Graphic Arts Operations). Based on emission inventory information, total estimated VOC emissions from this source category are about 82 tons per year. The emissions result from printing processes or related coating processes.

South Coast Rule 1130 (Graphic Arts) has lower VOC limits than Rule 67.16 for this source category for fountain solutions. In addition, South Coast Rule 1171 (Solvent Cleaning Operations) has lower VOC limits than Rule 67.16 for cleaning ink application equipment for roller washes and general ink cleaning. If the South Coast Rule 1130 and Rule 1171 VOC limits were incorporated in Rule 67.16, the estimated potential VOC emission reductions would be about 57 tons per year, or 0.23 tons per day. Nearly all (about 98%) of the emission reductions would result from reducing the VOC content of cleaning materials. This assumes that the lower VOC content cleaning materials are as effective as the current cleaning materials and that increased usage is not required. Both South Coast Rules 1130 and 1171 also have lower VOC limits than Rule 67.16 in several specialty ink or solvent cleaning categories (for example, flexographic ink on porous substrates and flexographic printing cleanup) and for adhesives. However, none of these materials have been identified as being used in San Diego County for this source category.

The District is assigning this category a medium priority for evaluation for future rule development, including estimating cost effectiveness and feasibility of more stringent standards. Because nearly all the emission reductions result from cleaning materials, the District may consider those changes as part of possible rule making for the wipe-cleaning source category.

D.8 High Emitting Spray Booth Facilities

South Coast Rule 1132 (Further Control of VOC Emissions from High-Emitting Spray Booth Facilities) applies to spray booths emitting more than 20 tons per year of VOCs. This rule requires a further 65% VOC emissions reduction from these operations beyond that required by South Coast coating VOC content rules. The District currently has no comparable rule. The District emission inventory information indicates that there may be five operations in San Diego for which VOC emissions from one spray booth (or a combination of spray booths) exceed 20 tons per year. However, four of these are wood coating operations and the estimated emission reductions resulting from implementation of Rule 67.11's technology forcing VOC content limits for wood coating operations that took effect July 1, 2005, would bring three of these operations well below the 20 ton per year threshold. Emissions from the remaining two facilities (after adjustment for projected Rule 67.11 reductions in 2005) are about 59 tons per year combined, and the estimated emissions reduction potential is about 39 tons per year, or 0.15 tons per day (65% additional control).

The District views this as a low to medium priority measure because more than half the emissions from the remaining two facilities are from one large wood coating operation. These wood coating emissions may be reduced more than projected by the technology forcing 2005 limits in Rule 67.11. Therefore, emission reductions from add-on controls may be significantly less than the projected 39 tons per year. The District is currently evaluating the feasibility of the Rule 67.11 technology forcing limits. If it is determined that some or all of the limits are not feasible or if the residual emissions warrant further control, the District will reevaluate the priority of this measure.

D.9 Equipment Leaks

Bay Area AQMD's Rule 8-18 (Equipment Leaks) establishes vapor and liquid leak standards to reduce emissions of volatile organic compounds from leaking equipment at refineries, bulk terminals, bulk plants and chemical plants. It exempts facilities with fewer than 100 valves or fewer than 10 pumps and compressors (Rule 8-22, Valves and Flanges at Chemical Plants, applies in these cases). It also exempts equipment handling organic liquids having initial boiling points above 302° F. It does not apply to connections between the loading racks at bulk terminals and bulk plants and the vehicle (mobile transports) being loaded. It sets inspection frequency criteria (daily visual, quarterly instrument checks for most components), repair requirements, and leak standards – 3 drops per minute for liquid leaks, 100 parts per million by volume (ppmv) as methane for most vapor leaks, and 500 ppmv as methane for pumps, compressors and pressure relief devices.

The Rule 8-18 definition of Chemical Plants includes any facility engaged in producing organic or inorganic chemicals or the manufacturing of products by chemical processes and having "325" as the first three digits in the applicable North American Industry Classification code. This code applies to dozens of facilities in San Diego County but likely few would have 100 or more valves or 10 or more pumps or compressors in VOC service. San Diego has no petroleum refineries that would be subject to such a rule. Possibly, a rule such as Rule 8-18 could apply to the major gasoline bulk terminals, some of the bulk plants, and two kelp-processing facilities. However, a valve, pump and compressor count would be needed to determine if the rule would apply to facilities in San Diego.

Rule 8-18 establishes the same liquid leak standard (3 drops per minute) as San Diego rules applicable to gasoline bulk terminals and bulk plants (Rules 61.1, 61.2 and 61.7), kelp processing (Rule 67.10), coating and printing ink manufacturers (Rule 67.19), and pharmaceutical and cosmetics manufacturers (Rule 67.15). However, the San Diego rules have a more stringent allowable leak repair period than Rule 8-18 (0-3 days versus 7 days). Rule 8-18 has a more stringent vapor leak standard for equipment at bulk terminals and bulk plants than do San Diego Rules 61.1 and 61.2 (100-500 ppmv @1.0 cm versus 1375 ppmv @1.3 cm as methane). However, San Diego Rule 61.1 applies to the vapor transfer path including the connection to a mobile transport while Bay Area Rule 8-18 specifically exempts such connections. Inspectors in San Diego County generally do not find vapor leaks at the bulk terminals and bulk plants along the hard-piped components. Typically, if vapor leaks are found, it is at the loading rack/mobile transport interface, and from the vapor fittings (e.g. drybreaks) on the mobile transport themselves (under ARB jurisdiction).

More detailed evaluation would be needed to determine the extent to which a rule such as Rule 8-18 would apply to local chemical plants and whether the standards for fugitive vapor leaks are technologically feasible and cost-effective. However, likely emission reductions from bulk plants and bulk terminals would be expected to be far less than 10 tons per year. The most recent inventory of these sources showed approximately 13 tons per year total VOC emissions from loading rack operations, and fugitive vapor and liquid leak emissions from hard-piped components, pumps and compressors are likely far less than this amount. As to kelp processing facilities, most fugitive vapor emissions are not associated with equipment or piping leaks. Lines used to transport VOC/air streams are operated at only a few inches of water gauge pressure.

Based on this initial evaluation, it does not appear that there is a significant emission reduction potential and therefore this item should be given a low priority for evaluation for future rule development.

D.10 Petroleum Storage Tanks

This source category is regulated by District Rule 61.1 (Receiving and Storing Volatile Organic Compounds at Bulk Plants and Bulk Terminals), which is applicable to large storage tanks for gasoline and other high volatility motor vehicle fuels. Based on emission inventory information and updated equipment descriptions, estimated emissions from this source category are about 46 tons per year. Rule 61.1 has standards for fittings for internal floating roof tanks, external floating roof tanks, and fixed roof tanks and requires Best Available Control Technology (BACT) for new or replacement rim seals for external and internal floating roof tanks.

South Coast 1178 (Further Reductions of VOC Emissions from Storage Tanks at Petroleum Facilities) has further control measures for this source category. This rule is applicable to above ground storage tanks at petroleum facilities emitting more than 20 tons per year of VOCs. The rule specifies rim seal types and fittings for external and internal floating roof tanks and fixed roof tanks. The rule also requires all external floating roof tanks subject to the rule be domed by July 1, 2008.

San Diego County has two petroleum storage facilities that emit more than 20 tons per year. Examination of the existing rim seals and fittings for the storage tanks at these facilities indicates that most of the existing seals and fittings at these facilities would meet the standards in South Coast Rule 1178. Based on emission factors in the South Coast Rule 1178 staff report, if the standards of South Coast Rule 1178 were incorporated in Rule 61.1 the estimated emission reduction potential would be about 21 tons per year. About 40% of the emission reduction potential (9 tons) would result from upgrading rim seals. However, since BACT is required by Rule 61.1 for rim seal replacement, these emission reductions will be achieved over time by existing Rule 61.1. The remaining potential emission reduction benefit of the Rule 1178 standards would be approximately 12 tons per year, or 0.03 tons per day, from the more stringent requirements for fittings and the requirement for external floating roof tanks to be domed. Based on this initial evaluation, the District does not plan further evaluation for rule development for this source category because of the very limited VOC emission reduction potential.

D.11 Mobile Transport Tanks Loading

This source category is regulated by District Rule 61.2 (Transfer of Organic Compounds into Mobile Transport Tanks). Rule 61.2 controls vapors displaced by loading of mobile transport tanks with gasoline and other high volatility fuels from bulk terminals and vapor and liquid leaks during the loading process. The primary standard of Rule 61.2 requires a 90% emission reduction for all VOC vapors displaced during the transport tank loading process. Based on emission inventory information, total estimated VOC emissions in San Diego County due to vapor displacement are about 13 tons per year from four bulk terminal loading rack facilities. San Joaquin Valley Rule 4621 (Gasoline Transfer into Stationary Storage Containers, Delivery Vessels and Bulk Plants) requires a 95% emission reduction for displaced VOC vapors. Source testing data for the largest San Diego facility shows that it consistently achieves greater than 99% control of VOC vapors released in the loading process. The estimated emission reduction potential for the three remaining facilities is about 6.4 tons per year, or 0.02 tons per day, if they were required to meet a 95% control level instead of the 90% control level in existing Rule 61.2. Based on this initial evaluation, the District does not plan further evaluation for rule development for this source category at this time because of the very limited VOC emission reduction potential.

D.12 Food Products Manufacturing/Processing

This source category is regulated by South Coast Rule 1131 (Food Product Manufacturing and Processing Operations), which requires use of solvents with less than 120 grams per liter VOC or an 85% emission reduction for nonsterilization operations (emission reductions of about 75% are required for sterilization operations). The staff report for South Coast's Rule 1131 indicates that the two solvents most often used for processing operations and sterilization processes in the food industry are hexane and IPA. Based on AB 2588 Hot Spots program information, total solvent use in San Diego County for facilities that manufacture or process food products is about 0.06 tons per year for hexane and 80 tons per year for IPA. However, more than 90% of these IPA emissions are from two kelp-processing facilities already regulated by District Rule 67.10 (Kelp Processing and Bio-Polymer Manufacturing Operations). Under Rule 67.10, the kelp processing facilities have reduced their VOC emissions more than 90%. If a rule incorporating South Coast standards for VOC emissions for food processing facilities were adopted, estimated potential VOC emission reductions from the remaining unregulated IPA emissions would be about 5.9 tons per year, or 0.02 tons per day. Based on this initial evaluation, the District does not plan further evaluation for rule development for this source category at this time because of the very limited VOC emission reduction potential.

D.13 Polyester Resins Operations

This source category is regulated by District Rule 67.12 (Polyester Resin Operations). Based on emission inventory information, total estimated VOC emissions for this source category are 79 tons per year from resins and gel coats.

South Coast Rule 1162 (Polyester Resins Operations) has slightly lower monomer content limits than Rule 67.12 for some resins and gel coats. If the South Coast monomer content limits were adopted the estimated potential emission reduction would be about 5.7 tons per year, or 0.02 tons per day, for resins and gel coats combined. Based on this initial evaluation, the District does not plan further evaluation for rule development for this source category at this time because of the very limited VOC emission reduction potential.

D.14 Aerospace Manufacturing Operations

Emissions in this category have greatly declined in San Diego County since 1990 due to implementation of District Rule 67.9 (Aerospace Coating Operations), the decline in government funding for aerospace operations and, in particular, the closing of one large facility. Based on emission inventory information, total VOC emissions from this source category are only 35 tons per year.

South Coast Rule 1124 (Aerospace Assembly and Component Manufacturing Operations) has lower VOC limits in several coating categories: adhesive bonding primers, antichafe coatings, dry lubricative materials (nonfastener), form release coatings, fuel tank coatings, and sealants. In addition, South Coast Rule 1124 has a lower VOC limit for paint strippers. Total estimated VOC emissions in San Diego for materials in these coating categories and for strippers that exceed the limits in South Coast Rule 1124 are less than two tons per year. Emission reductions have not been estimated but would be less than two tons per year, or less than 0.01 ton per day.

Based on this initial evaluation, the District does not plan further evaluation for rule development for this source category at this time because of the very limited VOC emission reduction potential.

D.15 Further Control of Industrial and Commercial Boilers, Process Heaters, and Steam Generators

Rule 69.2 (Industrial and Commercial Boilers, Process Heaters and Steam Generators) regulates NOx emissions from boilers with rated heat inputs of 5 million (MM) BTU per hour or more. Currently, Rule 69.2 exempts from NOx emission standards any unit with an annual heat input of less than 220,000 therms (for units with a heat input rating of less than or equal to 50 MMBTU per hour). These units are subject only to operational standards, such as unit maintenance, recordkeeping, and an annual boiler tune-up to minimize NOx emissions to the extent feasible. Facilities with annual heat inputs of 220,000 therms or more (or greater than 10% capacity factor for units with heat input ratings greater than 50 MMBtu per hour) must comply with NOx emission standards of 30 ppmv for gas-fired units and 40 ppmv for oil-fired units. Estimated NOx emissions from this source category are about 69 tons per year with over 99% of the emissions from gas-fired units.

The District has evaluated the feasibility, cost-effectiveness and emissions reduction potential of amending Rule 69.2 to lower the exemption level to 90,000 therms per year (consistent with ARB's Reasonably Available Control Technology/Best Available Retrofit Control Technology (RACT/BARCT) Guidance Document for boilers), to determine whether the resulting emission reductions would be cost-effective. The District also evaluated the local feasibility of more stringent emission limits in SJVUAPCD Rule 4306.

The additional analyses have been conducted. To determine local feasibility of these measures, the District evaluated the cost-effectiveness for the following three cases for gas-fired boilers:

1. <u>Lower Exemption Threshold/Retain Existing Emission Standards</u>. Require that all boilers with annual heat input between 90,000 and 220,000 therms meet the 30-ppmv NOx standard of existing Rule 69.2, and retain the existing 30-ppmv NOx standard for higher usage boilers. This measure would apply to about 40 units with annual heat input

between 90,000 and 220,000 therms, requiring installation of low NOx burners and/or flue gas recirculation to meet the 30-ppmv NOx standard.

2. Lower Exemption Threshold/Tighten Emission Standards. Require that all boilers with annual heat input of 90,000 therms or more meet more stringent standards of 15 ppmv NOx for units rated at less than or equal to 20 MMBtu per hour heat input, and 9 ppmv NOx for units rated at greater than 20 MMBtu per hour heat input. These NOx standards are consistent with those for San Joaquin Valley Rule 4306, adopted on September 18, 2003. This measure would require about 110 units with annual heat input of 90,000 therms or more to install emission controls such as ultra-low NOx burners and flue gas recirculation to meet the more stringent limits.
3. Retain Existing Exemption Threshold/Tighten Emission Standards. Require that boilers with annual heat input of 220,000 therms or more meet the more stringent (15 ppmv / 9 ppmv) NOx standards. Units with annual heat input rates of less than 220,000 therms would remain subject to the current exemption. This measure would require only the approximately 70 units with annual heat input of 220,000 therms or more to install additional or replacement emission controls to meet the more stringent limits.

For each case, cost-effectiveness values were estimated for each affected boiler. The potential emission reductions (averaged over 365 days of operation per year) and overall cost-effectiveness values for each of the three cases are summarized in Table D-1.

Table D-1
Overall Cost-Effectiveness

Case	Potential NOx Emission Reductions (tons/day)	Overall Cost-Effectiveness ($/lb NOx reduced)
1	0.03	12
2	0.10	24
3	0.05	18

For all three cases, the estimated overall cost-effectiveness significantly exceeds (by 100% to 300%) the District's rule development cost-effectiveness reference level of $6 per pound of NOx emission reductions for BARCT for small sources. An investigation of whether there is any subset of units for which further controls would be cost-effective determined that none of the further control measures were cost-effective for any individual boiler. Based on the poor cost-effectiveness and small emission-reduction potential, none of these further control measure combinations are feasible and therefore none will be further considered at this time.

D.16 Small Boilers and Large Commercial Water Heaters

SCAQMD Rule 1146.1 controls NOx emissions from Small Boilers with rated heat inputs between 2 MMBtu per hour to 5 MMBTU per hour. SCAQMD Rule 1146.2 controls NOx emissions from large commercial water heaters 75,000 BTU per hour to 2 MMBTU per hour.

The District is developing a rule to control NOx emissions from small boilers and large commercial water heaters with rated heat inputs between 1 MMBtu per hour to 5 MMBTU per hour, provided additional analyses during rule development show these measures to be feasible based on technology availability, emission reduction potential, and cost-effectiveness.

Control requirements can take three general forms, 1) requiring installation of retrofit control equipment, 2) requiring early replacement of existing units with new controlled units, or 3) focusing control requirements only on new units, and allowing new controlled units to gradually replace existing units, year after year, at the end of each existing unit's 25 years useful life. The ultimate emissions reduction potential is the same for all three options. The advantage of the first two options is that the emissions reductions can be required to occur within a relatively short time period (about 2 years), whereas with the third option, the emissions reductions accumulate gradually over 25 years. However, the first two options are considerably more costly.

Control feasibility and cost investigations concluded that requiring retrofitting or early replacement would not be cost-effective for existing boilers in the 1 – 5 MMBtu per hour size range. The estimated average cost-effectiveness to retrofit a 5 MMBtu per hour boiler with low-NOx burners is approximately $10 per pound of NOx reduced, which substantially exceeds the District's standard rule development cost-effectiveness threshold of $6 per pound. The cost-effectiveness becomes increasingly unfavorable with decreasing boiler size, reaching approximately $30 per pound for a 1 MMBtu per hour boiler.

An option was considered to require retrofits for only the few largest of the small boilers, for which cost-effectiveness would be the least unfavorable. However, that option would yield NOx emission reductions estimated to be only 0.08 ton per day, and some of those emission reductions will likely be achieved even without a retrofit requirement, through market penetration of low-NOx boilers in this size range. Consequently, a retrofit requirement for existing small boilers will not be further pursued at this time.

The cost-effectiveness of requiring immediate replacement of small boilers with new low-NOx boilers is even more unfavorable. Consequently, a replacement requirement for small boilers will not be further pursued at this time.

However, requiring low-NOx burners on new small boilers may be feasible, providing emission reductions when existing small boilers are replaced at the end of their useful life. New Rule 69.2.1 is under development to address this boiler size range that, as currently conceived, would require all new boilers meet a NOx limit of 30 ppmv. Upon full implementation, which would be after all current boilers are replaced at the end of their estimated 25 year average useful lifetimes, this measure would provide an estimated 0.3 ton per day reduction in NOx emissions.

The District also investigated the feasibility of controlling emissions from Large Commercial Water Heaters 75,000 BTU per hour to 1 MMBTU per hour. Standard retrofit low-NOx burners have not been developed for this size range, based on information provided by the South Coast Air Quality Management District. Consequently, the only possible option is requiring full replacement of the units with new low-NOx units. The cost-effectiveness for requiring replacement exceeds $16 per pound and therefore is not feasible at this time. The District will continue to investigate the cost-effectiveness of controlling NOx emissions for this size range of units.

D.17 Further Control of Residential Water Heaters Smaller Than 75,000 BTU per hour

Existing District Rule 69.5 (Natural Gas-Fired Water Heaters), adopted in 1998, limits emissions from new residential-type water heaters in San Diego County to 40 nanograms per Joule (ng/J) of heat output. SCAQMD's Rule 1121 requires most new water heaters sold in the South Coast region on or after January 1, 2006, to meet a 10 ng/J NOx limit. For certain specific kinds and sizes of units, the compliance deadline is delayed to 2007 or 2008.

The District intends to assess the commercial availability in San Diego County, and the cost-effectiveness, of units complying with the 10 ng/J emissions limit of SCAQMD's rule. If sufficient complying units are found to be commercially available and cost-effective, then the District will schedule amendment of Rule 69.5 to incorporate the 10 ng/J limit for new residential water heaters sold in San Diego County. Assuming a ten-year useful life for water heaters, it would take ten years after the requirement is adopted and becomes effective for all the water heaters in the County to be replaced with units that comply with the tightened standard. Tightening the water heater NOx emissions limit from the current 40 ng/J to 10 ng/J has been estimated to reduce San Diego County NOx emissions by approximately 1.5 tons per day. This emission reduction estimate is subject to refinement during future rule development.

ATTACHMENT E

CALCULATION OF CUMULATIVE POTENTIAL EMISSION REDUCTIONS FOR POSSIBLE REASONABLY AVAILABLE CONTROL MEASURES

Control Measure	VOC Emission Reduction Potential (Tons/Day)	NOx Emission Reduction Potential (Tons/Day)
Low VOC Solvent Cleaning	1	
Architectural Coatings	5	
Automotive Refinishing	1	
Adhesive and Sealant Applications	1.4	
Solvent Wipe Cleaning Operations	0.57	
Wood Products Coating Operations	0.25	
Graphic Arts	0.23	
High Emitting Spray Booth Facilities	0.15	
Petroleum Storage Tanks	0.03	
Mobile Transport Tanks Loading	0.02	
Food Products Manufacturing/Processing	0.02	
Polyester Resins Operations	0.02	
Equipment Leaks	<0.02	
Aerospace Manufacturing Operations	<0.01	
Industrial, Commercial, and Institutional Boilers		0.1
Small Boilers and Large Commercial Water Heaters		0.3
Residential Water Heaters		1.5
Stationary Sources Subtotal	**9.7**	**1.9**
Transportation Control Measures Subtotal	**1**	**2**
Total	**10.7**	**3.9**

ATTACHMENT F
GRAPHICAL AIR QUALITY TRENDS ANALYSES

Ozone concentrations and the number of ozone exceedances in San Diego County have decreased dramatically over the past thirty years. These decreases are attributable to reductions in ozone precursor emissions in the San Diego and adjoining air basins (i.e., the South Coast Air Basin). Further emissions reductions will lead to further decreases in ozone concentrations in San Diego County, resulting in attainment of the 8-hour ozone National Ambient Air Quality Standard (NAAQS) by the year 2008. This document uses weight of evidence to illustrate air quality improvements in San Diego County and how this rate of progress will continue in future years as ozone precursor emissions continue to decrease due to current and future air pollution control measures.

Continuous, hourly ozone concentrations are measured at nine monitoring stations in San Diego County. These measurements show that ozone concentrations have been decreasing for the past twenty-five plus years as air pollution controls have effectively removed large quantities of ozone precursor emissions from the atmosphere. Figure F-1 below shows the number of exceedances of the 1-hour NAAQS for ozone and the three-year running average of 1-hour exceedances, along with the best-fit linear trend line. As the graph indicates, San Diego County attained the 1-hour ozone NAAQS in 2001, a major milestone in the region's air quality improvement.

Figure F-1

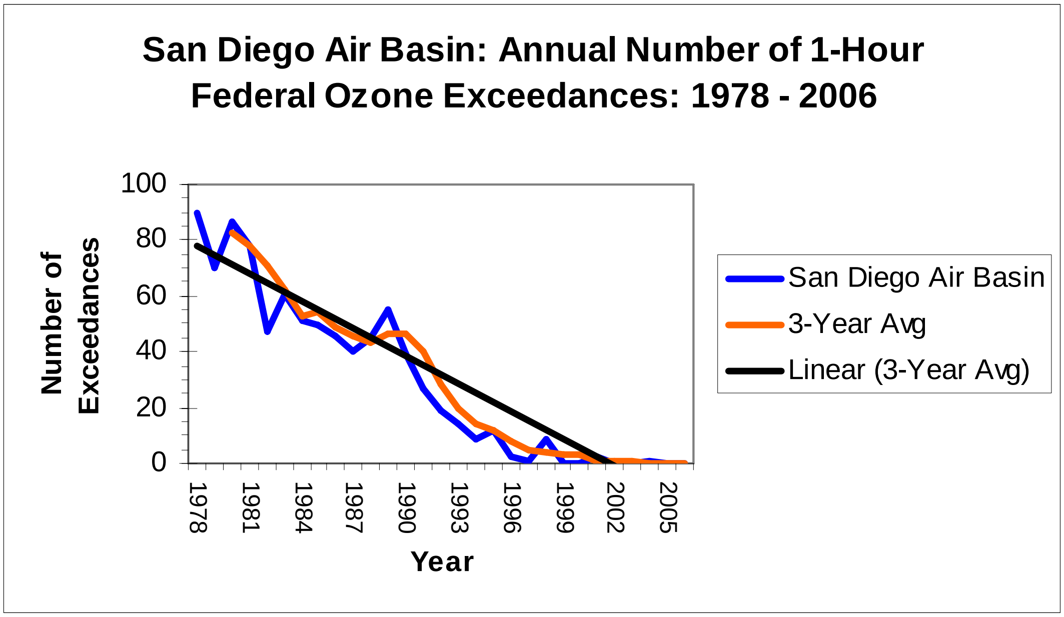
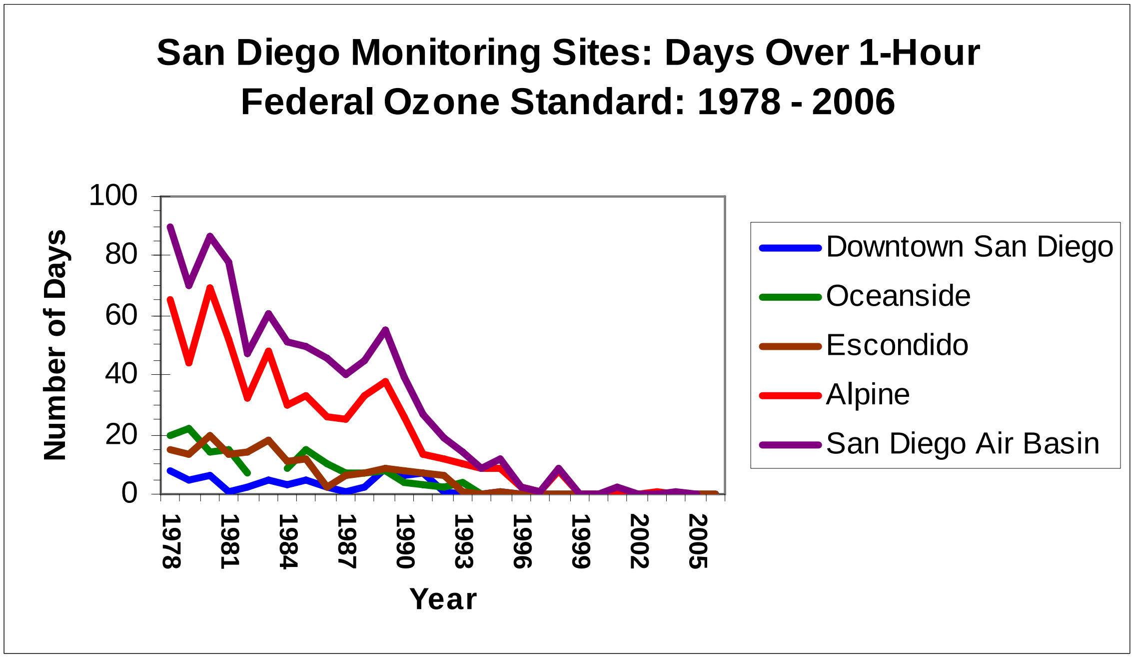


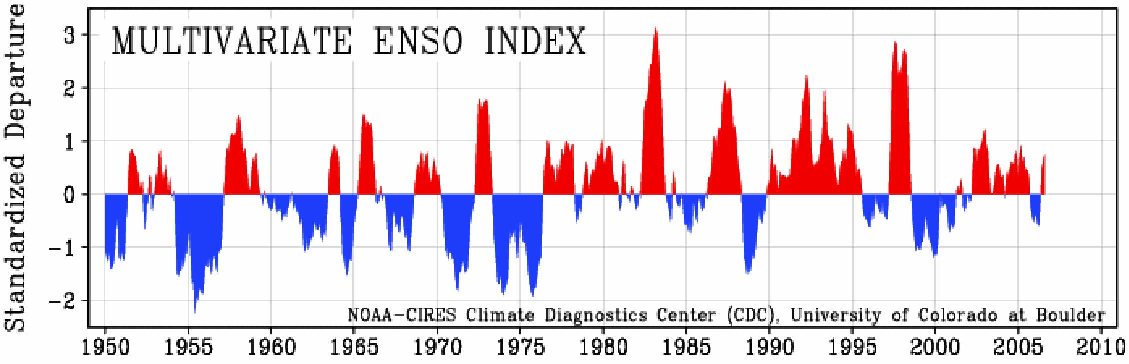
Figure F-2 below shows greater detail about when different portions of San Diego County attained the 1-hour NAAQS for ozone. This graph shows that since the mid-1990s, attainment of the 1-hour ozone standard in San Diego County was achieved in all areas except the Alpine monitoring station. This elevated site in the foothills east of metropolitan San Diego is impacted by local and transported emissions, keeping ozone concentrations higher than at all other monitoring stations in the county.

Figure F-2



The figures above show that the number of exceedances has decreased steadily over the years. The graphs also show that although the exceedance trend has been primarily downward, perturbations in the downward trend are evident. These occasional upward and downward spikes in the overall trend are caused, in part, by changes in weather patterns. Downward spikes in the trend are strongly associated with El Niño conditions (warm water anomalies in the tropical eastern Pacific Ocean), while upward spikes are likewise associated with La Niña conditions (cold water anomalies in the tropical central and eastern Pacific Ocean). Figure F-3 below illustrates the El Niño/Southern Oscillation (ENSO) pattern for the tropical Pacific Ocean. In this figure the positive departures (red) represent El Niño conditions while negative departures (blue) represent La Niña conditions.

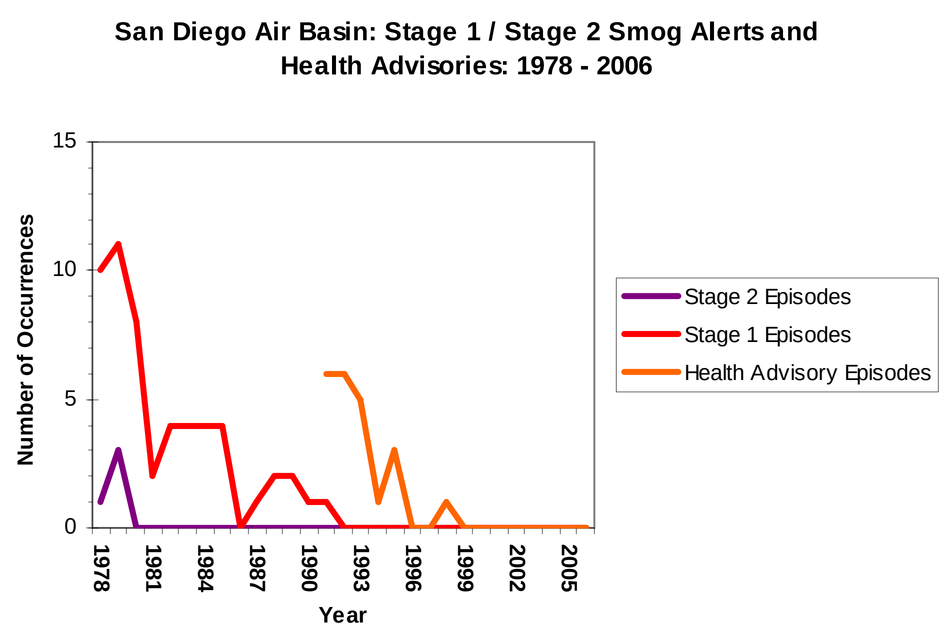
Figure F-3



These weather/climate fluctuations are normal and do influence air quality conditions over the course of an ozone season. These natural fluctuations are important as they have caused perturbations in the otherwise steady downward trend of peak concentrations and ozone exceedances.

Figure F-4 below is provided to show that the decreasing ozone concentrations have eliminated smog alerts and Health Advisory episodes. The last Stage II smog alert (0.35 ppm) in San Diego County was in 1979, the last Stage I smog episode (0.20 ppm) was in 1991, and the last Health Advisory (0.15 ppm) was in 1998. Lower ozone concentrations are decreasing health impacts for everyone in San Diego County.

Figure F-4



It is important to note that once the occurrence of Health Advisories first hit zero (1996), there has been only one Health Advisory after that year. This last Health Advisory was in 1998, a La Niña year. Decreasing emissions have since eliminated Health Advisories in San Diego County.

The 1-hour ozone concentrations shown above were presented to illustrate the ozone trends over the past decades. Since the 8-hour ozone standard is written differently than the older 1-hour standard, it is more appropriate to look at the actual 8-hour ozone concentrations. As with the 1-hour ozone standard, the attainment status of San Diego County for the 8-hour ozone standard is and has been driven in recent years by the Alpine monitoring station. Figure F-5 below shows the four highest 8-hour ozone concentrations measured in San Diego County for the years 1977 through 2006. This graph shows a general downward trend in peak ozone concentrations, along with the up and down spikes associated with climatic conditions. The graph further shows a convergence of the four highest values as concentrations have decreased to nearly the attainment point.

Figure F-5

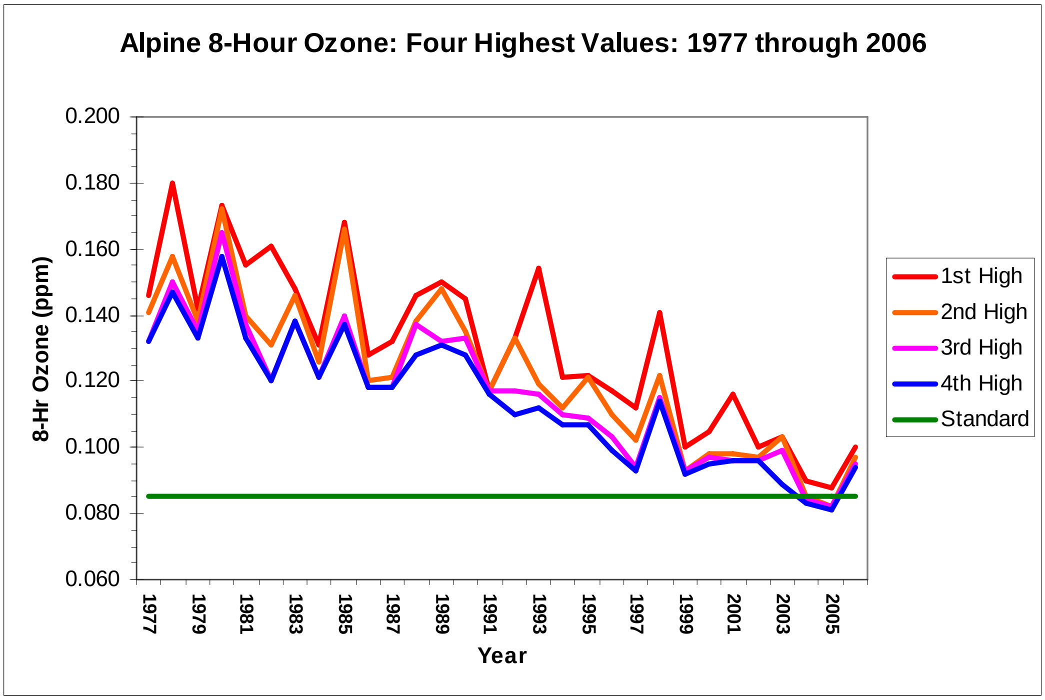
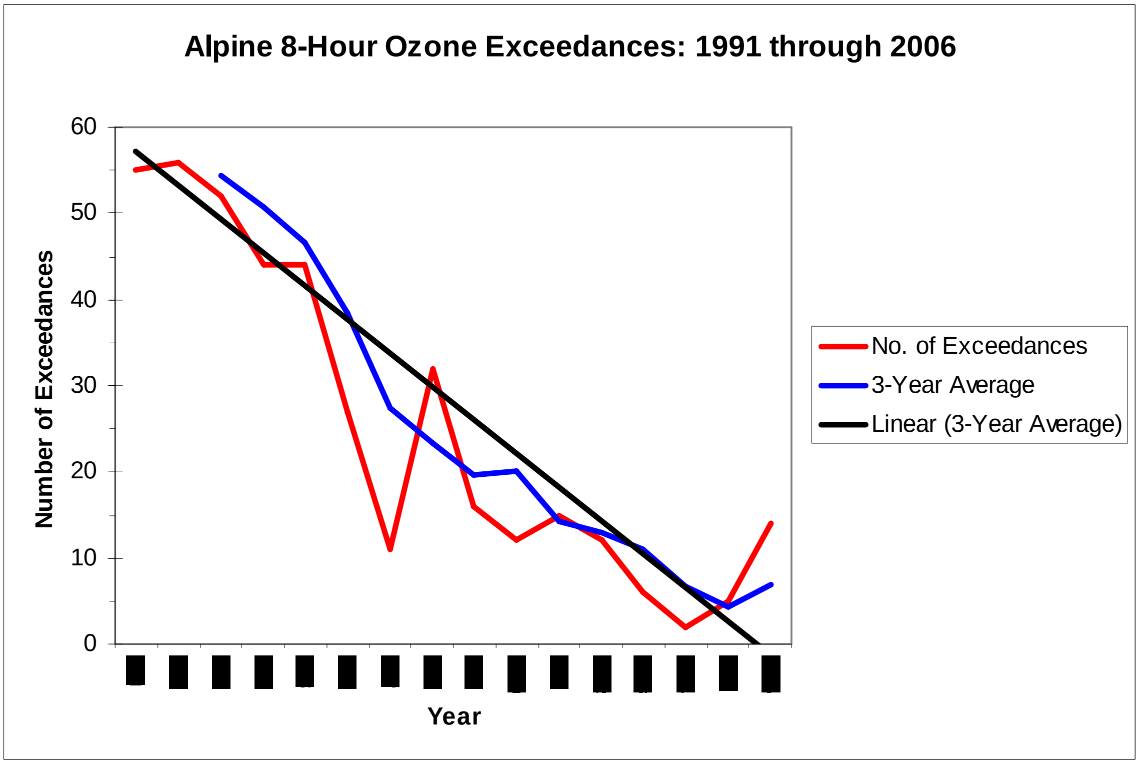


Figure F-6 below shows a large decrease in the total number of annual exceedances of the 8-hour ozone standard at the Alpine monitoring station.

Figure F-6



Since the 8-hour ozone standard is not written in terms of the numbers of exceedances, it is more appropriate to look at the 8-hour Design Value (i.e., three year average of the fourth highest concentration). Figure F-7 below shows the annual 4th highest value along with the 8-hour design value through 2006. This graph shows a downward trend in both the 4th highest values and the design value. This graph shows that San Diego County is nearing attainment of the 8-hour ozone standard. The upward spike in 2006 will affect the design value for two more years. However, the up and down spikes in the historic data suggest that subsequent years will trend even further downward.

Figure F-7

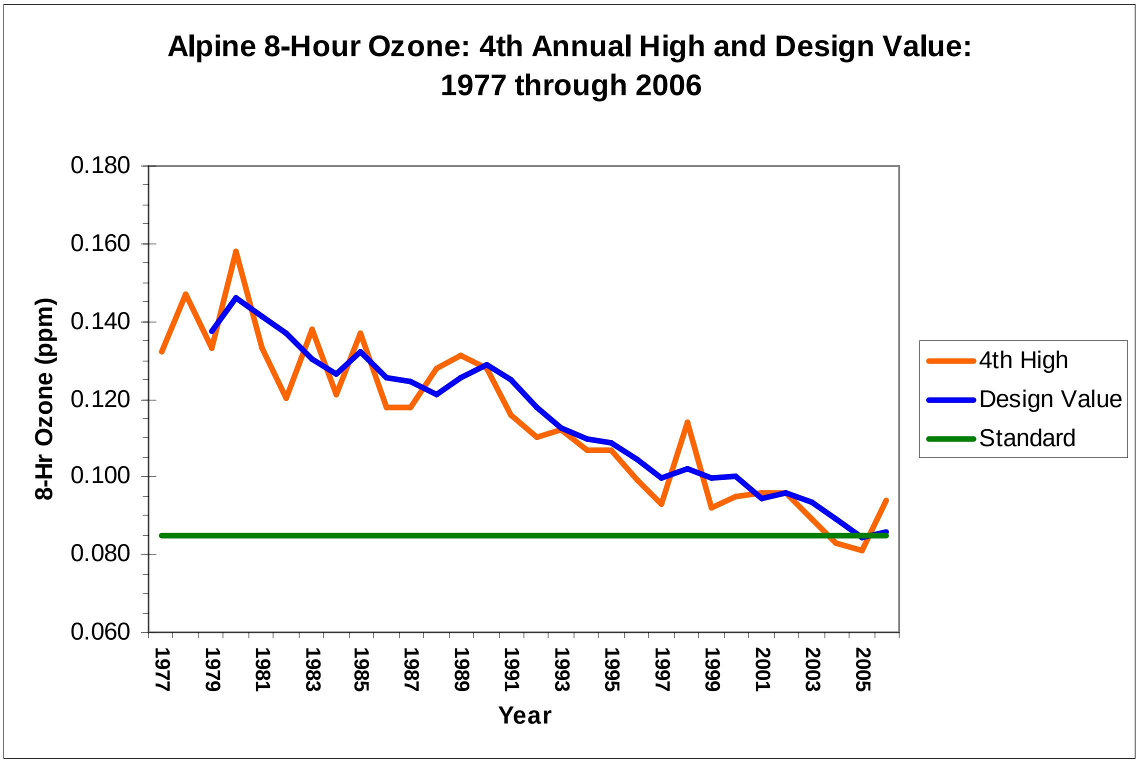
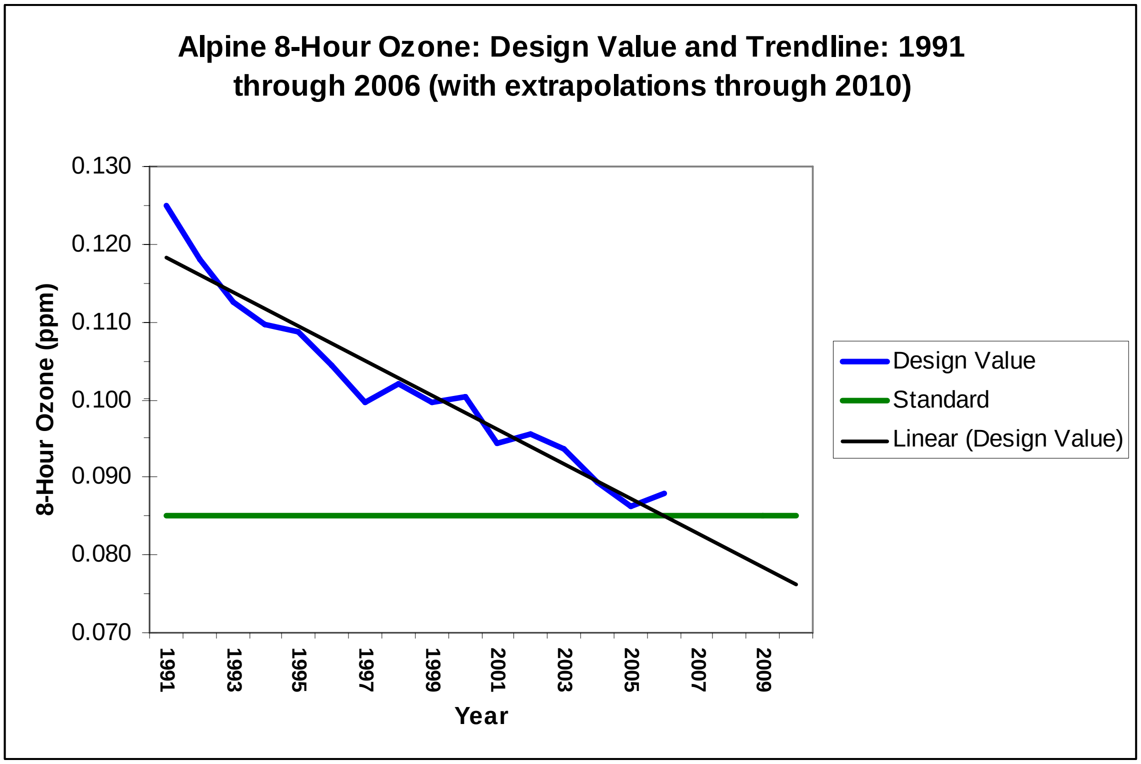


Figure F-8 below shows the 8-hour design value for the years 1991 through 2006 along with a best-fit trend line showing that a linear interpolation during this time period would put the design value below the 8-hour standard in 2007. In reality this will not occur due to the slight increase in the 4th highest 8-hour concentration in 2006.

However, past downward trends in 1-hour ozone concentrations show that the decreasing values result from decreasing emissions and an isolated year with anomalous weather will not reverse the decrease in ozone concentrations or design values (see Section 2.4.3 for additional information).

Figure F-8



It is also important to look at average concentrations, not just peak values, to see the effectiveness of emission controls on ozone concentrations in San Diego County. Figure F-9 below shows hourly averaged ozone data from the Alpine monitoring station (ALP) for 1995, 2000, and 2005. This graph shows that hourly averaged data have steadily decreased over the past ten years at this monitoring station, with peak hour concentrations decreasing by 0.009 ppm (roughly 1 ppb per year).

Figure F-9

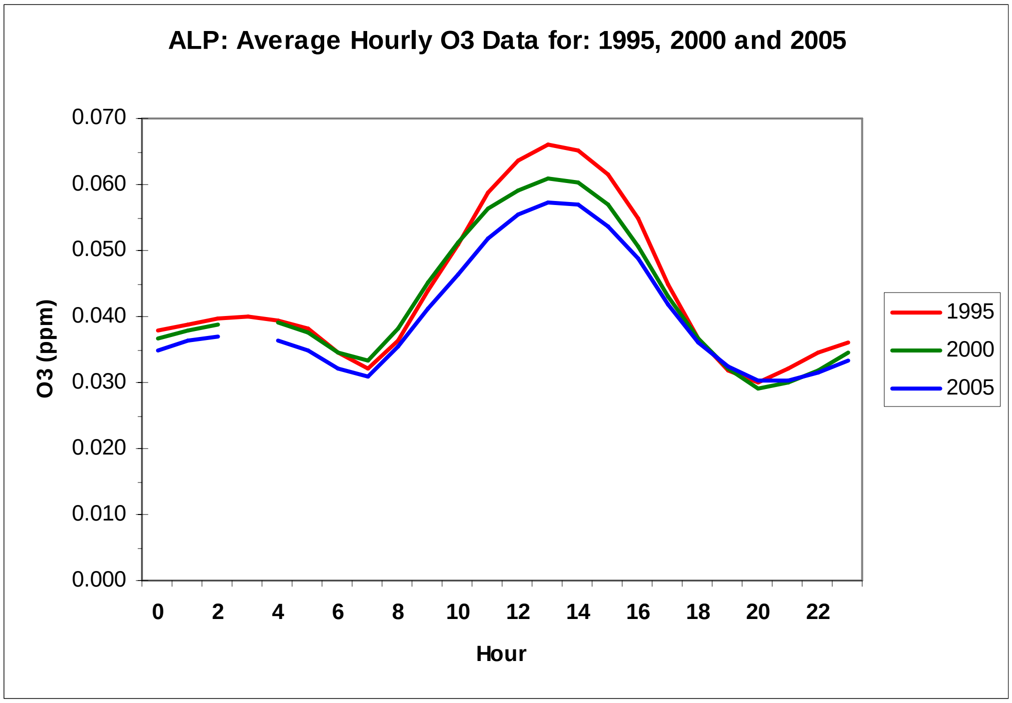
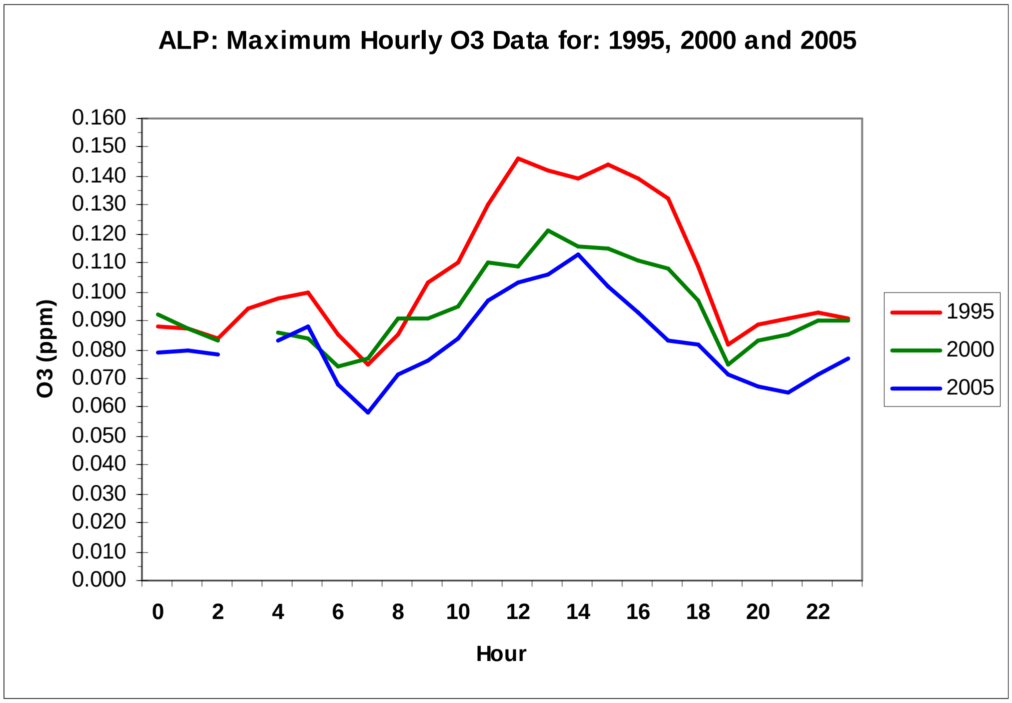


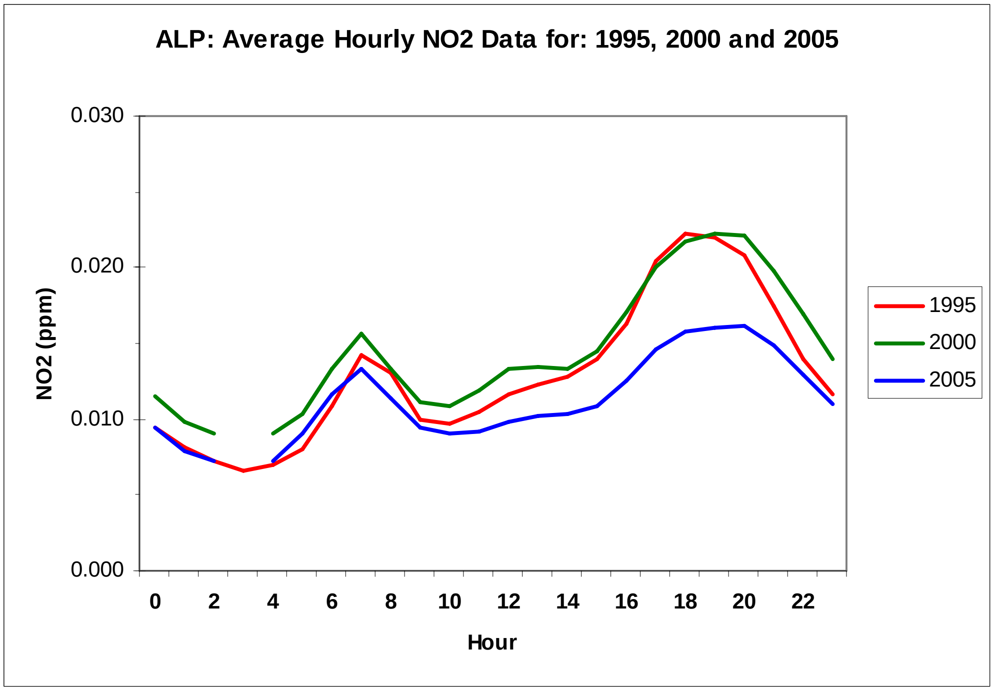
Figure F-10 below shows the hourly maximum ozone data for the years 1995, 2000, and 2005. This graph shows that peak values have fallen significantly at this monitoring station over the past ten years (peak values decreased 0.033 ppm between 1995 and 2005), as well as a shortening of the length of the "ozone day".

Figure F-10



Ozone values have decreased in the past as a result of precursor emissions reductions. Figure F-11 below shows hourly averaged NO2 data from the Alpine monitoring station (ALP) for 1995, 2000, and 2005. This graph shows that hourly averaged data have decreased significantly over the past ten years at this monitoring station, especially evening and nighttime concentrations (i.e., no photochemistry).

Figure F-11



This decrease in precursor emissions is also reflected in the decrease in 8-hour ozone concentrations at the Alpine monitoring stations. Figure F-12 below shows 8-hour averaged ozone data for 1995, 2000, and 2005. This graph shows that average 8-hour concentrations have steadily decreased over the past ten years at this monitoring station, with a decrease of 0.007 ppm between 1995 and 2005. The data suggest that this trend will continue in future years as ozone precursor emissions decrease.

Figure F-12

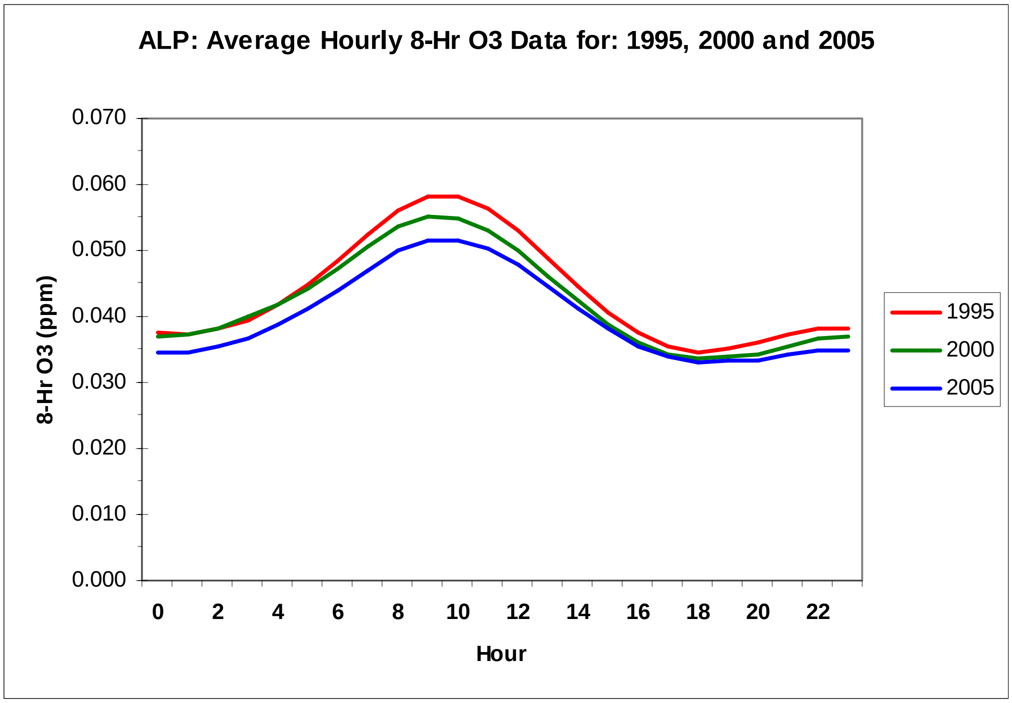
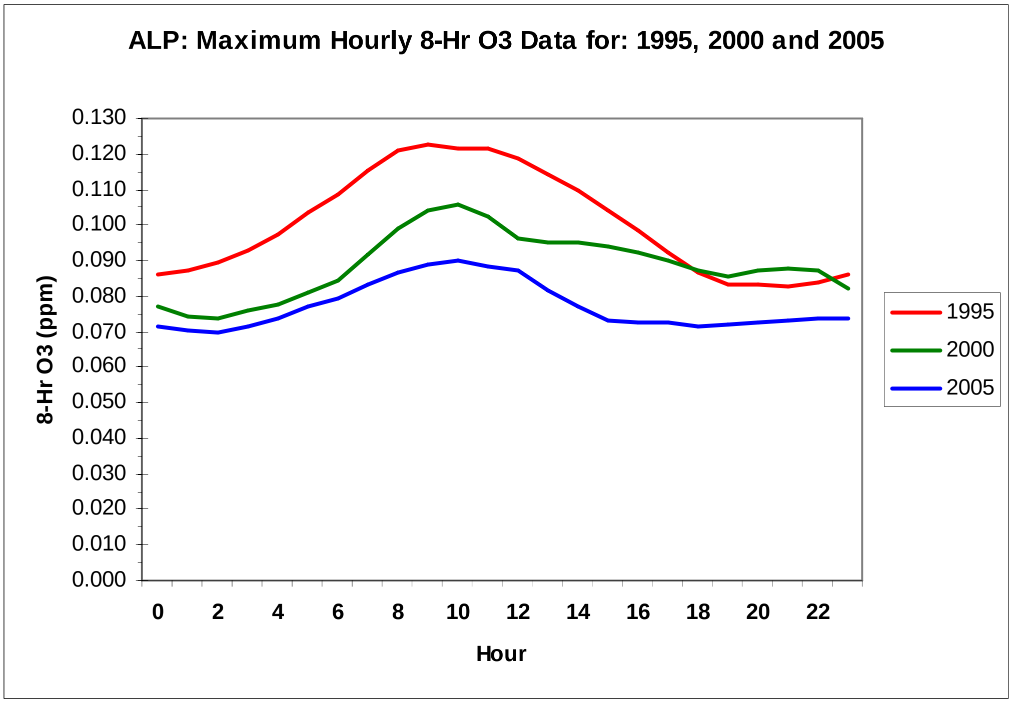


Figure F-13 below shows the hourly maximum 8-hour ozone data for the years 1995, 2000, and 2005. This graph shows that peak values have fallen significantly (0.034 ppm) at this monitoring station over the past ten year, as has the length of the “ozone day”.

Figure F-13



As indicated in Figure F-2 above, other regions of the county attained the 1-hour ozone standard many years before the Alpine area of the county. Figure X-14 below shows hourly averaged ozone data from the Downtown San Diego monitoring station (DTN) for 1995, 2000, and 2005. This graph shows that hourly averaged data have markedly decreased over the past ten years at this urbanized coastal region monitoring station.

Figure F-14

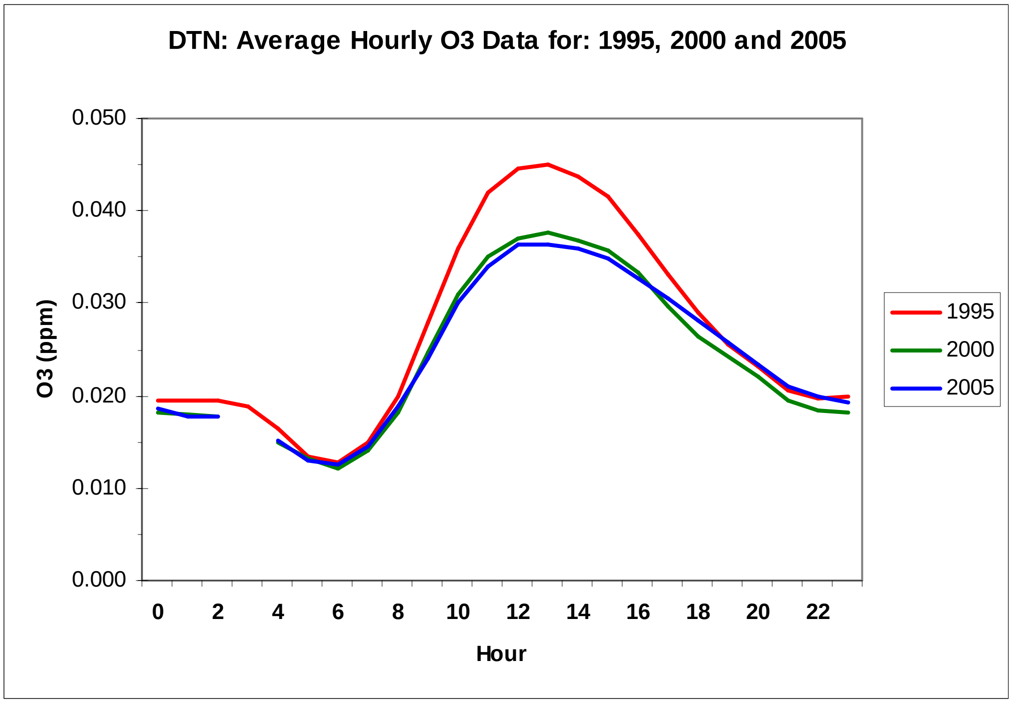
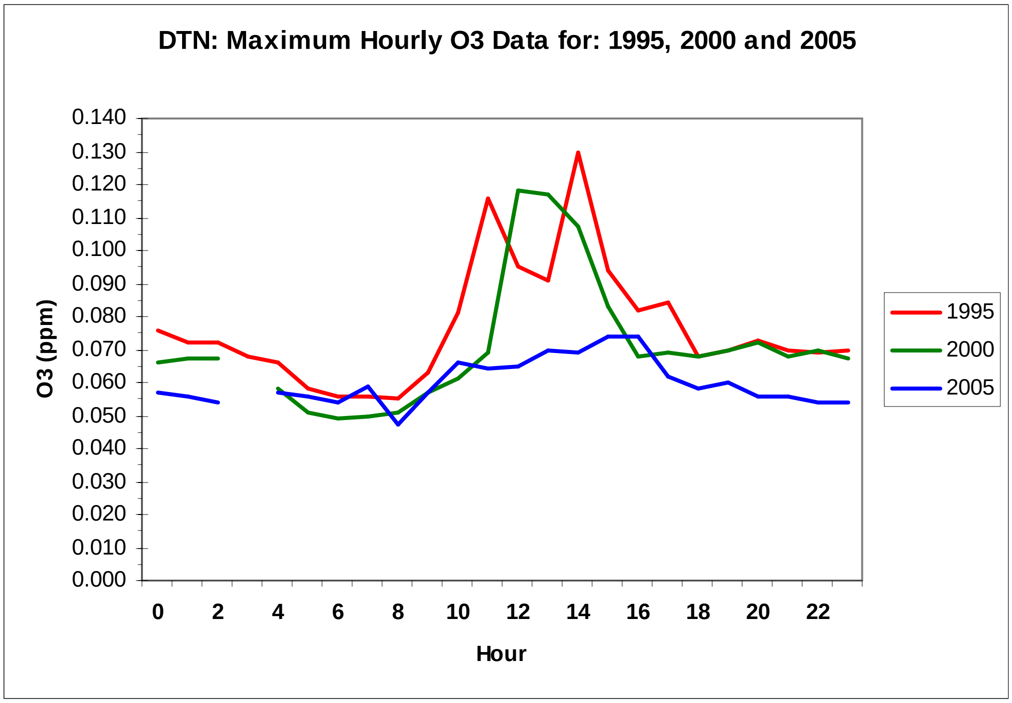


Figure F-15 below shows hourly maximum ozone data from the Downtown San Diego monitoring station (DTN) for 1995, 2000, and 2005. This graph shows that hourly maximum data have decreased over the past ten years at this monitoring station, as has the length of the "ozone day".

Figure F-15



Precursor emissions at the Downtown monitoring station have also shown a steady decrease over the past ten years. This is shown in Figure F-16 below, with average hourly NO2 data for the years 1995, 2000, and 2005.

Figure F-16

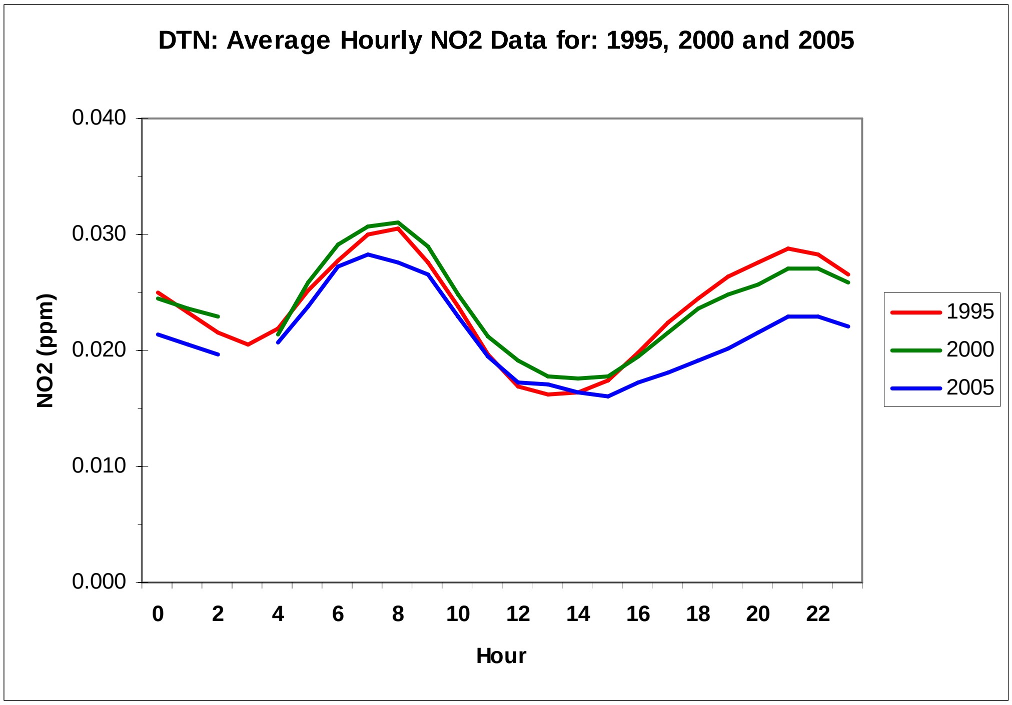
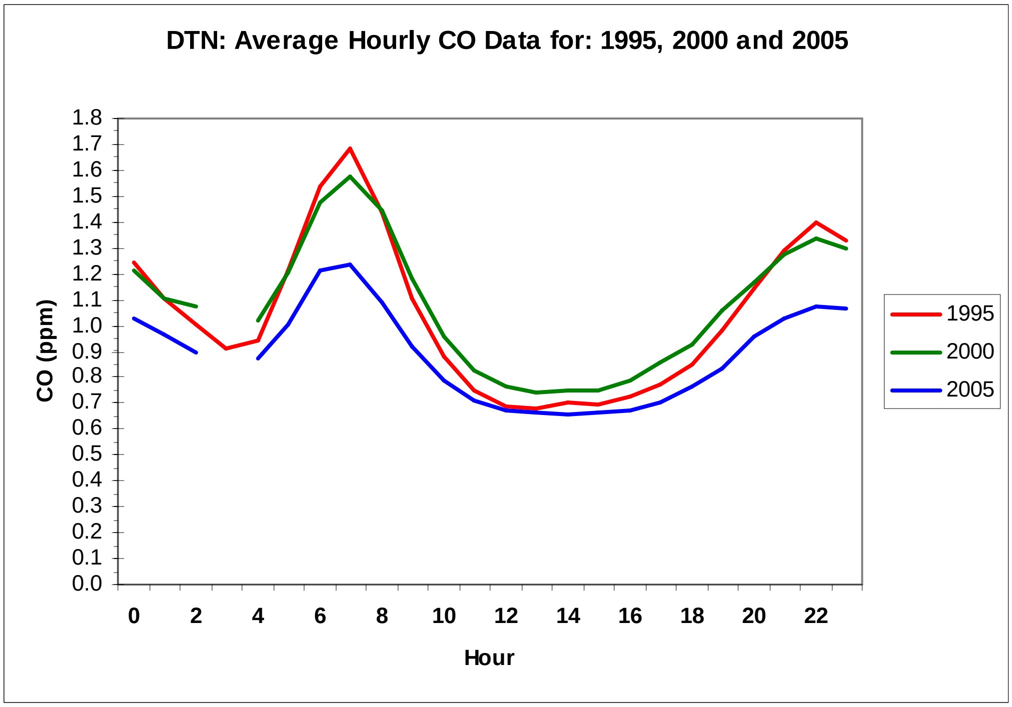


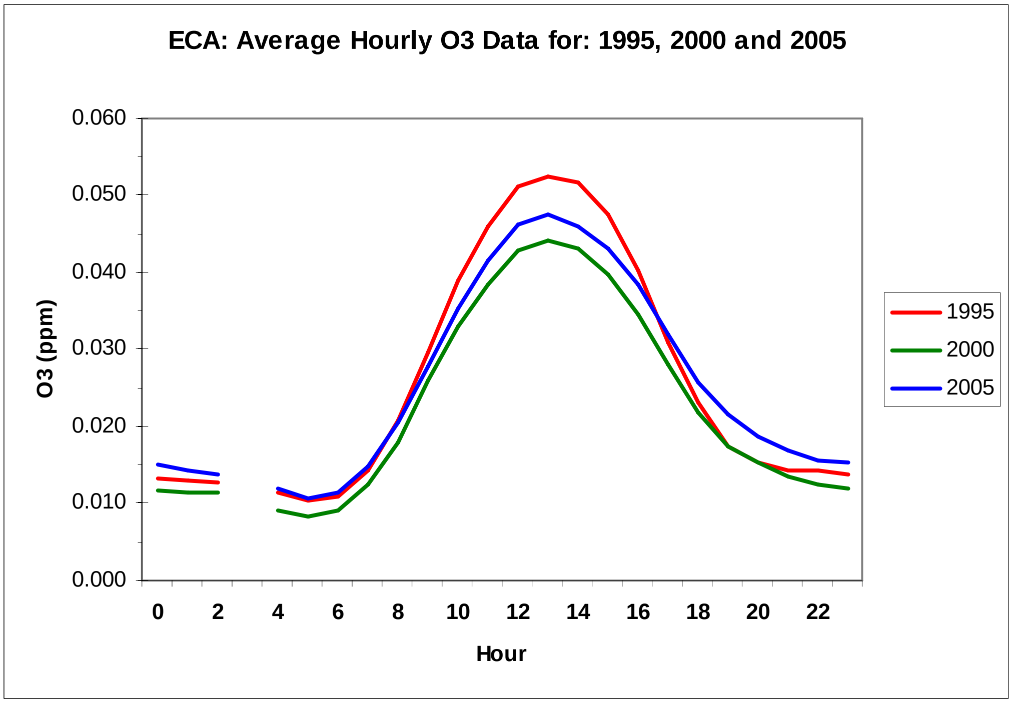
Figure F-17 below shows a similar trend for CO at the Downtown monitoring site. Although CO is not a significant precursor to atmospheric ozone formation, it can be considered a surrogate marker for mobile sources of Volatile Organic Compounds precursor emissions.

Figure F-17



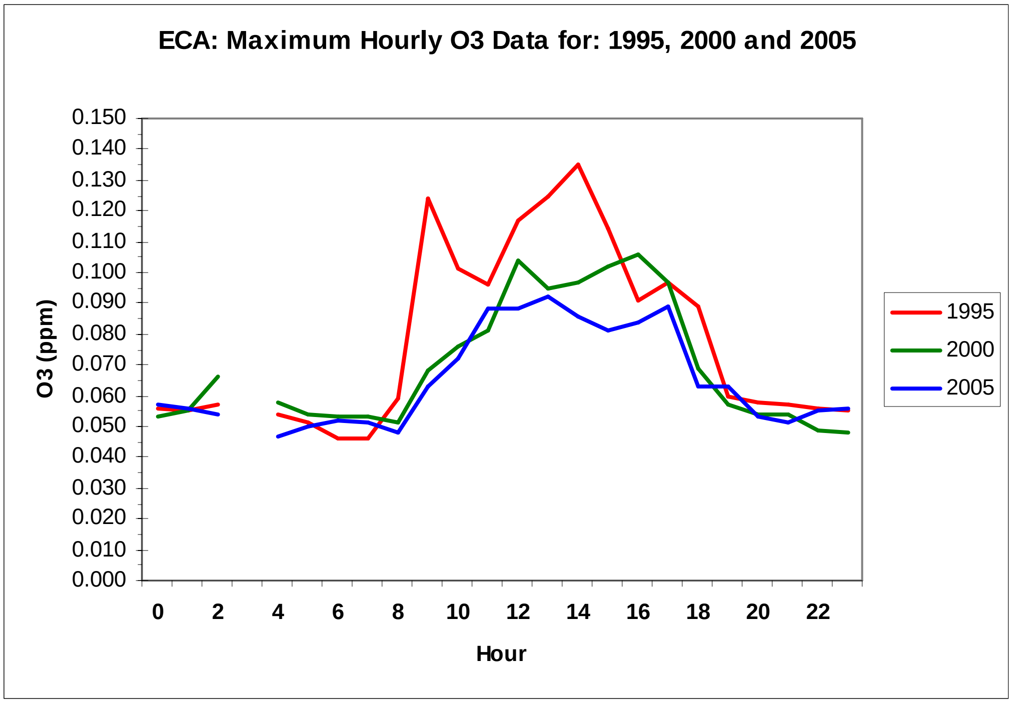
El Cajon, a major metropolitan area located in an inland valley upwind of the Alpine monitoring station also attained the 1-hour ozone standard many years before the Alpine site. Figure F-18 below shows the hourly averaged ozone data from the El Cajon monitoring station (ECA) for 1995, 2000, and 2005. This graph shows that hourly averaged data have steadily decreased from the higher values measured in 1995, although the 2005 data show a small increase in ozone concentrations over 2000.

Figure F-18



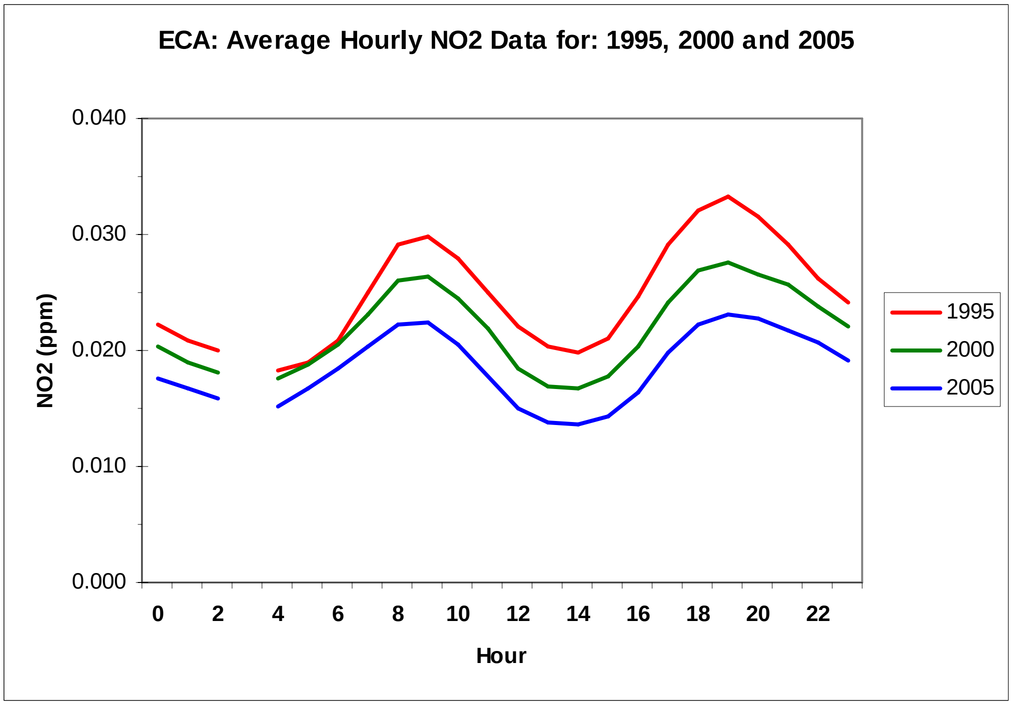
However, the maximum hourly concentrations in Figure F-19 below show a decrease over the years for this monitoring site, consistent with decreasing peak ozone concentrations throughout the county, as well as a shortening of the "ozone day".

Figure F-19



Precursor emissions in this region of the county have also decreased, as evidenced in Figure F-20 below, which shows hourly NO2 concentrations from the ECA monitoring station.

Figure F-20



Ozone precursor emissions will continue to decrease over the next several years due to existing, ongoing and future control measures. This will result in lower ozone concentrations and lower 8-hour ozone averages that are predicted to be below the level of the 8-hour ozone NAAQS by 2008.

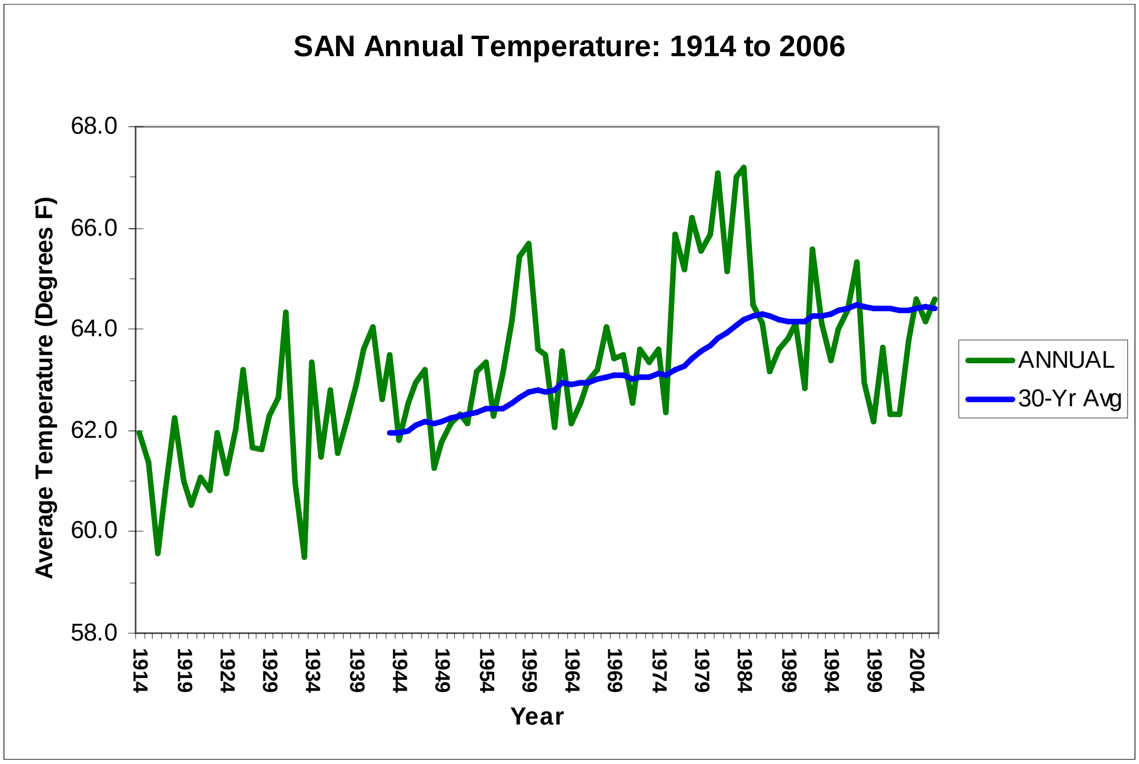
ATTACHMENT G
METEOROLOGICAL REPRESENTATIVENESS OF RECENT YEARS

G.1 Meteorological Variations

The relationship between climatic fluctuations and ozone exceedances in San Diego County was shown in the previous section. Figure G-1 below shows the annual temperature at Lindbergh Field (SAN) in San Diego for the years 1914 through 2006 (preliminary). This figure shows that the temperature in San Diego is variable on several time scales (i.e., a few years to decades). The 30-year average (typical climatological time scale) shows a rising average, with most of the rise occurring between the 1940s and the 1980s.

The variable nature of climatological conditions in San Diego must be considered when evaluating trends in ozone concentrations through the years. This is true for the more recent years as well as in the past.

Figure G-1



Emission reductions over the past several decades have resulted in lower ozone concentrations in San Diego County. This has been shown as a reduction in the number of annual exceedances of ozone standards and in the design values of ozone concentrations. The relationship between climatic variations (e.g., El Niño/La Niña conditions) and ozone exceedances was presented to partially explain upward and downward spikes in the otherwise downward trend of annual exceedances of ozone standards. The climatic variations in San Diego are a complex mixture of temperature, sea surface temperatures, atmospheric circulation patterns (e.g., position and strength of the Pacific High), and atmospheric stability. The most familiar, and easiest to measure and quantify is temperature.

Figure G-2 below shows plots of 3-year averages (for smoothing) of 8-hour ozone exceedances at Alpine and temperatures at SAN for the years 1979 through 2006 (preliminary). This graph clearly shows that the 3-year average number of ozone exceedances has been dramatically reduced since the early 1990s (from over 100 in 1990 to a minimum of only 4 in 2005).

Clearly, temperature is not the controlling factor in ozone exceedances in San Diego County, although it does play a role in ozone concentrations, and therefore, exceedances as well. Emissions reductions are the primary factor in reducing ozone concentrations and the number of exceedances. Figure G-2 shows that exceedances dropped precipitously even with stable annual average temperatures, and continued decreasing even when annual average temperatures trended upwards.

Figure G-2

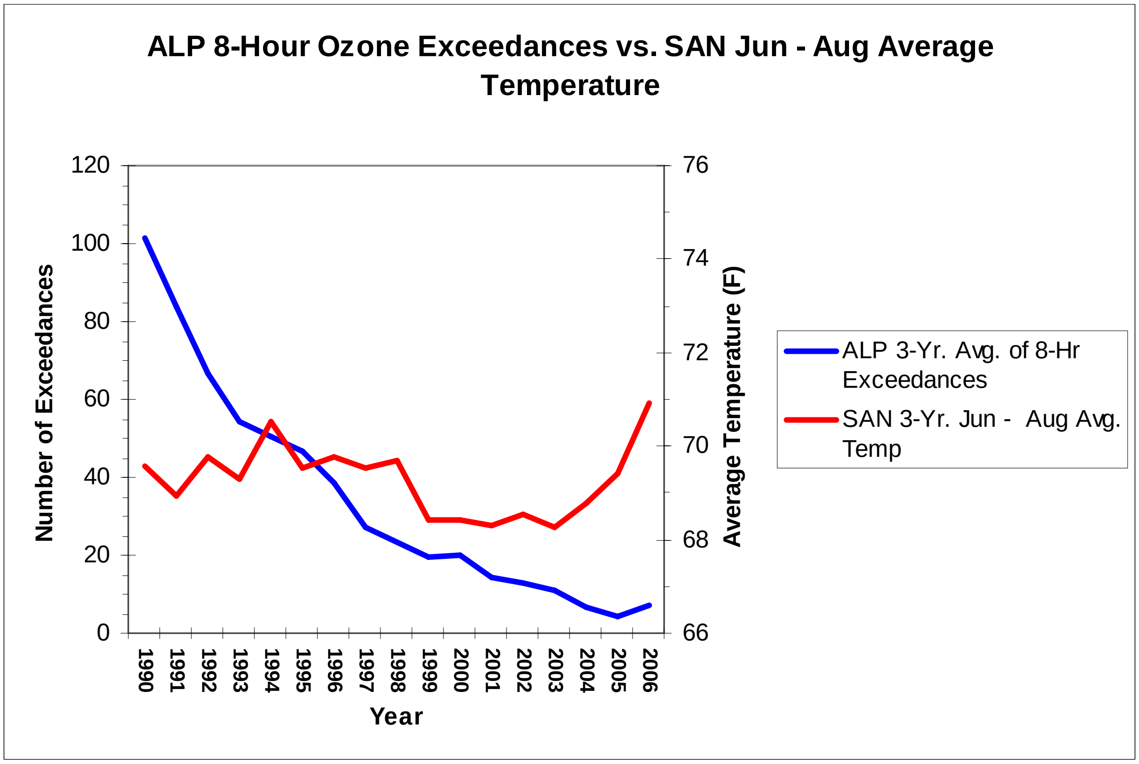
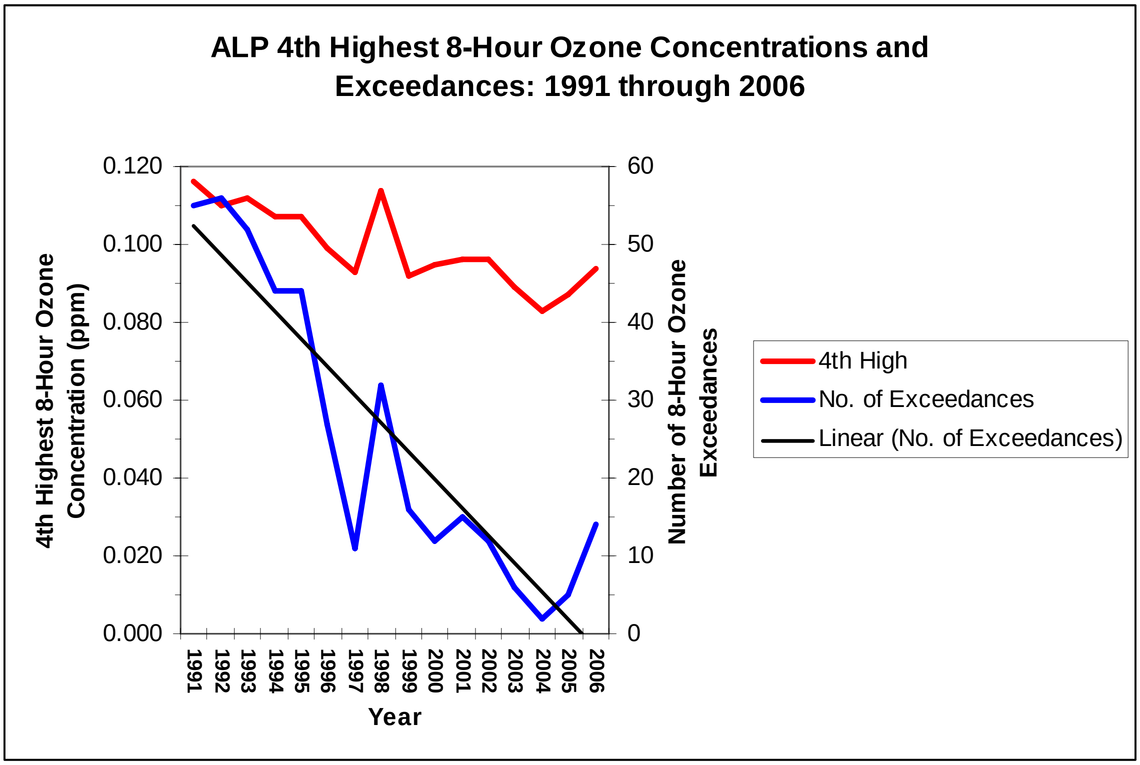


Figure G-3 below shows a more detailed subset of the graph shown above, concentrating on the years 1991 through 2006. A linear trend-line based on the number of 8-hour exceedances shows the projected date of zero exceedances as being between 2005 and 2006. This has not occurred as of this writing.

Figure G-3



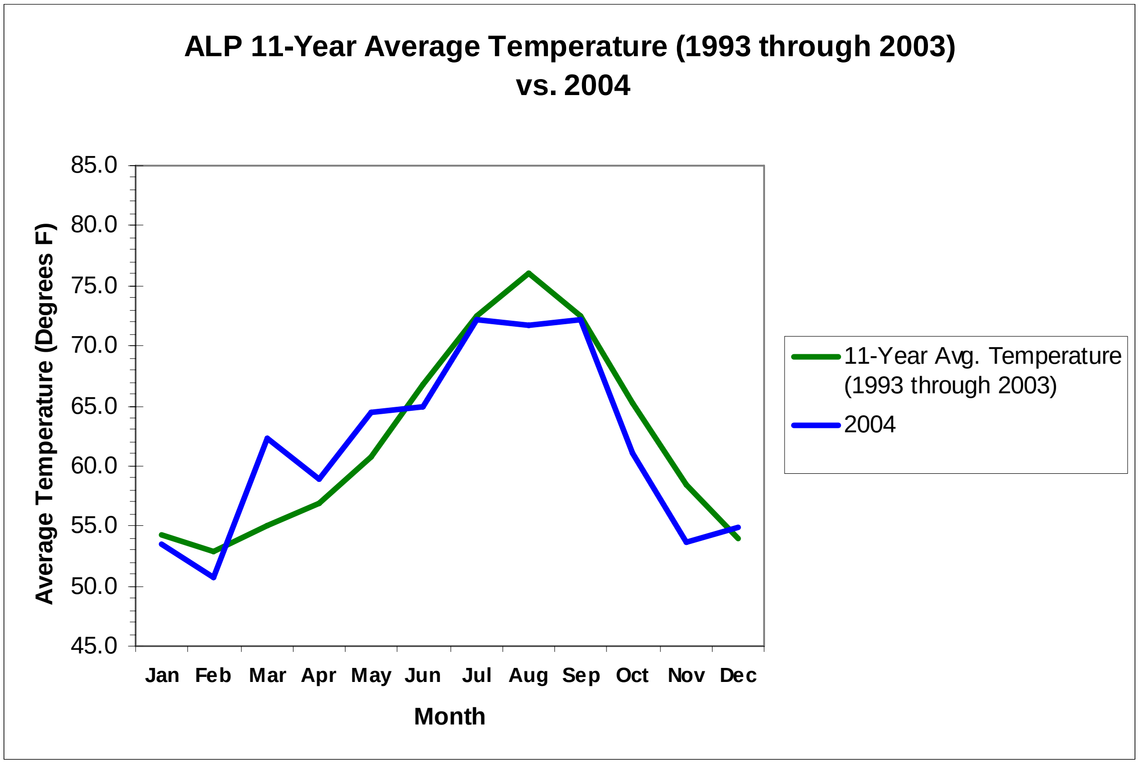
In the following subsections we will discuss the meteorology of three recent years and look at how temperature can influence ozone concentrations and exceedances in San Diego.

G.2 2004 – Clean Year

2004 represented the first time ever that the Alpine monitoring station measured less than four exceedances (only two exceedances, with the fourth highest value of 0.083 ppm) of the 8-hour ozone standard (on the road to attainment!). The downward trend in the number of exceedances in the figure above indicates that 2004 was a continuation of this trend. The upward trend in annual average temperatures during this time period lessens the possibility that 2004 merely an anomalous year with no foreseeable repeat occurrence.

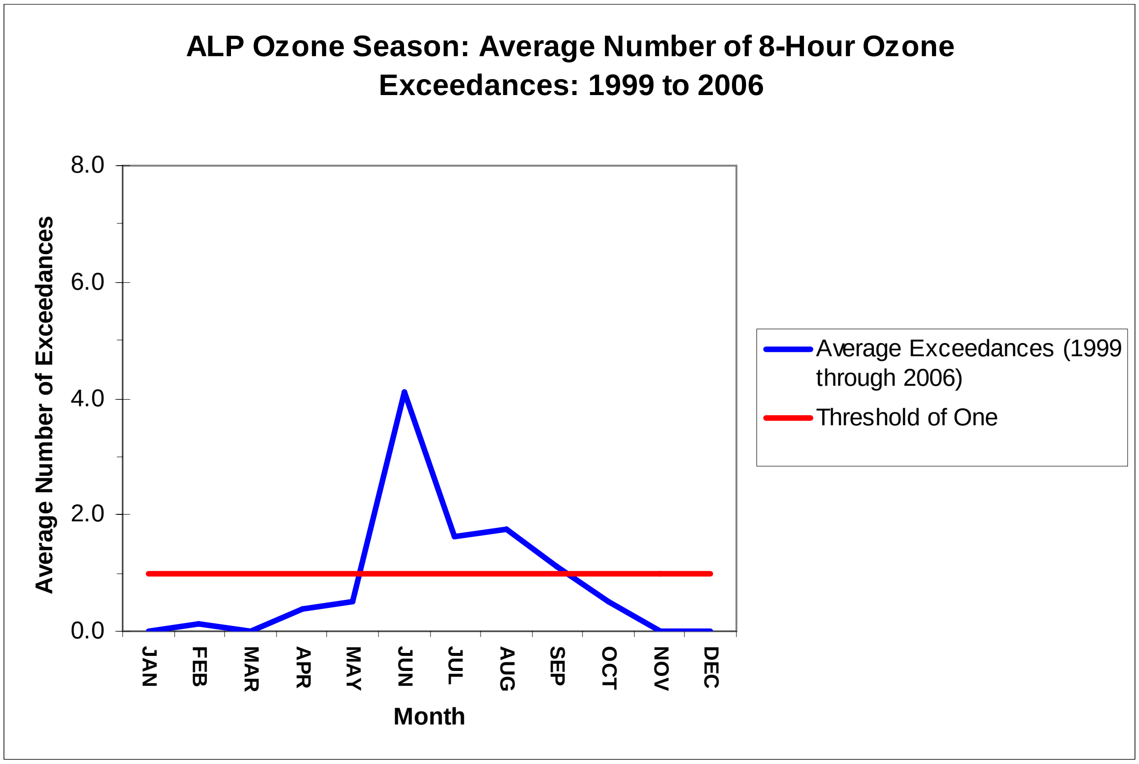
Figure G-4 below shows the average monthly temperatures at the Alpine monitoring station for the year 2004 versus the 11-year averages for the years 1993 (first available year of meteorological data for the Alpine monitoring station) through 2003 (2004 and later years not included to reduce effects of autocorrelation). This graph shows that average monthly temperatures in 2004 were near the 11-year average during June, July, and September, and cooler than normal during August.

Figure G-4



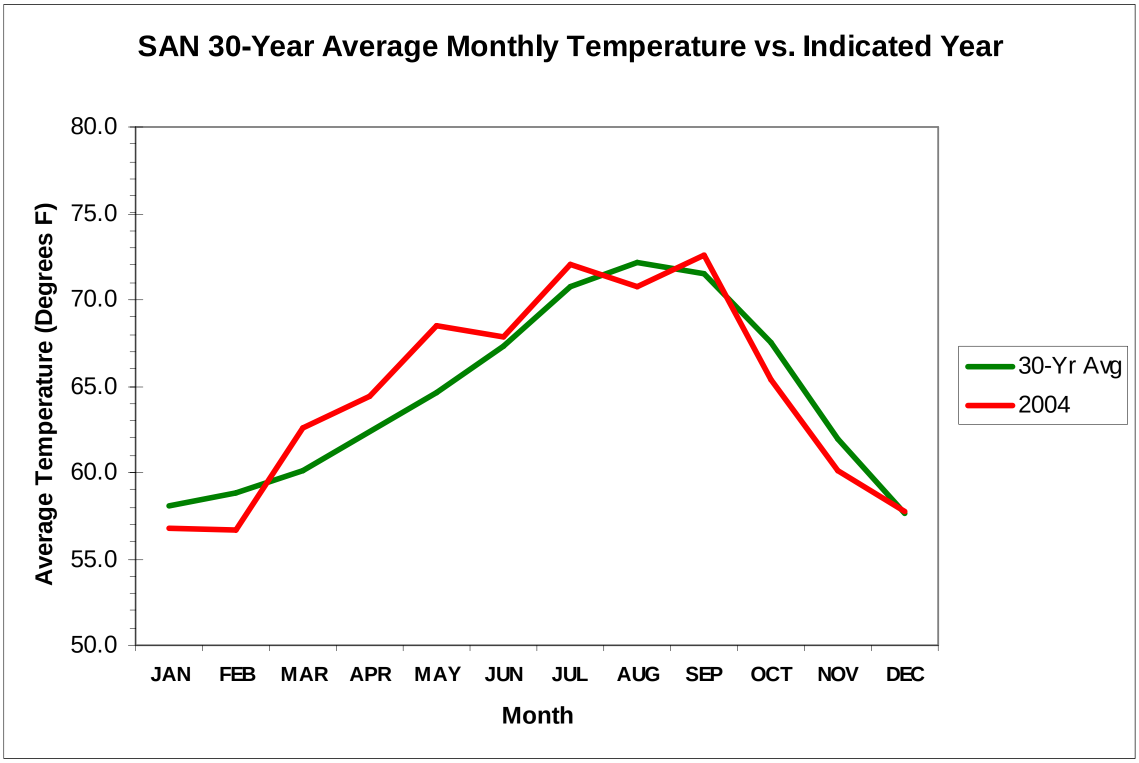
The normal 8-hour ozone season for recent years at San Diego is primarily June through September, with June being the month of maximum occurrence, as illustrated in Figure G-5 below.

Figure G-5



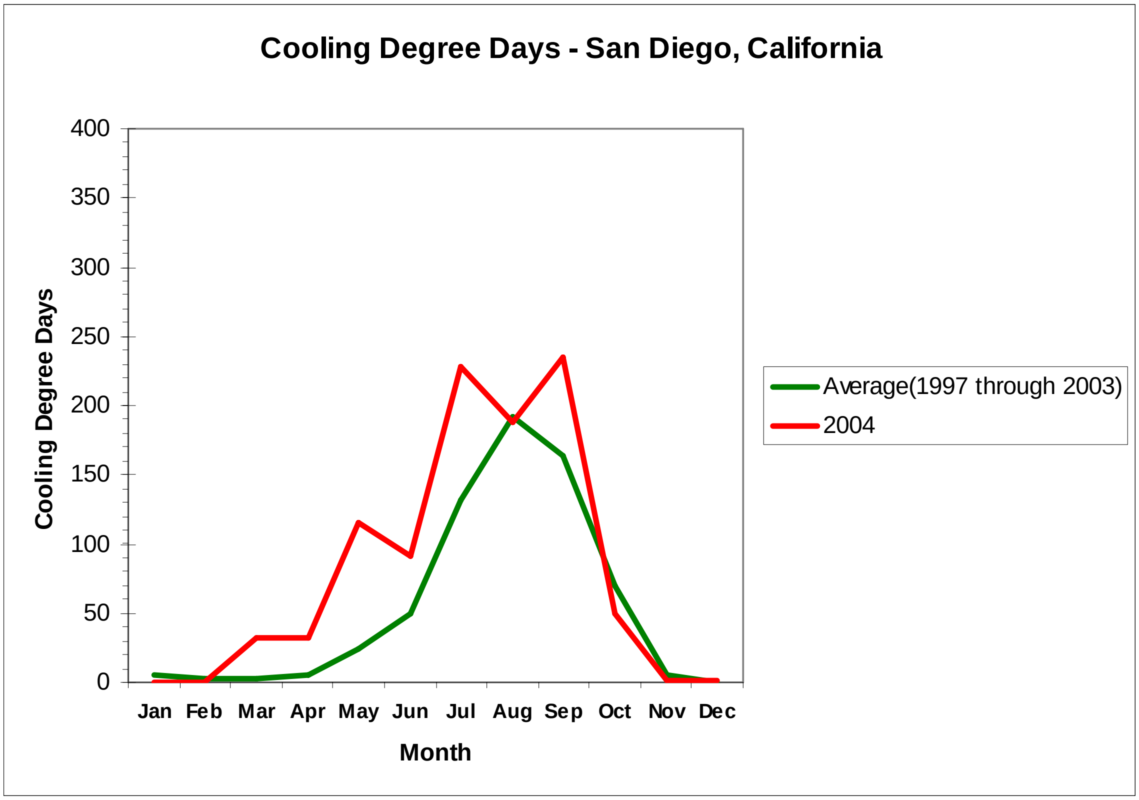
Monthly averaged temperature data for Lindbergh Field (SAN) are also shown in Figure G-6 below for consistency. The average August temperature was slightly cooler than normal at SAN, possibly indicating a deeper marine layer and coastal stratus or extensive high-level cloudiness. However, August is typically not the month of maximum ozone exceedances and therefore the more typical months of June and July would have had a greater influence on the annual totals.

Figure G-6



Further evidence that 2004 was not an anomalous year climatologically is shown by the cooling degree data for San Diego. One cooling degree-day is given for each degree that the daily mean temperature departs above the base of 75° F. Figure G-7 below shows the monthly cooling degree day averages for the years 1997 through 2003 and the monthly cooling degree values for 2004. This graph shows that in 2004 the cooling degree day values were near normal in June and August and slightly above normal for July and September. Therefore, during the 2004 ozone season the cooling degree day values were higher than normal, but not significantly.

Figure G-7



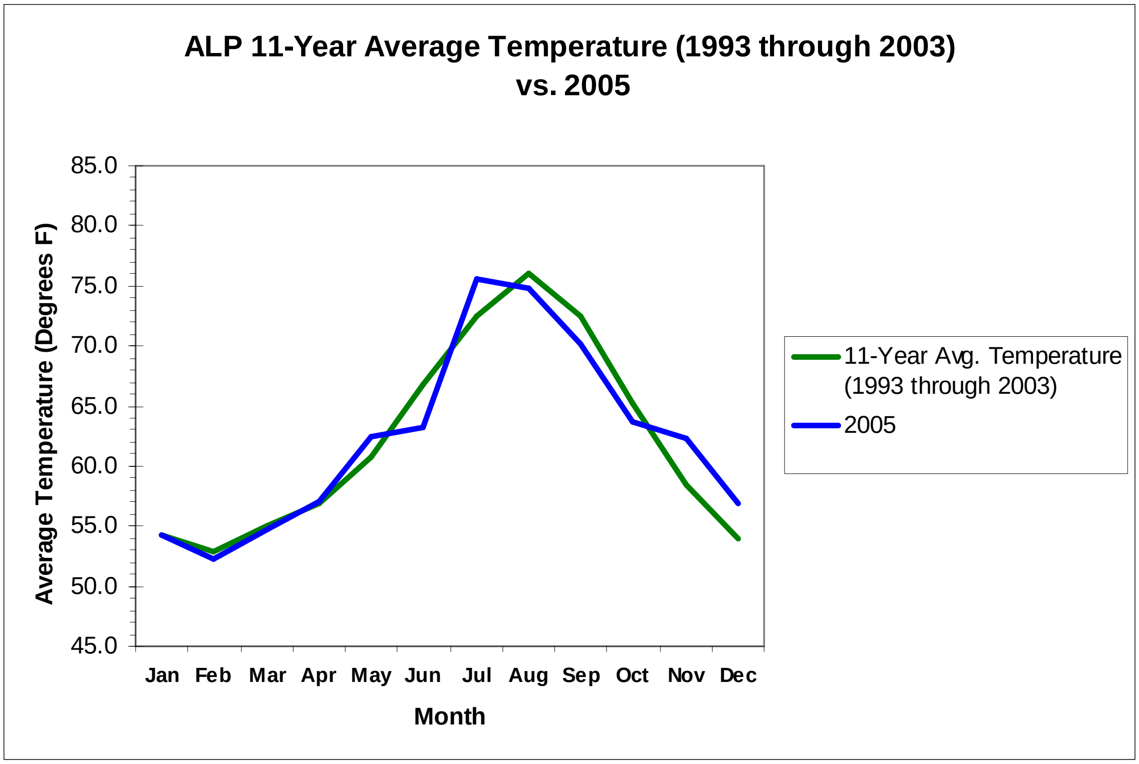
Climatologically, 2004 was near normal in terms temperature in San Diego. This "clean air" year was more the result of decreased emissions in Southern California than anomalous climatological conditions.

G.3 2005 – Typical Ozone Year

The clean air quality year of 2004 was followed by a rather typical ozone year in 2005. There were five 8-hour ozone exceedances at Alpine in 2005, versus the 2 measured in 2004, and the 4th highest concentration was 0.087 (still closing in on attainment).

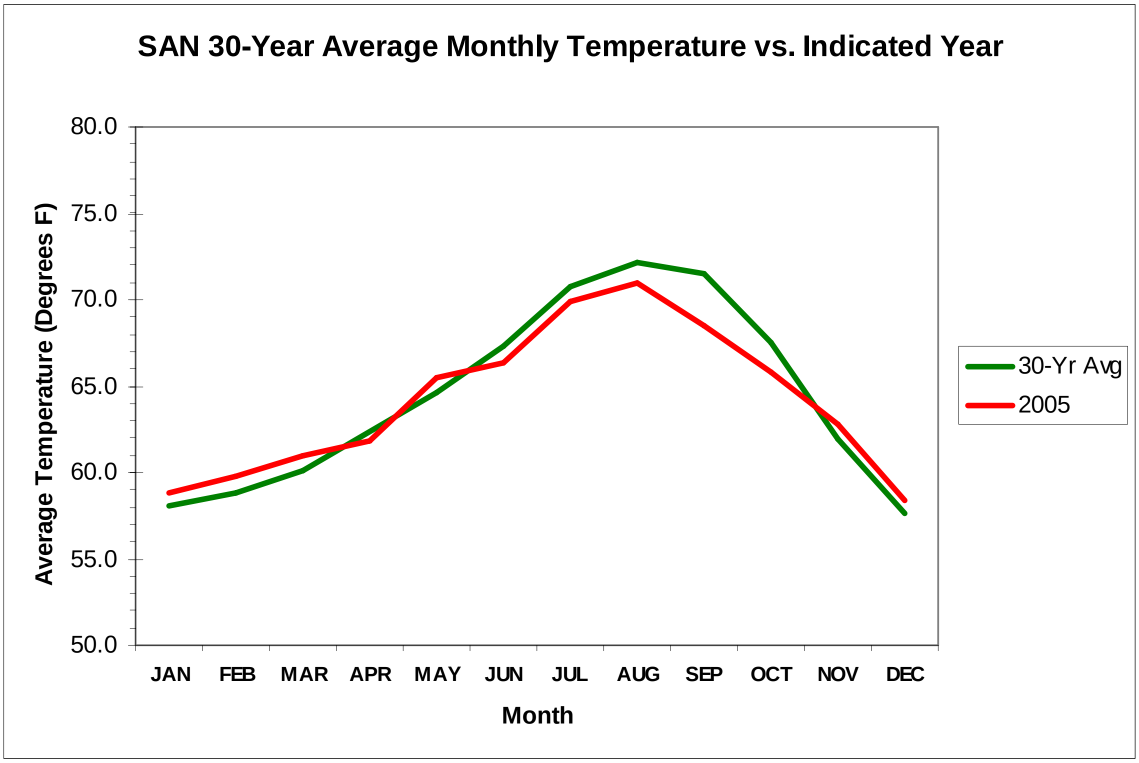
Figure G-8 below shows the average monthly temperatures at the Alpine monitoring station for the year 2005 versus the 11-year averages for the years 1993 (first available year of meteorological data for the Alpine monitoring station) through 2003. This graph shows that average monthly temperatures in 2005 were near the 11-year average for all months of the year.

Figure G-8



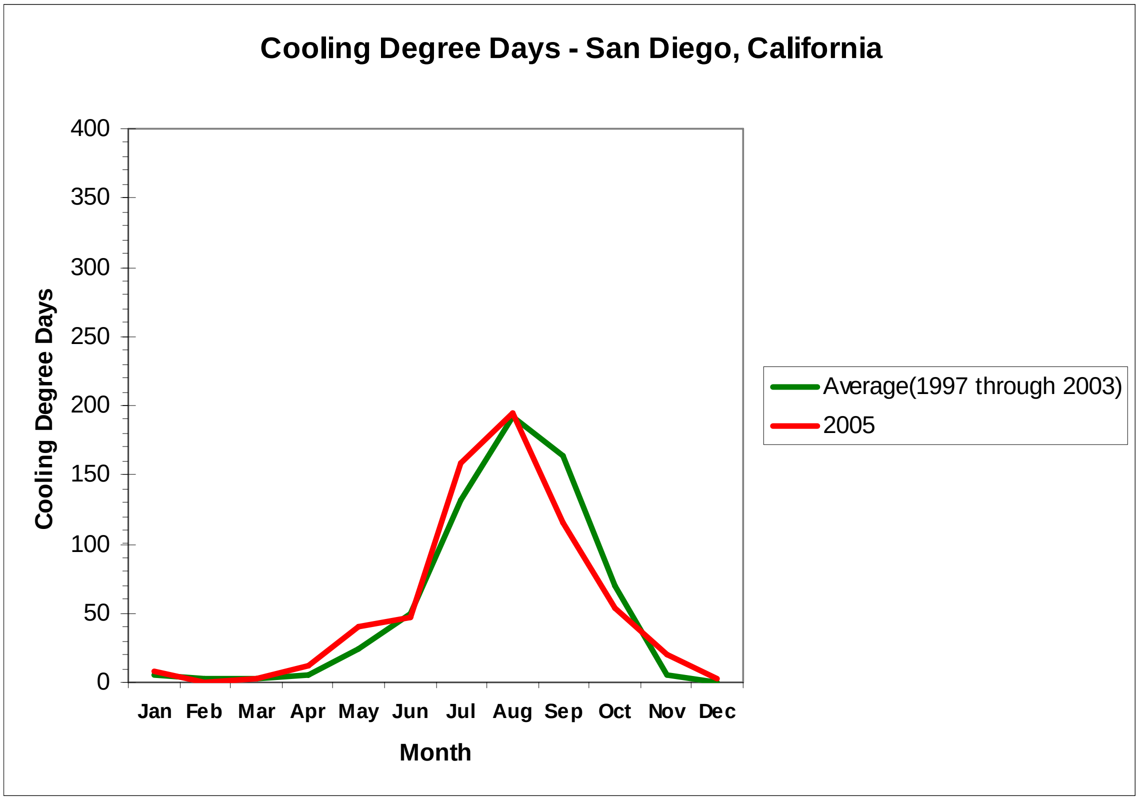
The monthly averaged temperature data for Lindbergh Field (SAN) are also shown in Figure G-9 below for consistency (i.e., data from this location show similar pattern, with September and October slightly below the 30-year average – although these months are on the tail-end of the normal "ozone season"). For the entire year the average temperature at SAN was only 0.9° F warmer than the 30-year average. This represents a fairly typical year for San Diego.

Figure G-9



Further evidence that 2005 was a typical year climatologically is shown by the cooling degree data for San Diego. Figure G-10 below shows the monthly cooling degree day averages for the years 1997 through 2003 and the monthly cooling degree values for 2005. This graph shows that in 2005 the cooling degree day values were near normal in June, July, and August and slightly below normal for September and October. Therefore, during the 2005 ozone season the cooling degree day values were very close to normal.

Figure G-10



The 4th high 8-hour ozone concentration for 2005 was only 0.002 ppm higher than the standard – attainment is in sight!

G.4 2006 Heat Wave – High Ozone

In contrast to the years 2004 and 2005, 2006 showed a marked increase in the number of 8-hour ozone exceedances in San Diego from previous years (14 in 2006, versus 5 in 2005 and 2 in 2004), and the measured 8-hour concentrations increased as well (4th highest value in 2006 was 0.094 ppm, versus 0.087 ppm in 2005, and 0.083 ppm in 2004).

Warmer temperatures can result in higher ozone concentrations for a variety of reasons. These include increased evaporative emissions, increased biogenic emissions, and more rapid reactivity in the production of ozone. For these reasons warmer than normal temperatures can result in higher than normal ozone concentrations. Prolonged warmer than normal temperatures during the ozone season can also result in a higher than normal number of exceedances of the ozone standard. These conditions can also lead to higher than normal peak 8-hour ozone concentrations.

The summer of 2006 was much warmer than normal, resulting in the higher number of 8-hour ozone exceedances and higher concentrations measured at the Alpine monitoring station. Figure G-11 below shows the average monthly temperatures at the Alpine monitoring station for the year 2006 versus the 11-year averages for the years 1993 (first available year of meteorological data for the Alpine monitoring station) through 2003. This graph shows that average monthly temperatures in 2006 were much higher than normal during June and July, the peak ozone months of the typical ozone season.

Figure G-11

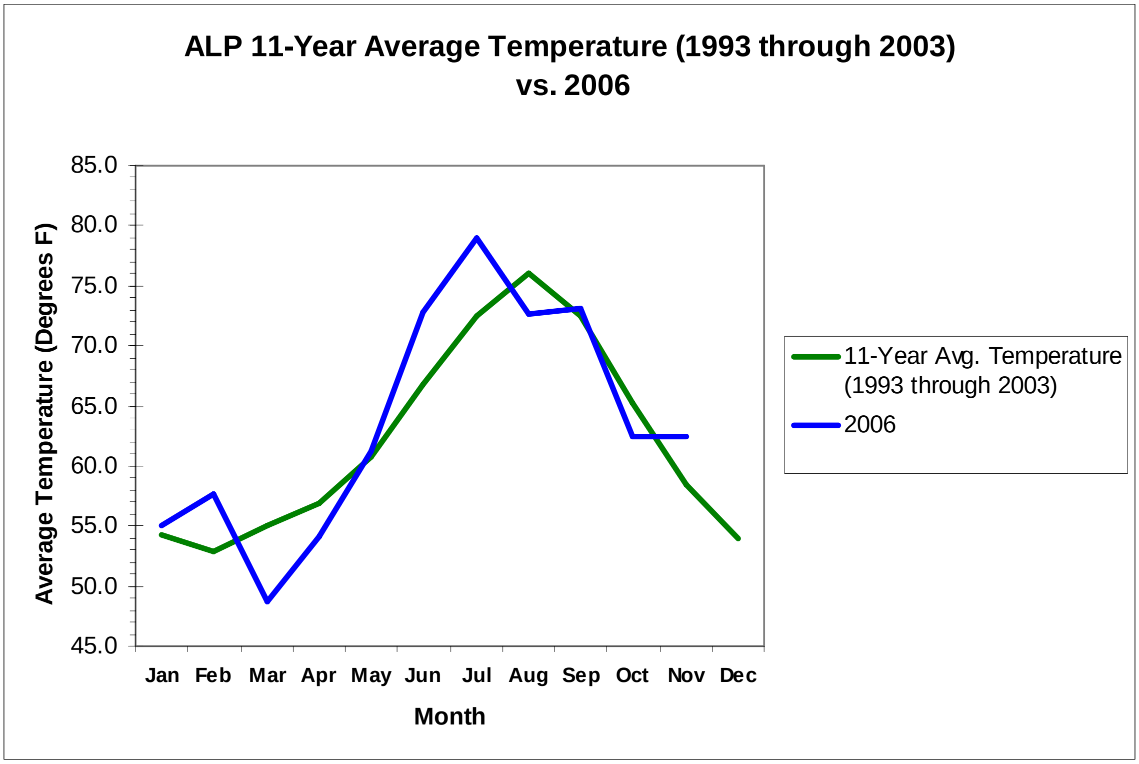


Figure G-12 below shows the monthly average temperature departure from the 11-year mean at Alpine. This chart shows that the average temperature at Alpine was more than 6°F warmer than normal during June and July of 2006.

Figure G-12

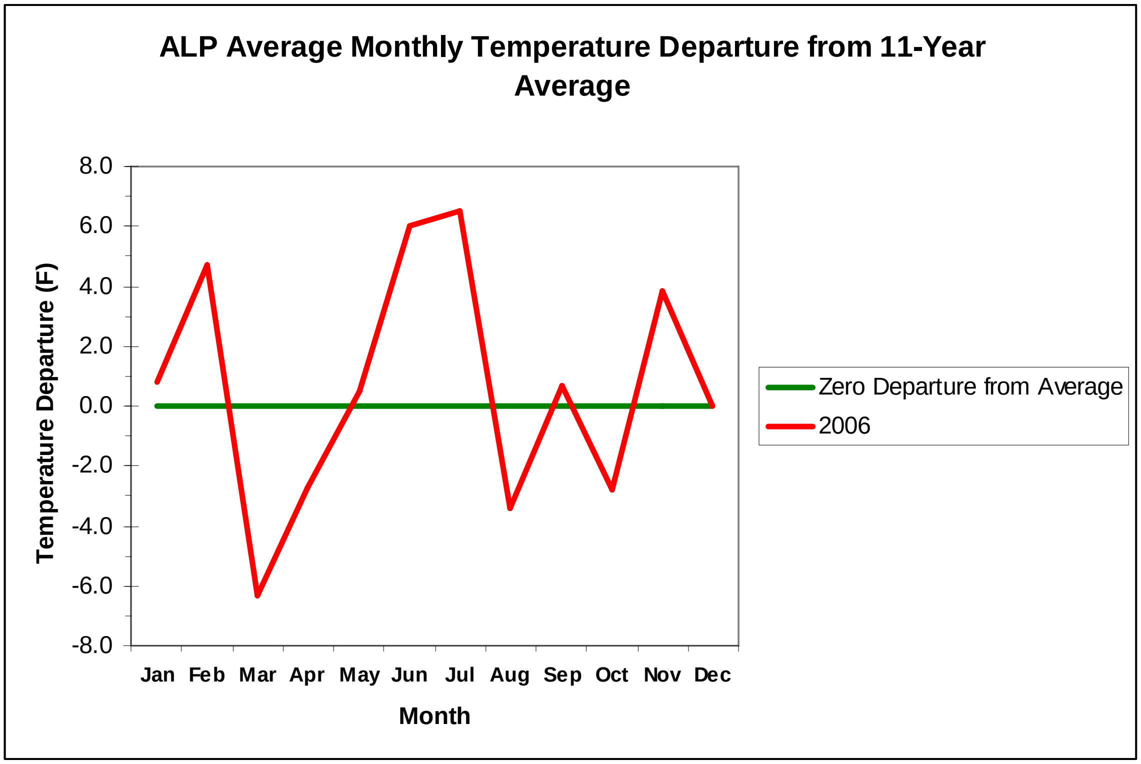


Figure G-13 below shows the average temperature departure plotted along with the number of 8-hour ozone exceedances at Alpine during 2006.

Figure G-13

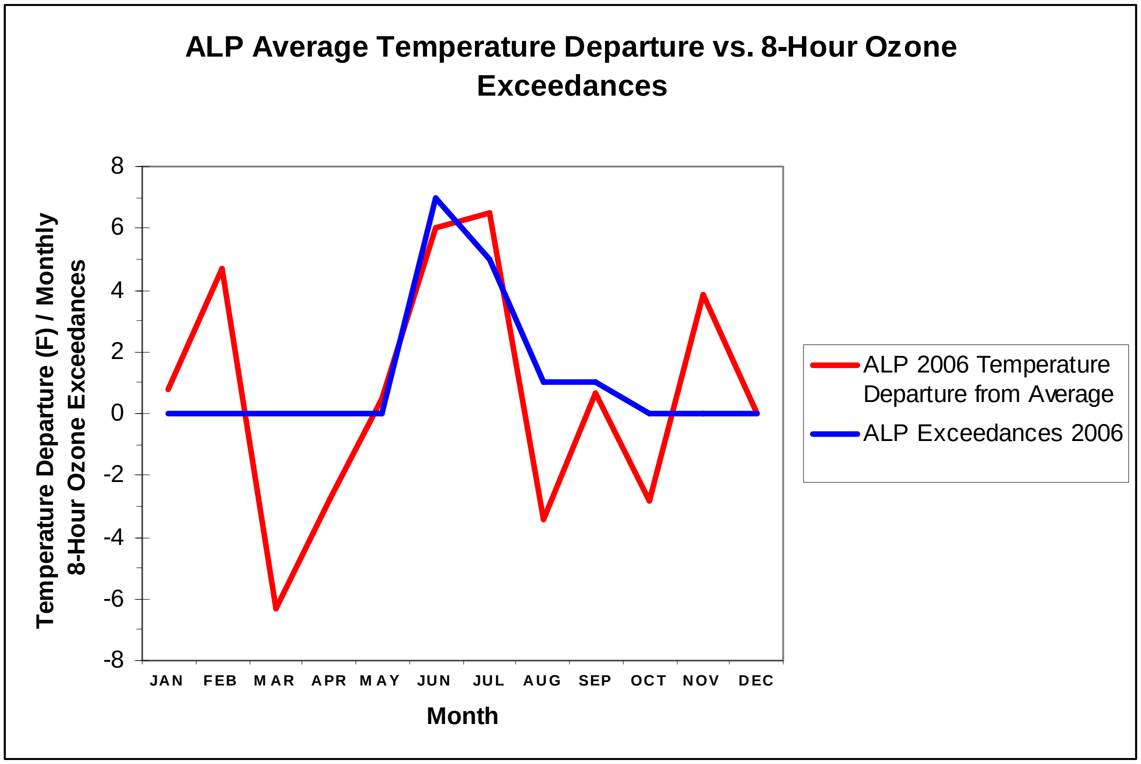
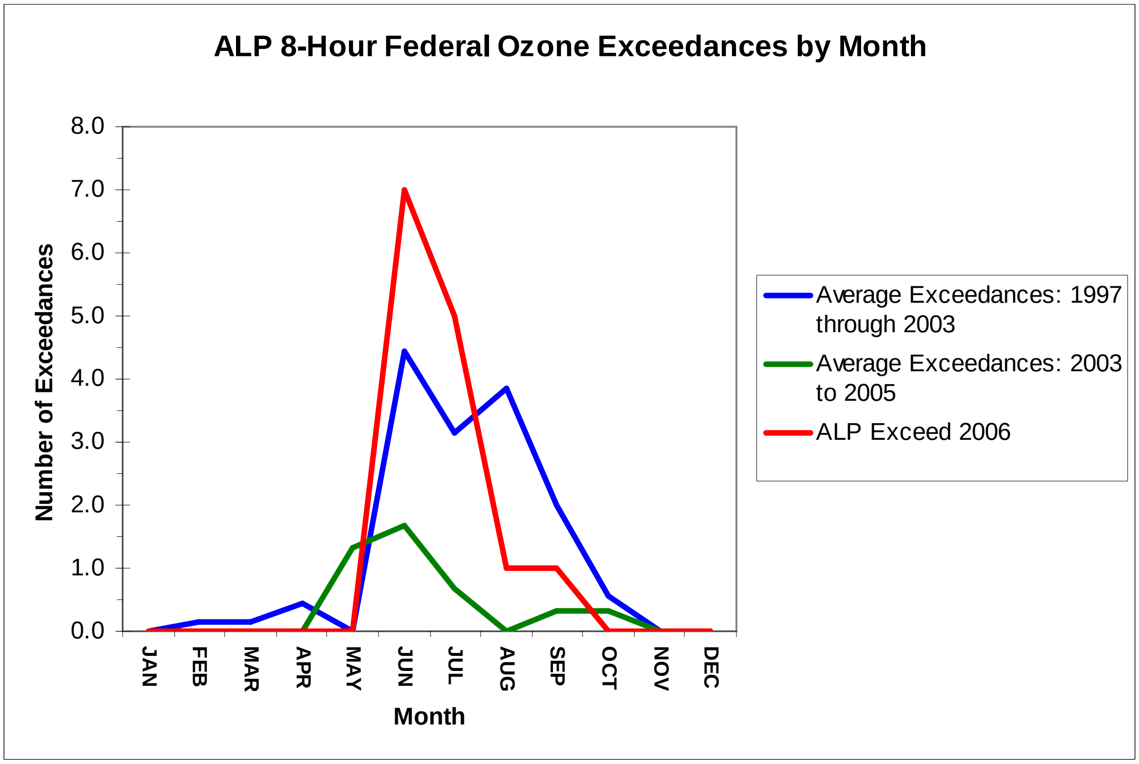


Figure G-14 below shows that the higher than normal number of 8-hour ozone exceedances occurred during June and July of 2006, coinciding with the warmer than normal temperatures.

Figure G-14



The monthly averaged temperature data for Lindbergh Field (SAN) are also shown in Figure G-15 below for consistency. This graph shows that monthly averaged temperatures at SAN were much warmer than the 30-year average for June and July (3.5° F and 5.6° F, respectively), and warmer during August as well (1.1° F).

Figure G-15

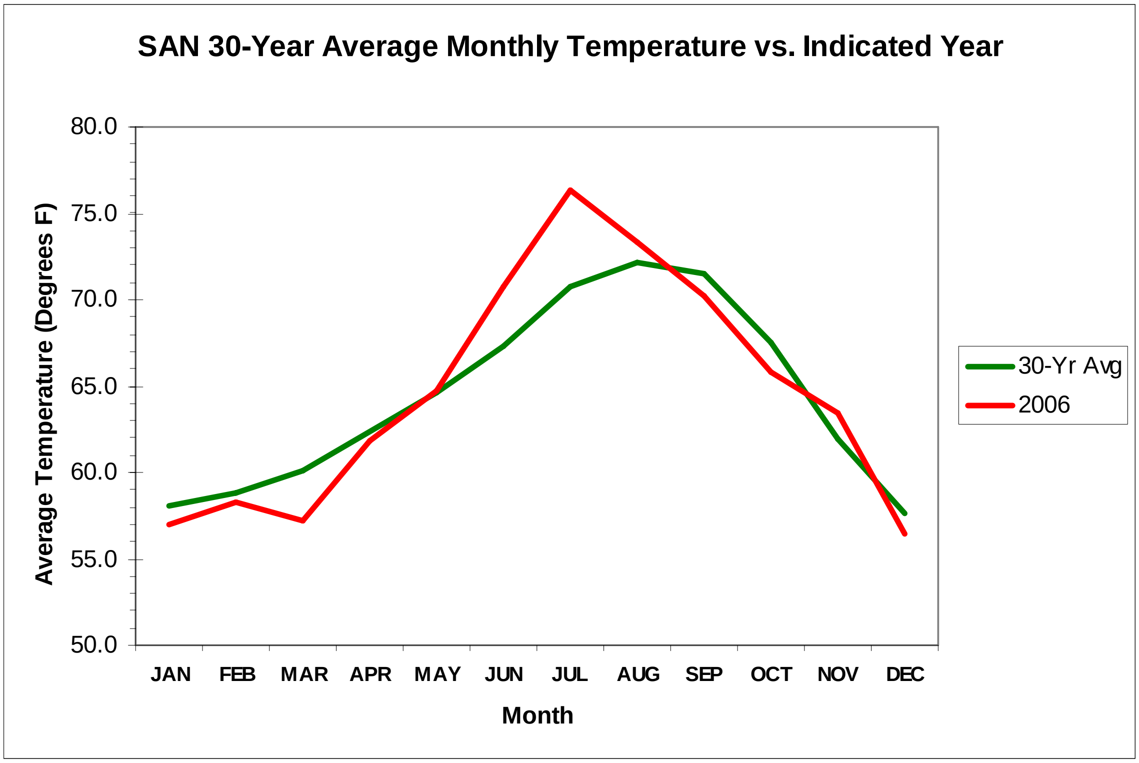
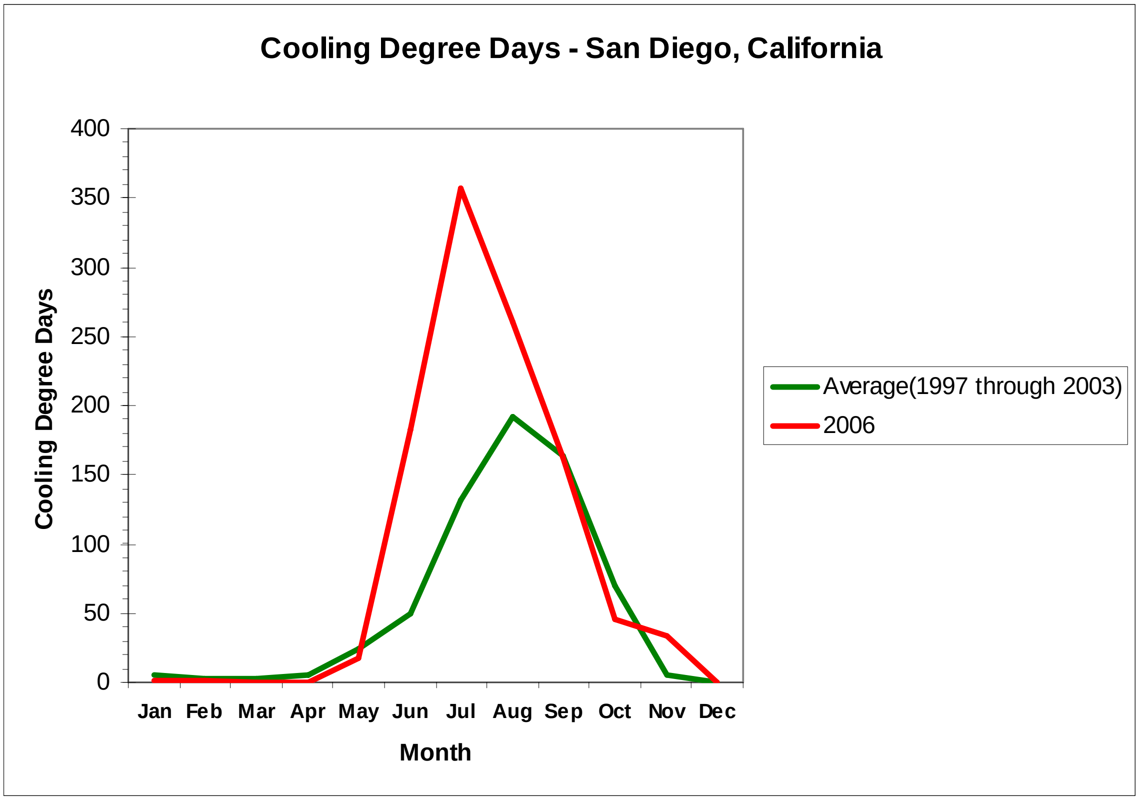


Figure G-16 below shows the cooling degree day data for 2006 compared to the 1997 through 2003 average. This graph shows that the cooling degree values were much higher than normal for June and July, and higher than normal for August. In July 2006 a large portion of California was undergoing a prolonged heat wave, resulting in record electrical energy usage.

The higher than normal number of 8-hour ozone exceedances and the higher concentrations in 2006 were the result of anomalous meteorological conditions. Based on historical records, the likelihood that these anomalous conditions will repeat within the next few years is extremely remote and will not require new or expanded control measures in San Diego County to meet the 8-hour ozone standard.

Figure G-16



ATTACHMENT H

Meteorological and Photochemical Modeling for the San Diego County 2007 Eight-Hour Ozone State Implementation Plan

Meteorological and Photochemical Modeling for the San Diego County 2007 8 Hour Ozone State Implementation Plan

Prepared for

San Diego Air Pollution Control District
10124 Old Grove Road
San Diego, CA 92123

Prepared by

Kit K. Wagner, Ph.D.
Atmospheric Information Systems
P. O. Box 721165
Norman, OK 73070

April 4, 2007

TABLE OF CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

A modeled attainment demonstration is required for the San Diego County portion of the 2007 State Implementation Plan for eight-hour averaged ozone. This document describes the procedures used to apply meteorological and air quality models for that attainment demonstration.

Meteorological and air quality models are used to simulate the meteorological and air quality conditions during two ozone episodes that occurred during the 1997 Southern California Ozone Study (SCOS97) (Croes and Fujita 2003). These episodes occurred August 4-7, 1997, and September 27-28, 1997. SCOS97 provides an extensive meteorological and air quality database that supports the development of a modeling application for the attainment demonstration.

1.1 Conceptual Model of Ozone in San Diego County

Ozone in San Diego County originates from both distant and local sources. The staff of the California Air Resource Board (ARB 1989) have identified the South Coast Air Basin as a source region for ozone and ozone precursors transported into San Diego County. In a later report the staff of the California Air Resource Board (ARB 1993) identified Mexico as a contributor to ozone and ozone precursor transported into San Diego County. These California Air Resource Board (ARB) reports summarize the studies of air pollution transport in California.

Because the predominant wind flow in Southern California is westerly (Hayes et al. 1984) transport from the South Coast Air Basin (SCAB) into San Diego County is infrequent. However, when the westerly flow weakens or is replace by easterly flow the possibility of transport from the SCAB into San Diego County can develop. Hayes et al. (1984) indicate that this happens 23 percent of the time in winter, 17 percent of the time in spring, 14 percent of the time in summer, and 21 percent of the time in the fall. For transport to contribute to a significant air quality impact several other meteorological factors must be present. The pollutants from the SCAB must remain concentrated in a shallow marine layer below an elevated temperature inversion or within a stable inversion layer aloft. Clear sky and low wind speed also contribute to significant transport impacts. Emissions from the SCAB move to near the coast or are transported westward offshore. Subsequent northwesterly winds transport these air pollutants either along a path over the water into San Diego County or along a path inland near the coastline.

Pollutant transport from the SCAB is sufficient to produce high concentrations of ozone at coastal sites without any contribution from San Diego emissions. Transported pollutants can continue to move inland through the County where local emissions are added to produce high ozone concentrations inland.

There are five meteorological scenarios associated with transport that contribute to high ozone concentrations in San Diego County. Each scenario has a unique signature which can be discerned from the surface and upper air meteorological and air quality data. In the first regime, polluted air from the Los Angeles area is transported over the coastal waters into San Diego near the surface (100 to 300 meters above sea level), in or below a surface based or very low elevation marine inversion. High ozone concentrations of ozone are observed at San Diego coastal air monitoring sites near sea level such as Oceanside or Del Mar. Inland sites may have much lower ozone concentrations. Local emissions of NO react with the transported ozone to form NO_2 and reduce the concentration of the transported ozone. Sites near the coast such as Overland observe a lower ozone concentration as the transported pollution arrives than would have been observed in the absence of NO_x scavenging.

In the second regime, polluted air from the Los Angeles area is transported aloft (300 to 500 meters above sea level) over the coastal waters into San Diego near the base or within a slightly elevated marine inversion. As the air moves inland it either encounters the elevated mesas (approximately 150 meter above sea level) in the coastal plain or is mixed downward (fumigated) to the surface. Fumigation occurs because of convection caused by solar heating of the ground surface inland. High ozone concentrations are observed at the inland stations such as Escondido and Overland, while ozone concentrations at the coastal stations are less, being below the ozone aloft. At the inland stations ozone concentrations are low until the transported ozone arrives. Local NO emissions will scavenge the fumigated ozone and local ROG and NO_x emissions may make a contribution to additional ozone generation as the air moves further inland.

The third regime also involves transport aloft, but at a higher elevation (500 to 1000 meters above sea level). The marine layer is deeper and the transport is at the base or in the elevated marine inversion. As the polluted air moves inland into San Diego County the ozone aloft is not fumigated to the surface until the air has reached the inland elevated foothills. High ozone concentrations in this regime are observed at sites such as Alpine.

The fourth transport route is emissions from the Inland Empire (i.e., Riverside County) transported near the surface down the Interstate 15 corridor under northerly wind conditions. This regime usually impacts the air quality at the inland Escondido and Overland monitoring stations.

The fifth regime is for transport of ozone and ozone precursors from Mexico, namely the city of Tijuana, which lies to the south of San Diego. This transport regime requires southerly winds at some time during the day. Southerly winds are usually associated with coastal eddy circulations. These conditions can transport urban pollutants, including ozone, from Tijuana during the daytime hours (impacts Otay Mesa and El Cajon stations), or transport ozone precursors offshore during nighttime drainage along the Tijuana River basin and then back onshore into San Diego County (impacting Chula Vista, Downtown, Otay Mesa, or Overland monitoring stations) the next day.

The meteorological conditions associated with ozone transport are part of the normal atmospheric circulation patterns of Southern California and are therefore repeatable. All ozone transport corridors have been identified through extensive data analysis of past events (ARB 1996).

Emissions in San Diego County are sufficient to generate ozone concentrations exceeding the state and federal standards. Ozone precursors of NO_x and ROG are emitted in the high population density areas near the coast in the morning. Ozone is created by chemical reactions as the sea breeze carries the precursors inland. Maximum ozone concentrations are reached in the early afternoon to the east of the coastal plain. When transport is completely absent, local emissions are the sole source of ozone in the County. This is usually evidenced by a lack of a northerly or southerly component to the wind near the surface and aloft.

1.2 Modeling Protocols

Modeling protocols were prepared to guide the modeled attainment demonstration for San Diego County. General modeling procedures appear in a modeling protocol for Southern California (ARB 2000). Specific modeling procedures for San Diego County appear in a supplement (SDAPCD 2002). These protocols are attached to this document.

2.0 CHARACTERIZATION AND SELECTION OF MODELING EPISODES

August 4-7, 1997, is an ozone episode where both local contributions and transport contributed to exceedances of the ozone standards in San Diego County. Peak one-hour ozone during this episode was 0.12 ppm on August 3 at Alpine and on August 5 at Otay Mesa. Exceedances of the California one-hour standard (0.09 ppm) were wide spread on August 5. Alpine alone exceeded the California one-hour standard on August 6. The peak eight-hour averaged ozone in San Diego County during this episode was 0.099 ppm which occurred at a supplemental monitor (Black Mountain). The highest eight-hour averaged ozone at an official monitor was 0.087 at Alpine on August 5. The peak 1-hour ozone concentration of 0.19 ppm and the peak 8 hour concentration of 0.125 ppm measured in the South Coast air basin during this period were the highest not associated with an exceptional event during SCOS97.

The meteorological conditions during this August 1997, ozone episode have been characterized in detail by Rosenthal et al. (2003) and by Boucouvala and Bornstein (2003). The meteorological episode began on Sunday August 3 under a ridge of high pressure aloft with 500 mb heights in excess of 5900m each day. Weak onshore flow gave way to stagnant winds through the middle of the episode, ultimately resulting in a well developed coastal eddy beginning late on August 6th and continuing into August 7th. The excessive regional surface temperatures and stagnant flow also contributed to a massive wildfire in the mountainous portions of eastern Ventura and southeastern Santa Barbara counties during the later part of the episode.

September 27-28, 1997, is weekend episode. Peak one-hour averaged ozone in San Diego County occurred on Sunday, September 28, with a concentration of 0.11 ppm at Alpine. Additional exceedances of the California one-hour standard occurred at other monitors in the County. Both local sources and transport contributed to the exceedances. Exceedances of the ozone standard on weekends are important in San Diego County. In 1997 forty-two percent of the days with exceedances of the California one-hour ozone standard were on Saturday or Sunday. In 2001 this had increased to fifty-two percent. In San Diego County during this episode 0.096 ppm was the peak eight-hour averaged ozone which occurred at a supplemental monitor (Black Mountain). Eight-hour averaged ozone did not exceed 0.084 ppm at the official monitors during this episode. This episode includes the second highest ozone concentrations measured in the South Coast air basin during a SCOS97 intensive operations period. The peak 1-hour (0.17 ppm) and 8 hour (0.107 ppm) ozone concentrations in the South Coast air basin were both observed at Upland.

3.0 MODELING METHODS

The modeled attainment demonstration is carried out using the Comprehensive Air Quality Model with Extensions (CAMx) to model ozone in San Diego County. Version 4.20 (ENVIRON 2005) of CAMx with the SAPRC99 chemical mechanism is used. CAMx requires emission, meteorological, and air quality data inputs. The procedures used to prepare those inputs are described below.

3.1 Emissions

The emission inputs were prepared by the California Air Resources Board (ARB) staff and delivered to the San Diego Air Pollution Control District (SDAPCD) in CAMx-ready point source and area source emission input files. The ROG emissions were speciated for the SAPRC99 chemical mechanism. The CAMx area source file was delivered in five separate component files:

- area source emissions
- motor vehicle emissions
- biogenic emissions
- smaller point source emissions not placed in the point source file
- Mexico emissions

These components were aggregated into a single CAMx area source input file for the simulation.

The CAMx point source file was delivered in three component files:

- large point source emissions
- large Mexico point source emissions
- wildfire emissions

These components were aggregated into a single CAMx point source file for the simulation.

The ARB provided 1997, 2002, and 2010 emissions for the August 3-7, 1997, period. August 3 is a Sunday. August 4-7 is Monday to Thursday. These emissions were day specific for motor vehicle, biogenic, and wildfire emissions. The area source, large point source, and smaller point source emissions were for a mid-summer weekday and a mid-summer weekend day. The Mexico area source emissions were for a single summer day. The Mexico large point source emissions were not used because of uncertainty in emission rates and locations of sources. The 1997 biogenic and Mexico emissions were used unchanged for 2002 and 2010. Wildfire emissions were not included in the 2002 and 2010 emissions.

For September 24, 25, 26, and 29 (Wednesday, Thursday, Friday, Monday) the area source, small point source, motor vehicle, and large point source emission inputs are the August 4, 1997, (Monday) emissions. For September 27 and 28 (Saturday and Sunday) the area source, small point source, motor vehicle, and large point source emission inputs are the August 3, 1997, (Sunday) emissions. The ARB provided 1997 biogenic emissions for September 27, 1997, which were used for all September days. Mexico emissions are the same as for the August episode. Wildfires were not included in the large point source emissions for the September 24-29. 1997, period or the 2002 and 2010 future year emissions.

The ARB was unable to provide a 2008 emission inventory. The year 2008 is the year required for the modeled attainment demonstration. A 2008 CAMx emission inventory for the August 4-7, 1997, ozone episode was created by projecting the 2010 CAMx area sources, small point sources, large point sources, and motor vehicles emissions back to 2008. The adjustment factors for projecting the modeling emissions, which were developed by the San Diego Air Pollution Control District (SDAPCD) staff, are based on the changes in the planning emission inventories for 1997, 2002, 2008, and 2010. The modeling domain was divided into four regions and separate adjustment factors calculated for each region. The four regions are: (1) offshore north of the Orange County - San Diego County line; (2) offshore south of that line; (3) onshore north of the Orange County/Riverside County - San Diego County line; (4) onshore south of that line. These factors were applied uniformly to all source categories within the general categories. Figure 1 shows the areas in the modeling domain. The adjustment factors are listed in Table 1.

Figure 1. CAMx emissions adjustment regions.

There are several changes in military operations emission sources in 2008 in San Diego County that are not in the ARB 2010 emission inventory. These emission adjustments were made to the 2008 CAMx area source emission file after the 2008 emissions were created from the 2010 emissions using the projection factors in Table 1 and aggregated into the CAMx input file. These emission adjustments are listed in Table 2.

Table 1. Factors to adjust 2010 CAMx emissions to 2008 CAMx emissions.

Emission Component	South Coast Offshore		South Coast Onshore		San Diego Offshore		San Diego Onshore	
	ROG	NOx	ROG	NOx	ROG	NOx	ROG	NOx
Area source	1.005726	0.952796	1.023532	1.116261	1.020826	0.960846	1.016061	1.064352
Small point source	1.023532	1.116261	1.023532	1.116261	1.016061	1.064352	1.016061	1.064352
Motor vehicle	1.143991	1.095840	1.143991	1.095840	1.136895	1.112645	1.136895	1.112645
Biogenic	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mexico	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Large point source	1.023532	1.116261	1.023532	1.116261	1.016061	1.064352	1.016061	1.064352

Table 2. Adjustments to 2008 area source emissions for military operations.

Source	Location: grid cell (west-east, south-north)	NOx (tons/day)	VOC (tons/day)
Offshore San Diego Harbor	(73, 13)	+0.6	0.0
Miramar Air Station	(75, 19)	+1.0	-1.8
Camp Pendleton	(70, 28)	+0.7	-0.1

For 2008 September 24, 25, 26, and 29 (Wednesday, Thursday, Friday, Monday) the area source, small point source, motor vehicle, and large point source emission inputs are the 2008 August 4 (Monday) emissions. For 2008 September 27 and 28 (Saturday and Sunday) the area source, small point source, motor vehicle, and large point source emission inputs are the 2008 August 3 (Sunday) emissions. The ARB provided 1997 biogenic emissions for September 27, 1997, which were used for all September days in 2008. Mexico emissions are the same as for the August episode for 2008.

Emission totals for San Diego County for ROG and NO_x for the August 4-7, 1997, ozone episode for the years 1997, 2002, and 2008 are listed in Tables 3 to 8. Emission totals for San Diego County for ROG and NO_x for the September 27-28, 1997, ozone episode for the years 1997, 2002, and 2008 are listed in Tables 9 to 14. The Mexico emissions listed in the tables occur in grid cells divided by the San Diego County-Mexico border.

Table 3. San Diego County 1997 NOx emissions in tons per day for the August 4-7, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	large point	wild fire	Total point
Sunday 3-Aug	73.2	0.6	105.5	0	5.5	184.9	0.1	4.5	4.5
Monday 4-Aug	89.0	8.7	139.2	0	5.5	242.4	5.8	1.5	7.3
Tuesday 5-Aug	89.0	8.7	144.6	0	5.5	247.7	5.8	0	5.8
Wednesday 6-Aug	89.0	8.7	138.0	0	5.5	241.2	5.8	0	5.8
Thursday 7-Aug	89.0	8.7	134.4	0	5.5	237.6	5.8	1.1	6.9

Table 4. San Diego County 1997 ROG emissions in tons per day for the August 4-7, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	large point	wild fire	Total point
Sunday 3-Aug	147.8	1.4	108.2	130.9	16.0	404.3	0	29.5	29.5
Monday 4-Aug	141.1	15.9	131.7	137.7	16.0	442.4	0.4	9.7	10.1
Tuesday 5-Aug	141.1	15.9	138.8	162.4	16.0	474.2	0.4	0	0.4
Wednesday 6-Aug	141.1	15.9	133.4	139.5	16.0	445.9	0.4	0	0.4
Thursday 7-Aug	141.1	15.9	127.3	86.1	16.0	376.4	0.4	7.3	3.8

Table 5. San Diego County 2002 NOx emissions in tons per day for the August 4-7, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	Total point
Sunday 3-Aug	78.5	0	86.7	0	5.5	168.0	0
Monday 4-Aug	83.2	5.4	118.3	0	5.5	212.5	1.8
Tuesday 5-Aug	83.2	5.4	122.3	0	5.5	216.4	1.8
Wednesday 6-Aug	83.2	5.4	117.4	0	5.5	211.6	1.8
Thursday 7-Aug	83.2	5.4	114.7	0	5.5	208.9	1.8

Table 6. San Diego County 2002 ROG emissions in tons per day for the August 4-7, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	Total point
Sunday 3-Aug	144.8	0.1	73.0	130.9	16.0	364.8	0
Monday 4-Aug	130.7	17.1	88.0	137.7	16.0	390.2	0.4
Tuesday 5-Aug	130.7	17.1	93.4	162.4	16.0	419.6	0.4
Wednesday 6-Aug	130.7	17.1	89.9	139.5	16.0	393.2	0.4
Thursday 7-Aug	130.7	17.1	86.2	86.1	16.0	336.1	0.4

Table 7. San Diego County 2008 NOx emissions in tons per day for the August 4-7, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	Total area*	Total point
Sunday 3-Aug	79.2	0	64.0	0	5.5	148.7	151.0	0
Monday 4-Aug	82.1	6.5	91.8	0	5.5	186.0	188.3	3.6
Tuesday 5-Aug	82.1	6.5	94.2	0	5.5	188.4	190.7	3.6
Wednesday 6-Aug	82.1	6.5	91.1	0	5.5	185.3	187.6	3.6
Thursday 7-Aug	82.1	6.5	89.6	0	5.5	183.8	186.1	3.6

*Total includes adjustments for military operations emissions.

Table 8. San Diego County 2008 ROG emissions in tons per day for the August 4-7, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	Total area*	Total point
Sunday 3-Aug	129.2	0	48.1	130.9	16.0	324.2	322.4	0
Monday 4-Aug	127.0	20.7	58.4	137.7	16.0	359.8	357.9	0.8
Tuesday 5-Aug	127.0	20.7	62.1	162.4	16.0	388.2	386.3	0.8
Wednesday 6-Aug	127.0	20.7	59.3	139.5	16.0	362.5	360.7	0.8
Thursday 7-Aug	127.0	20.7	56.1	86.1	16.0	305.9	304.0	0.8

*Total includes adjustments for military operations emissions.

Table 9. San Diego County 1997 NOx emissions in tons per day for the September 27-28, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	Total point
Thursday 25-Sep	89.0	8.7	139.2	0	5.5	242.4	5.8
Friday 26-Sep	89.0	8.7	139.2	0	5.5	242.4	5.8
Saturday 27-Sep	73.2	0.6	105.5	0	5.5	184.8	0.1
Sunday 28-Sep	73.2	0.6	105.5	0	5.5	184.8	0.1
Monday 29-Sep	89.0	8.7	139.2	0	5.5	242.4	5.8

Table 10. San Diego County 1997 ROG emissions in tons per day for the September 27-28, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	Total point
Thursday 25-Sep	141.1	15.9	131.7	61.8	16.0	366.6	0.4
Friday 26-Sep	141.1	15.9	131.7	61.8	16.0	366.6	0.4
Saturday 27-Sep	147.8	1.4	108.2	61.8	16.0	335.2	0.0
Sunday 28-Sep	147.8	1.4	108.2	61.8	16.0	335.2	0.0
Monday 29-Sep	141.1	15.9	131.7	61.8	16.0	366.6	0.4

Table 11. San Diego County 2002 NOx emissions in tons per day for the September 27-28, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	Total point
Thursday 25-Sep	83.2	5.4	118.3	0	5.5	212.5	1.8
Friday 26-Sep	83.2	5.4	118.3	0	5.5	212.5	1.8
Saturday 27-Sep	75.8	0	86.7	0	5.5	168.0	0
Sunday 28-Sep	75.8	0	86.7	0	5.5	168.0	0
Monday 29-Sep	83.2	5.4	118.3	0	5.5	212.5	1.8

Table 12. San Diego County 2002 ROG emissions in tons per day for the September 27-28, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	Total point
Thursday 25-Sep	130.7	17.1	88.8	61.8	16.0	314.4	0.4
Friday 26-Sep	130.7	17.1	88.8	61.8	16.0	314.4	0.4
Saturday 27-Sep	144.8	0.1	73.0	61.8	16.0	295.7	0.0
Sunday 28-Sep	144.8	0.1	73.0	61.8	16.0	295.7	0.0
Monday 29-Sep	130.7	17.1	88.8	61.8	16.0	314.4	0.4

Table 13. San Diego County 2008 NOx emissions in tons per day for the September 27-28, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total Area	Total area*	Total point
Thursday 25-Sep	82.1	6.5	91.8	0	5.5	186.0	188.3	3.6
Friday 26-Sep	82.1	6.5	91.8	0	5.5	186.0	188.3	3.6
Saturday 27-Sep	79.2	0	64.0	0	5.5	148.7	151.0	0
Sunday 28-Sep	79.2	0	64.0	0	5.5	148.7	151.0	0
Monday 29-Sep	82.1	6.5	91.8	0	5.5	186.0	188.3	3.6

*Total includes adjustments for military operations emissions.

Table 14. San Diego County 2008 ROG emissions in tons per day for the September 27-28, 1997, ozone episode.

Day	area	small point	motor vehicle	biogenic	Mexico	Total area	Total area*	Total point
Thursday 25-Sep	127.0	20.7	58.4	61.8	16.0	283.9	282.1	0.8
Friday 26-Sep	127.0	20.7	58.4	61.8	16.0	283.9	282.1	0.8
Saturday 27-Sep	129.2	0	48.1	61.8	16.0	255.1	253.4	0
Sunday 28-Sep	129.2	0	48.1	61.8	16.0	255.1	253.4	0
Monday 29-Sep	127.0	20.7	58.4	61.8	16.0	283.9	282.1	0.8

*Total includes adjustments for military operations emissions.

3.2 Meteorology

3.2.1 Meteorological Model Selection

Sonoma Technology Inc. (STI) (Wheeler 2003) examined prior meteorological modeling of the SCOS97 episodes. STI recommended that the SDAPCD use MM5 for its meteorological modeling. The STI report also made specific recommendations for implementing MM5 for San Diego County. MM5 is a prognostic non-hydrostatic mesoscale model. The application of MM5 in California has been described by Seaman et al. (1995).

A second meteorological model, CALMET (Scire et al. 2000), is also used in the preparation of meteorological inputs to the air quality model. CALMET is a diagnostic meteorological model with extensive micro-meteorological parameterizations of the atmospheric boundary layer. CALMET is used to calculate the planetary boundary layer heights for estimating the atmospheric vertical mixing coefficients for CAMx.

3.2.2 Domain, Terrain, and Land Use

The meteorological modeling uses the same domains as indicated in the modeling protocols (ARB 2000, SDAPCD 2002) except the 5 km resolution interior domain is expanded to provide boundary cells on each side of the photochemical modeling domain. MM5 is executed on three nested domains. The outer coarse domain has a resolution of 45 km grid cells. This coarse domain is 63 cells east-west by 61 cells north-south. The next interior domain has a resolution of 15 km grid cells with 85 cells east-west and 91 cells north-south. The innermost domain has a resolution of 5 km grid cells with 91 grid cells east-west and 127 grid cells north-south. The domains are defined as:

- A Lambert Conformal map projection
- True latitudes of 30.0 degrees North and 60.0 degrees North
- A central longitude of 118.00 degree West
- The center of the projection is at 34.54 degrees North and 118.0 degrees West
- The center of the coarse 45 km resolution domain (63 x 61) is at 34.54 degrees North and 118.0 degrees West.
- The southwest corner grid cell of the 15 km resolution domain (91 x 85) is at cell 17 east-west, 17 north-south in the 45 km resolution domain
- The southwest corner grid cell of the 5 km resolution domain (127 x 91) is at cell 23 east-west, 25 north-south in the 15 km resolution domain

The three nested grids are shown in Figure 2. The meteorological variables from the 5km MM5 grid are mapped into the CAMx grid. The CAMx grid is offset to the northeast of the MM5 5 km grid. This offset is to allow for the 5 boundary cells on each side of the MM5 5 km grid to surround the CAMx grid.

The terrain elevations are defined in the MM5 TERRAIN file. Terrain elevations are extracted from a database from the National Center for Atmospheric Research (NCAR). The terrain elevations for the coarse grid are determined from 5 arc-minute resolution terrain data. The terrain elevations for the 15 km grid are determined from 2 arc-minute resolution terrain data. The terrain elevations for the 5 km grid are determined from 30 arc second resolution terrain data. The actual terrain elevations from the databases are used to create the TERRAIN file.

Land use for each grid cell is defined in the TERRAIN file. As with the terrain elevations NCAR 5 arc-minute, 2 arc-minute, and 30 arc second data are used for the three domains. The 25 category land use data is used. The land use in the grid cells where the Salton Sea is located is changed from water to wetland as recommended by Wheeler (2003). The high temperatures of the Salton Sea and surrounding land are inconsistent with the parameterization of the area as a water body.

The TERRAIN file for the 5 km domain and for those grid cells covered by the Salton sea was edited to change the land use category from water (category 16) to wetland (category 17). The LANDUSE.TBL file for MM5 was edited for category 17 to specify albedo, emissivity fraction, roughness length, snow effect factor, and bulk heat capacity to be the same as a water body. Soil moisture availability fraction was changed to 0.50.

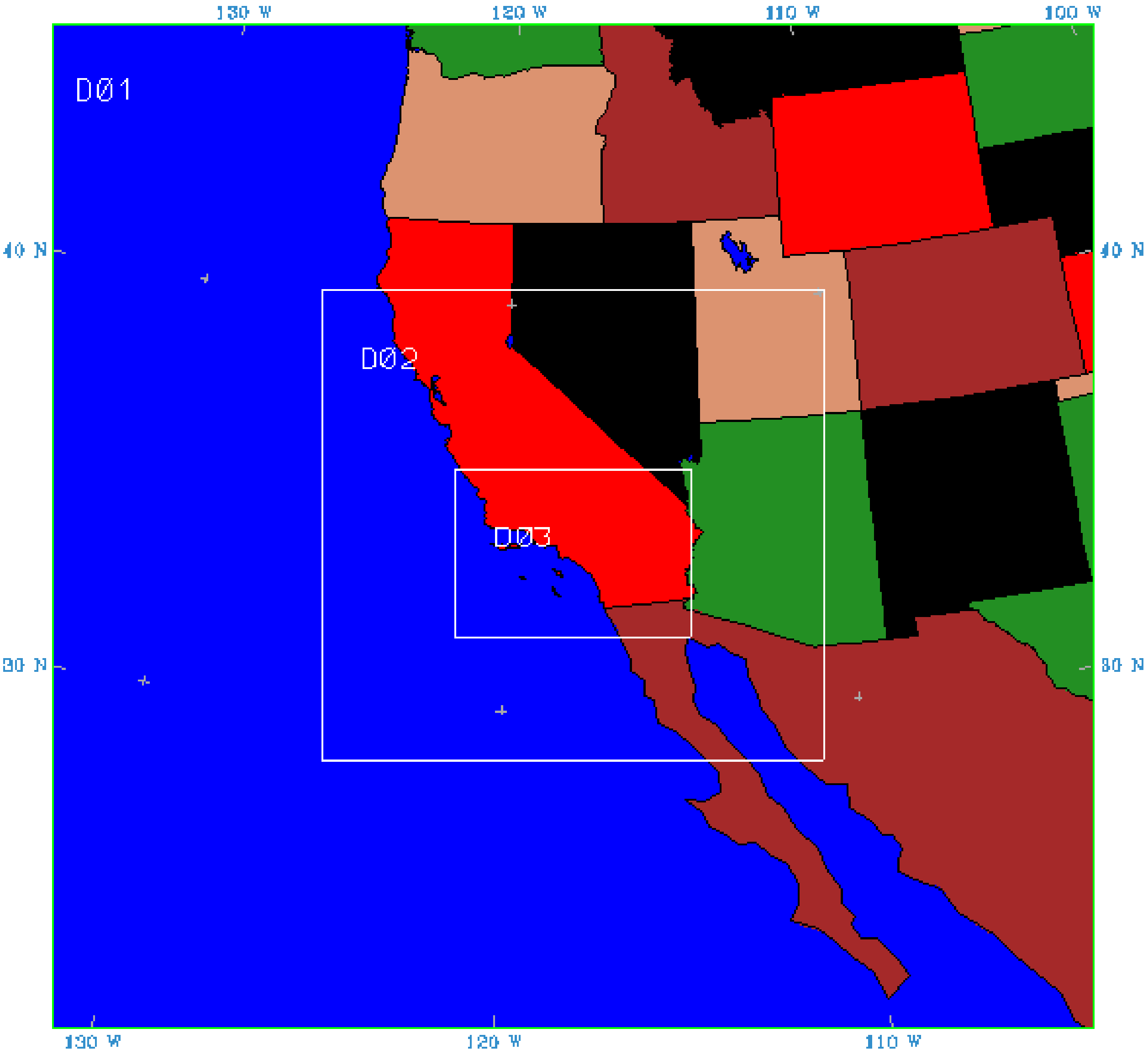


Figure 2. MM5 nested grids: D01 45 km grid; D02 15 km grid; D03 5 km grid.

3.2.3 Initial Conditions - August 3-8, 1997

The MM5 simulation is initialized at 1200 UTC on August 3, 1997, and run 120 hours until 1200 UTC on August 8, 1997. The first step in preparing the initial conditions and boundary conditions for MM5 is to create the REGRID file. This file has horizontal two dimensional slabs of meteorological data such as winds, temperature, and moisture specified on several pressure surfaces (such as 500hPa) for each of a domain's grid cells. These meteorological fields are interpolated from global or regional analyses on a different grid to the specific grid structure of the MM5 domains. Subsequent steps will interpolate the data vertically to the MM5 vertical grid structure.

Input data for this step come from global or large scale meteorological analyses. The National Center for Environmental Prediction (NCEP) Eta Data Assimilation System (EDAS) database is used as input. The NCEP EDAS are three-dimensional fields of meteorological variables at 40 km spatial resolution analyzed every 3 hours.

For sea surface temperature (SST) inputs we obtained SST data from the California Institute of Technology Jet Propulsion Laboratory (JPL) web site. JPL archives the NOAA/ NASA AVHRR Oceans Pathfinder sea surface temperature data which are derived from the 5-channel Advanced Very High Resolution Radiometers (AVHRR) on board the NOAA -7, -9, -11 and -14 polar orbiting satellites. We obtained the 9 km resolution SST data for the August 1997 monthly averaged sea surface temperatures. We used the monthly averaged data set because the daily data have many spatial gaps due to cloud cover. There are two monthly data sets, one for daytime SSTs and one for nighttime SSTs. We applied the daytime SSTs at 12 and 18 UTC and the nighttime SSTs at 00 and 06 UTC.

The next steps in preparing the initial and boundary conditions and four-dimensional data assimilation (FDDA) inputs are the RAWINS/LITTLE_R and INTERP preprocessors. The RAWINS and LITTLE_R are two different versions of preprocessor programs that use the REGRID output analyses as a first guess and then interpolates observed upper air and surface data to create analyses on pressure surfaces. The purpose of this step is to introduce higher spatial resolution observational data into the coarser spatial resolution global or regional analyses. Because the EDAS data already have surface and upper air observations on a smaller scale contributing to the analysis the RAWINS/LITTLE_R processors were not run. The output from REGRID was input directly into the INTERP processor.

The INTERP preprocessor interpolates the output from REGRID vertically to the MM5 vertical coordinates. We used a 30-layer vertical grid structure for MM5. The vertical grid structure is defined in MM5 in a sigma coordinate system based on pressure, (P), normalized by the difference between the surface pressure, (P_s), and the pressure at the top of the domain, (P_t).

$$\sigma = (P - P_t)/(P_s - P_t)$$

The 31 sigma levels at the top and bottom of the 30 vertical layers are specified in Table 15. The height and pressure are calculated for a reference atmosphere with surface pressure of 100000Pa, surface temperature 275K, lapse rate of 50 K/lnP, and 10000Pa pressure at the top.

Table 15. Vertical structure of MM5 grid.

Layer Top and Bottom			Layer Center		
sigma	Pressure Pa	Height meters	½ sigmas	Pressure Pa	Height meters
0	10000	14649			
0.035	13150	13314	0.0175	11575	13950
0.07	16300	12189	0.0525	14725	12730
0.11	19900	11084	0.09	18100	11616
0.156	24040	9984	0.133	21970	10514
0.199	27910	9077	0.1775	25975	9518
0.241	31690	8281	0.22	29800	8669
0.284	35560	7538	0.2625	33625	7901
0.326	39340	6870	0.305	37450	7197
0.372	43480	6194	0.349	41410	6526
0.423	48070	5502	0.3975	45775	5841
0.464	51760	4982	0.4435	49915	5238
0.508	55720	4456	0.486	53740	4715
0.552	59680	3958	0.53	57700	4204
0.6	64000	3445	0.576	61840	3698
0.65	68500	2940	0.625	66250	3189
0.698	72820	2479	0.674	70660	2706
0.74	76600	2093	0.719	74710	2284
0.777	79930	1766	0.7585	78265	1928
0.814	83260	1450	0.7955	81595	1606
0.84	85600	1233	0.827	84430	1341
0.866	87940	1022	0.853	86770	1127
0.884	89560	878	0.875	88750	950
0.902	91180	737	0.893	90370	807
0.918	92620	613	0.91	91900	674
0.934	94060	490	0.926	93340	551
0.95	95500	369	0.942	94780	429
0.966	96940	249	0.958	96220	309
0.98	98200	146	0.973	97570	198
0.992	99280	58	0.986	98740	102
1	100000	0	0.996	99640	29

3.2.4 MM5 Parameters and Four Dimensional Data Assimilation - August 3-8, 1997

Various parameters for MM5 are set to govern the execution of the simulation. The ICUPA control parameter is set to1 for the 5 km domain to turn off cumulus parameterization. The parameter ICUPA was set to 6, Kain-Fritch parameterization, for the 45 km and 15 km domains. To change the moisture availability for grassland, shrubland and irrigated cropland we modified the LANDUSE.TBL file which is read during MM5 execution. We made additional changes to the LANDUSE.TBL file for roughness length to implement recommendations from Boucouvala et al. (2003). The values for the parameters in LANDUSE.TBL are shown in Table 16. The soil treatment was simplified by setting the control parameter ISOIL to 0 which implements the Blackadar force/restore slab model.

The MM5 simulation used four dimensional data assimilation (FDDA) with observed meteorological analyses and observation to “nudge” the predictions toward the observed state. The observational data set includes SCOS97 surface and radar wind profiler meteorological observations. The parameters used for FDDA are indicated below where the MM5 input stream for FDDA parameters are reproduced for the August 3-8, 1997, MM5 simulation. The first parameter value on a line is for the 45 km domain, the second for the 15 km domain, and the third for the 5 km domain.

```
;    **************** ANALYSIS NUDGING *****************
;     IS THIS A GRID 4DDA RUN? 0 = NO; 1 = YES
I4D= 1,1,1,      ;Three-dimensional analysis nudging
      0,1,0,     ;Surface analysis nudging

 ;     SPECIFY THE TIME IN MINUTES BETWEEN THE INPUT USED FOR GRID FDDA
 DIFTIM=360.,360.,360.,        ; Three-dimensional analysis nudging
          180.,180.,180.,      ; Surface analysis nudging

 IWIND=1,1,1,  ;Three-dimensional analysis nudging
         0,1,0,  ; Surface analysis nudging

;     NUDGING COEFFICIENT FOR WINDS ANALYSES
 GV=2.5E-4,2.5E-4,1.0E-4,      ; Three-dimensional analysis nudging
     2.5E-4,2.5E-4,1.0E-4,     ; Surface analysis nudging

;     GRID NUDGE THE TEMPERATURE FIELD? 0 = NO; 1 = YES
 ITEMP=1,1,0,  ; Three-dimensional analysis nudging
         0,0,0, ; Surface analysis nudging

;     NUDGING COEFFICIENT FOR TEMPERATURE ANALYSES
 GT=2.5E-4,2.5E-4,1.0E-4,      ; 3D ANALYSIS NUDGING
     2.5E-4,2.5E-4,1.0E-4,     ; SFC ANALYSIS NUDGING

 IMOIS=1,1,0,   ; 3D ANALYSIS NUDGING
         0,0,0,   ; SFC ANALYSIS NUDGING
```

```
;       NUDGING COEFFICIENT FOR THE MIXING RATIO ANALYSES
GQ=1.E-5,1.E-5,1.0E-5,        ; 3D ANALYSIS NUDGING
        1.E-5,1.E-5,1.0E-5,      ; SFC ANALYSIS NUDGING

;       GRID NUDGE THE ROTATIONAL WIND FIELD? 0 = NO; 1 = YES
IROT=0,0,0,    ; 3D ANALYSIS NUDGING

;       NUDGING COEFFICIENT FOR THE ROTATIONAL COMPONENT OF THE WINDS
GR=0.,0.,0.,         ; 3D ANALYSIS NUDGING

;        IF GRID NUDGING (I4D(1,1)=1) AND YOU WISH TO EXCLUDE THE
;        BOUNDARY LAYER FROM FDDA OF COARSE GRID THREE DIMENSIONAL
;        DATA (USUALLY FROM INTERP),
;             0 = NO,  INCLUDE BOUNDARY LAYER NUDGING
;             1 = YES, EXCLUDE BOUNDARY LAYER NUDGING
INONBL =1,0,0,        ; U WIND
                  1,0,0,        ; V WIND
                  1,1,1,        ; TEMPERATURE
                   1,1,1,        ; MIXING RATIO

;        RADIUS OF INFLUENCE FOR SURFACE ANALYSIS (KM).
RINBLW=250.,

;      **************** OBSERVATION NUDGING ***************

;       IS THIS INDIVIDUAL OBSERVATION NUDGING? 0 = NO; 1 = YES
I4DI   =0,1,1,

;       OBS NUDGE THE WIND FIELD FROM STATION DATA? 0 = NO; 1 = YES
ISWIND =0,1,1,

;       NUDGING COEFFICIENT FOR WINDS FROM STATION DATA
GIV  =4.E-3,4.E-3,4.E-3,

;      OBS NUDGE THE TEMPERATURE FIELD FROM STATION DATA? 0 = NO; 1 = YES
ISTEMP=0,1,1,

;       NUDGING COEFFICIENT FOR TEMPERATURES FROM STATION DATA
GIT  =4.E-4,4.E-4,4.E-4,

;       OBS NUDGE THE MIXING RATIO FIELD FROM STATION DATA? 0 = NO; 1 = YES
ISMOIS=0,1,1,

;       NUDGING COEFFICIENT FOR THE MIXING RATIO FROM STATION DATA
GIQ  =4.E-4,4.E-4,4.E-4,

RINXY=30.,

RINSIG=0.001,
```

```
TWINDO=40.0,

;     FREQUENCY (IN CGM TIMESTEPS) TO COMPUTE OBS NUDGING WEIGHTS
IONF=2,

IDYNIN=0,  ;for dynamic initialization using a ramp-down function to gradually
;          turn off the FDDA before the pure forecast, set idynin=1 [y=1, n=0]

DTRAMP=60.,;the time period in minutes over which the
;          nudging (obs nudging and analysis nudging) is ramped down
;          from one to zero.
```

Table 16. Modified LANDUSE.TBL file with original values in parentheses.

Category Number	Albedo percent	Soil Moisture Availability fraction	Emissivity at 9nm fraction	Roughness Length cm	Thermal Inertial 100*cal $cm^{-2}K^{-1}s^{-1/2}$	Snow Effect Factor fraction	Bulk Heat Capacity J $m^{-3}K^{-1}$	Land Use Description
1	18.	.10	.88	150.(50.)	3.	.52	18.9e5	Urban and Built-Up Land
2	17.	.30	.92	15.	4.	.60	25.0e5	Dryland Cropland and Pasture
3	18.	.30(.50)	.92	15.	4.	.60	25.0e5	Irrigated Cropland and Pasture
4	18.	.25	.92	15.	4.	.60	25.0e5	Mixed Dryland/Irrigated Cropland and Pasture
5	18.	.25	.92	14.	4.	.60	25.0e5	Cropland/Grassland Mosaic
6	16.	.35	.93	20.	4.	.60	25.0e5	Cropland/Woodland Mosaic
7	19.	.05(.15)	.92	10.(12.)	3.	.60	20.8e5	Grassland
8	22.	.05(.10)	.88	20.(10.)	3.	.62	20.8e5	Shrubland
9	20.	.05(.15)	.90	30.(11.)	3.	.60	20.8e5	Mixed Shrubland/Grassland
10	20.	.15	.92	40.(15.)	3.	0.	25.0e5	Savanna
11	16.	.30	.93	100.(50.)	4.	.56	25.0e5	Deciduous Broadleaf Forest
12	14.	.30	.94	50.	4.	.50	25.0e5	Deciduous Needleleaf Forest
13	12.	.50	.95	50.	5.	0.	29.2e5	Evergreen Broadleaf Forest
14	12.	.30	.95	100.(50.)	4.	.50	29.2e5	Evergreen Needleleaf Forest
15	13.	.30	.94	50.	4.	.54	41.8e5	Mixed Forest
16	8.	1.0	.98	1.(.01)	6.	0.	9.0e25	Water Bodies
17	8.(14.)	.50(.60)	.98(.95)	1.(20.)	6.	0.(.55)	9.0e25(29.2e5)	Herbaceous Wetland
18	14.	.35	.95	40.	5.	.58	41.8e5	Wooded Wetland
19	25.	.02	.85	10.	2.	.62	12.0e5	Barren or Sparsely Vegetated
20	15.	.50	.92	10.	5.	.60	9.0e25	Herbaceous Tundra
21	15.	.50	.93	30.	5.	.60	9.0e25	Wooded Tundra
22	15.	.50	.92	15.	5.	.60	9.0e25	Mixed Tundra
23	25.	.02	.85	10.	2.	.62	12.0e5	Bare Ground Tundra
24	80.	.95	.95	0.01	5.	0.	9.0e25	Snow or Ice

3.2.5 Initial Conditions - September 24-30, 1997

The MM5 simulation is initialized at 1200 UTC on September 24, 1997, and run 144 hours until 1200 UTC on September 30, 1997. Our experience with the August 3-7, 1997, indicted that the EDAS data showed better results for Southern California than the GDAS and NCEP/NCAR Reanalysis. We obtained from the National Center for Atmospheric Research (NCAR) the NCEP Eta 212 Grid three dimensional and surface analysis data sets for September 1997. The NCEP EDAS are three-dimensional fields of meteorological variables at 40 km spatial resolution analyzed every 3 hours.

For sea surface temperature (SST) inputs we obtained SST data from the California Institute of Technology Jet Propulsion Laboratory. After we modeled the August 4-7, 1997, ozone episode, higher resolution sea surface temperature data became available. We obtained the 4 km resolution SST data averaged for the eight day period, September 22-29, 1997. We used the eight day averaged data set because the daily data have many spatial gaps due to cloud cover. There are two eight day data sets, one for daytime SSTs and one for nighttime SSTs. We applied the daytime SSTs at 12, 15, 18, 21, and 00 UTC and the nighttime SSTs at 03, 06, and 09 UTC.

The next steps in preparing the initial and boundary conditions and FDDA inputs are the RAWINS/LITTLE_R and INTERP preprocessors. We obtained data files of rawinsonde upper air observations and surface meteorological observations for September 24-30, 1997, from NCAR. These data and the output files from REGRID were input into LITTLE_R. Output from LITTLE_R are two dimensional fields of meteorological variables on pressure surfaces in the grid cells of the MM5 horizontal grid domains.

As discussed above we used EDAS analyses as input to REGRID. We compared the analyses created by REGRID and the analyses output by LITTLE_R using upper air and surface observations. Because EDAS analyses are high resolution analyses we did not find that LITTLE_R added any significant information to the MM5 initial and boundary conditions. For this reason we skipped the LITTLE_R step and input REGRID analyses directly into the INTERP preprocessor.

The INTERP preprocessor interpolates the output from REGRID or RAWINS/LITTLE_R vertically to the MM5 vertical coordinates. We used the same vertical grid structure for MM5 as the August simulation. The 31 sigma levels at the top and bottom of the 30 vertical layers are specified in Table 15.

3.2.6 MM5 Parameters and Four Dimensional Data Assimilation - September 24-30, 1997

The same MM5 parameters used for the August 3-7, 1997, modeling are used for the September 24-30, 1997, period except for FDDA. For the September 24-30, 1997, MM5 modeling we did not use observational FDDA for temperature and moisture on the 5 km grid. This is based on a recommendation we received from a reviewer of our paper on the August episode modeling (Wagner et al. 2005). The observational data set includes SCOS97 surface and radar wind profiler meteorological observations. The parameters used are indicated below where the MM5 input stream for FDDA parameters is reproduced. When multiple values occur on a line the first parameter value is for the 45 km domain, the second for the 15 km domain, and the third for the 5 km domain.

```
;
 ;     ************* 4DDA OPTIONS *********************
 ;
 ;    THE FIRST DIMENSION (COLUMN) IS THE DOMAIN IDENTIFIER:
 ;        COLUMN 1 = DOMAIN #1, COLUMN 2 = DOMAIN #2, ETC.
 ;
 ;      START TIME FOR FDDA (ANALYSIS OR OBS) FOR EACH DOMAIN
 ;      (IN MINUTES RELATIVE TO MODEL INITIAL TIME)
 FDASTA=0.,0.,0.,0.,0.,0.,0.,0.,0.,0.
 ;      ENDING TIME FOR FDDA (ANALYSIS OR OBS) FOR EACH DOMAIN
 ;      (IN MINUTES RELATIVE TO MODEL INITIAL TIME)
 FDAEND=8640.,8640.,8640.,0.,0.,0.,0.,0.,0.,0.,
 ;
 ;     **************** ANALYSIS NUDGING ******************
 ;
 ;    THE FIRST DIMENSION (COLUMN) OF THE ARRAYS DENOTES THE
 ;    DOMAIN IDENTIFIER:
 ;        COLUMN 1 = DOMAIN #1, COLUMN 2 = DOMAIN #2, ETC.
 ;    THE SECOND DIMENSION (ROW OR LINE) EITHER REFERS TO THE 3D VS
 ;    SFC ANALYSIS OR WHICH VARIABLE IS ACCESSED:
 ;        LINE 1 = 3D, LINE 2 = SFC   OR
 ;        LINE 1 = U, LINE 2 = V, LINE 3 = T, LINE 4 = Q
 ;
 ;      IS THIS A GRID 4DDA RUN? 0 = NO; 1 = YES
 I4D= 1,1,1,0,0,0,0,0,0,0,
     0,1,0,0,0,0,0,0,0,0,
 ;
 ;      SPECIFY THE TIME IN MINUTES BETWEEN THE INPUT (USUALLY
 ;      FROM INTERP) USED FOR GRID FDDA
 DIFTIM=180.,180.,180.,0.,0.,0.,0.,0.,0.,0.,     ; 3D ANALYSIS NUDGING
       180.,180.,180.,0.,0.,0.,0.,0.,0.,0.,     ; SFC ANALYSIS NUDGING
 ;
 ;      GRID NUDGE THE WIND FIELD? 0 = NO; 1 = YES
 IWIND=1,1,1,0,0,0,0,0,    ; 3D ANALYSIS NUDGING
      0,1,0,0,0,0,0,0,0,0,    ; SFC ANALYSIS NUDGING
 ;
 ;      NUDGING COEFFICIENT FOR WINDS ANALYSES
 GV=2.5E-4,2.5E-4,1.0E-4,0.,0.,0.,0.,0.,0.,0.,      ; 3D ANALYSIS NUDGING
   2.5E-4,2.5E-4,1.0E-4,0.,0.,0.,0.,0.,0.,0.,      ; SFC ANALYSIS NUDGING
 ;
 ;      GRID NUDGE THE TEMPERATURE FIELD? 0 = NO; 1 = YES
 ITEMP=1,1,0,0,0,0,0,0,0,0,    ; 3D ANALYSIS NUDGING
      0,0,0,0,0,0,0,0,0,0,    ; SFC ANALYSIS NUDGING
 ;
```

```
;      NUDGING COEFFICIENT FOR TEMPERATURE ANALYSES
GT=2.5E-4,2.5E-4,1.0E-4,0.,0.,0.,0.,0.,0.,0.,       ; 3D ANALYSIS NUDGING
   2.5E-4,2.5E-4,1.0E-4,0.,0.,0.,0.,0.,0.,0.,       ; SFC ANALYSIS NUDGING
;
;      GRID NUDGE THE MOISTURE FIELD? 0 = NO; 1 = YES
IMOIS=1,1,0,0,0,0,0,0,0,0,    ; 3D ANALYSIS NUDGING
      0,0,0,0,0,0,0,0,0,0,    ; SFC ANALYSIS NUDGING
;
;      NUDGING COEFFICIENT FOR THE MIXING RATIO ANALYSES
GQ=1.E-5,1.E-5,1.0E-5,0.,0.,0.,0.,0.,0.,0.,        ; 3D ANALYSIS NUDGING
   1.E-5,1.E-5,1.0E-5,0.,0.,0.,0.,0.,0.,0.,        ; SFC ANALYSIS NUDGING
;
;      GRID NUDGE THE ROTATIONAL WIND FIELD? 0 = NO; 1 = YES
IROT=0,0,0,0,0,0,0,0,0,0,     ; 3D ANALYSIS NUDGING
;
;      NUDGING COEFFICIENT FOR THE ROTATIONAL COMPONENT OF THE WINDS
GR=0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,          ; 3D ANALYSIS NUDGING
;
;       IF GRID NUDGING (I4D(1,1)=1) AND YOU WISH TO EXCLUDE THE
;       BOUNDARY LAYER FROM FDDA OF COARSE GRID THREE DIMENSIONAL
;       DATA (USUALLY FROM INTERP),
;            0 = NO,  INCLUDE BOUNDARY LAYER NUDGING
;            1 = YES, EXCLUDE BOUNDARY LAYER NUDGING
INONBL =1,0,0,0,0,0,0,0,0,0,         ; U WIND
        1,0,0,0,0,0,0,0,0,0,         ; V WIND
        1,1,1,1,1,1,1,1,1,1,         ; TEMPERATURE
        1,1,1,1,1,1,1,1,1,1,         ; MIXING RATIO
;
;       RADIUS OF INFLUENCE FOR SURFACE ANALYSIS (KM).
;       IF I4D(2,1)=1 OR I4D(2,2)=1, ETC, DEFINE RINBLW (KM) USED
;       IN SUBROUTINE BLW TO DETERMINE THE HORIZONTAL VARIABILITY
;       OF THE SURFACE-ANALYSIS NUDGING AS A FUNCTION OF SURFACE
;       DATA DENSITY.  OVER LAND, THE STRENGTH OF THE SURFACE-
;       ANALYSIS NUDGING IS LINEARLY DECREASED BY 80 PERCENT AT
;       THOSE GRID POINTS GREATER THAN RINBLW FROM AN OBSERVATION
;       TO ACCOUNT FOR DECREASED CONFIDENCE IN THE ANALYSIS
;       IN REGIONS NOT NEAR ANY OBSERVATIONS.
RINBLW=250.,
;
;       SET THE NUDGING PRINT FREQUENCY FOR SELECTED DIAGNOSTIC
;       PRINTS IN THE GRID (ANALYSIS) NUDGING CODE (IN CGM
;       TIMESTEPS)
NPFG=1000,
;
;     **************** OBSERVATION NUDGING ***************
;
;
;     INDIVIDUAL OBSERVATION NUDGING.  VARIABLES THAT ARE ARRAYS
;     USE THE FIRST DIMENSION (COLUMN) AS THE DOMAIN IDENTIFIER:
```

```
;        COLUMN 1 = DOMAIN #1, COLUMN 2 = DOMAIN #2, ETC.
;
;      IS THIS INDIVIDUAL OBSERVATION NUDGING? 0 = NO; 1 = YES
I4DI   =0,1,1,0,0,0,0,0,0,0,
;
;      OBS NUDGE THE WIND FIELD FROM STATION DATA? 0 = NO; 1 = YES
ISWIND =1,1,1,0,0,0,0,0,0,0,
;
;      NUDGING COEFFICIENT FOR WINDS FROM STATION DATA
GIV  =4.E-3,4.E-3,4.E-3,0.,0.,0.,0.,0.,0.,0.,
;
;      OBS NUDGE THE TEMPERATURE FIELD FROM STATION DATA? 0 = NO; 1 = YES
ISTEMP=0,0,0,0,0,0,0,0,0,0,
;
;      NUDGING COEFFICIENT FOR TEMPERATURES FROM STATION DATA
GIT  =4.E-4,4.E-4,4.E-4,0.,0.,0.,0.,0.,0.,0.,
;
;      OBS NUDGE THE MIXING RATIO FIELD FROM STATION DATA? 0 = NO; 1 = YES
ISMOIS=0,0,0,0,0,0,0,0,0,0,
;
;      NUDGING COEFFICIENT FOR THE MIXING RATIO FROM STATION DATA
GIQ  =4.E-4,4.E-4,4.E-4,0.,0.,0.,0.,0.,0.,0.,
;
;      THE OBS NUDGING RADIUS OF INFLUENCE IN THE
;      HORIZONTAL IN KM FOR CRESSMAN-TYPE DISTANCE-WEIGHTED
;      FUNCTIONS WHICH SPREAD THE OBS-NUDGING CORRECTION
;      IN THE HORIZONTAL.
RINXY=30.,
;
;      THE OBS NUDGING RADIUS OF INFLUENCE IN THE
;      VERTICAL IN SIGMA UNITS FOR CRESSMAN-TYPE DISTANCE-
;      WEIGHTED FUNCTIONS WHICH SPREAD THE OBS-NUDGING
;      CORRECTION IN THE VERTICAL.
RINSIG=0.001,
;
;      THE HALF-PERIOD OF THE TIME WINDOW, IN MINUTES, OVER
;      WHICH AN OBSERVATION WILL AFFECT THE FORECAST VIA OBS
;      NUDGING. THAT IS, THE OBS WILL INFLUENCE THE FORECAST
;      FROM TIMEOBS-TWINDO TO TIMEOBS+TWINDO.  THE TEMPORAL
;      WEIGHTING FUNCTION IS DEFINED SUCH THAT THE OBSERVATION
;      IS APPLIED WITH FULL STRENGTH WITHIN TWINDO/2. MINUTES
;      BEFORE OR AFTER THE OBSERVATION TIME, AND THEN LINEARLY
;      DECREASES TO ZERO TWINDO MINUTES BEFORE OR AFTER THE
;      OBSERVATION TIME.
TWINDO=40.0,
;
;      THE NUDGING PRINT FREQUENCY FOR SELECTED DIAGNOSTIC PRINT
;      IN THE OBS NUDGING CODE (IN CGM TIMESTEPS)
NPFI=1000,
```

```
;
;     FREQUENCY (IN CGM TIMESTEPS) TO COMPUTE OBS NUDGING WEIGHTS
IONF=2,
IDYNIN=0,  ;for dynamic initialization using a ramp-down function to gradually
;          turn off the FDDA before the pure forecast, set idynin=1 [y=1, n=0]
DTRAMP=60.,;the time period in minutes over which the
;          nudging (obs nudging and analysis nudging) is ramped down
;          from one to zero.  Set dtramp negative if FDDA is to be ramped
;          down BEFORE the end-of-data time (DATEND), and positive if the
;          FDDA ramp-down period extends beyond the end-of-data time.
&END
```

3.2.7 Post Processing MM5 Outputs To CAMx Inputs

A post processor program *mm5camx* is available from Environ (2005) to convert MM5 output files to CAMx compatible meteorological input files. We used version 4.3 of this program which was released on June 15, 2005.

Wheeler (2003) and others have suggested that the planetary boundary layer (PBL) heights and subsequent vertical mixing parameters diagnosed from MM5 are inadequate for stable and neutral conditions. The *mm5camx* post processing program mentioned above has several algorithms to calculate the vertical mixing coefficients used in CAMx. This program, *mm5camx*, uses the TKE (total kinetic energy) or the planetary boundary layer height output from MM5 to make those calculations. Various other parameterizations are available for estimating the vertical mixing coefficients or planetary boundary layer height. We chose to use the profile approach in *mm5camx* and the parameterizations in the CALMET diagnostic meteorological model (Scire et al. 2000) for re-diagnosing the planetary boundary layer height. We implemented this by running the CALMET model using the MM5 output as the only observational input to CALMET. We used CALMET in the objective analysis mode and asked CALMET to calculate planetary boundary layer heights (mixing heights). CALMET outputs Pasquill-Gifford-Turner (PGT) stability classes which indicates if the atmospheric is stable, neutral, or convective. The CALMET calculated mixing heights are substituted for the MM5 mixing height in the *mm5camx* program when calculating the vertical mixing coefficients using the profile approach.

There is an additional postprocessor program, *kvpatch*, that can be run after *mm5camx*. This program replaces the vertical mixing parameter, K_v, in the lowest 100 m with a land use dependent value if the value from *mm5camx* is below a minimum value. This procedure insures that vertical mixing due to surface roughness occurs even if MM5 did not predict such mixing. The program *kvpatch* has been used to prepare the vertical mixing coefficient for CAMx.

3.3 Air Quality

3.3.1 Photochemical Model Selection

Version 4.20 (ENVIRON 2005) of the. Comprehensive Air Quality Model with Extensions (CAMx) with the SAPRC99 chemical mechanism was used for photochemical ozone modeling in San Diego County. Model selection is discussed further in the protocol documents.

3.3.2 Modeling Domain

The SCOS97 modeling domain completely encompasses the South Coast Air Basin and San Diego County, almost all of the South Central Coast Air Basin (excepting a small piece of San Luis Obispo County), the California-Mexico border regions, and includes most of the inland desert areas (Figure 3). This domain is chosen to eliminate the need to define boundary concentrations between the air basins. The domain extends far enough offshore to contain wind flow patterns conducive to over water recirculation. Vertically, the modeling domain extends to a height of at least 5,000m AGL for a more complete representation of atmospheric processes. This will contain observed high ozone concentrations aloft and allow three-dimensional wind flow patterns near elevated terrain features to be represented providing more accurate representations of pollutant transport and recirculation. The CAMx grid domain is defined as:

- A Lambert Conformal map projection
- True latitudes of 30.0 degrees North and 60.0 degrees North
- A central longitude of 118.00 degree West
- The center of the projection is at 30.0 degrees North and 118.0 degrees West
- The origin of the grid (southwest corner of the southwest grid cell) is at -290000 m West and 225000 m North of the projection center in the Lambert map projection
- A 116 cell east-west by 80 cell north-south grid with 5 km resolution

The first 20 layers above the surface in MM5 modeling domain are mapped directly into the 20 layers of the CAMx grid. Thus, the MM5 sigma coordinate vertical structure defines the CAMx vertical layers. Table 17 shows the sigma coordinate values and the pressure and height of the layers in the MM5 reference atmosphere.

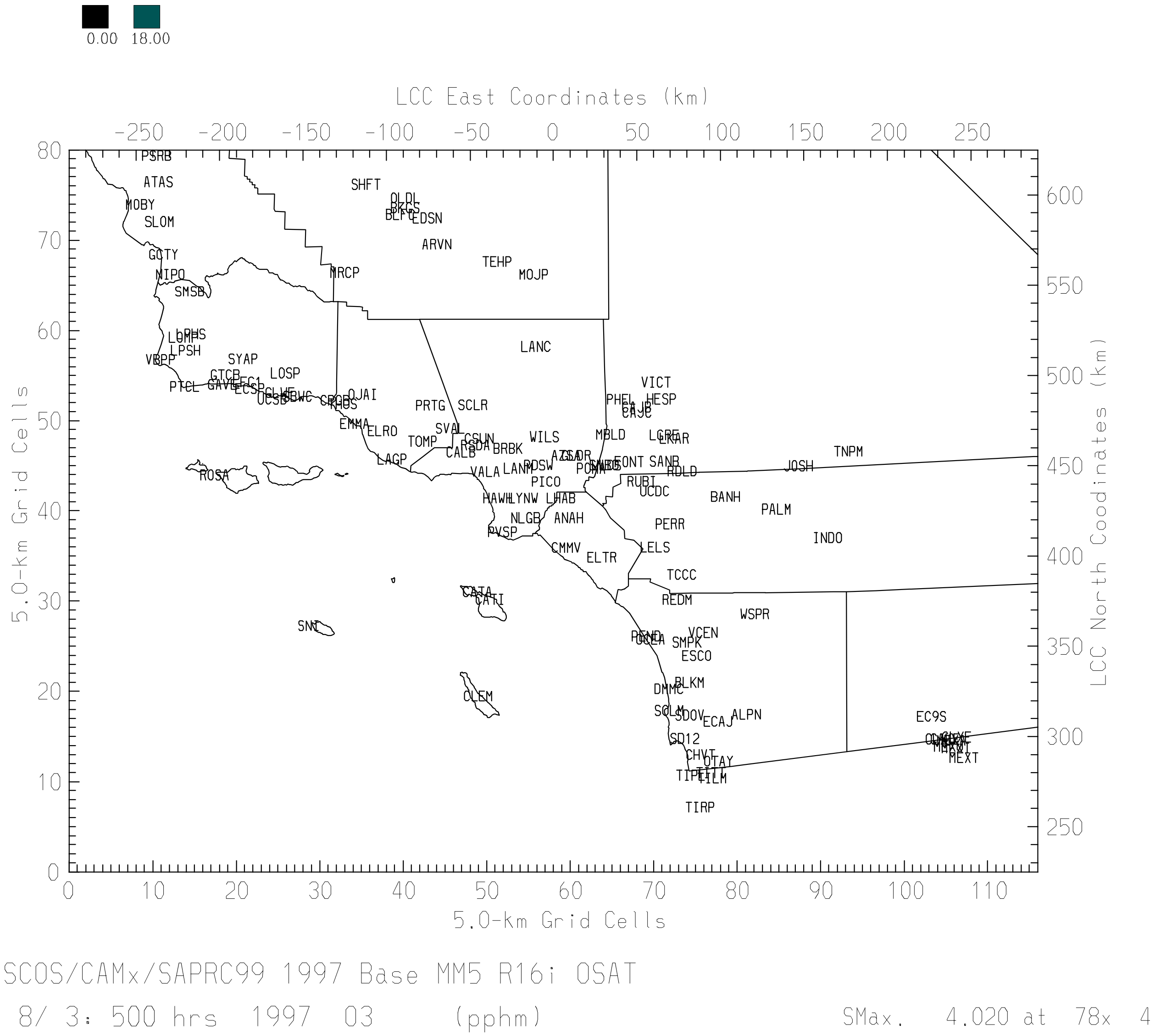


Figure 3. Photochemical modeling domain.

Table 17. Vertical structure of the CAMx grid.

Layer Top and Bottom				Layer Center		
sigma	Pressure (Pa)	Height (meters)	Layer	½ sigmas	Pressure (Pa)	Height (meters)
0.423	48070	5502				
0.464	51760	4982	20	0.4435	49915	5238
0.508	55720	4456	19	0.486	53740	4715
0.552	59680	3958	18	0.53	57700	4204
0.6	64000	3445	17	0.576	61840	3698
0.65	68500	2940	16	0.625	66250	3189
0.698	72820	2479	15	0.674	70660	2706
0.74	76600	2093	14	0.719	74710	2284
0.777	79930	1766	13	0.7585	78265	1928
0.814	83260	1450	12	0.7955	81595	1606
0.84	85600	1233	11	0.827	84430	1341
0.866	87940	1022	10	0.853	86770	1127
0.884	89560	878	9	0.875	88750	950
0.902	91180	737	8	0.893	90370	807
0.918	92620	613	7	0.91	91900	674
0.934	94060	490	6	0.926	93340	551
0.95	95500	369	5	0.942	94780	429
0.966	96940	249	4	0.958	96220	309
0.98	98200	146	3	0.973	97570	198
0.992	99280	58	2	0.986	98740	102
1	100000	0	1	0.996	99640	29

3.3.3 Initial and Boundary Condition Inputs

The initial and boundary conditions are specified as time and spatially invariant. We used “clean” values to reduce the possible impact of boundary and initial conditions on future year simulations. The initial and boundary concentrations are listed in Table 18. These initial and boundary conditions are used for the 1997 baseline simulations and the 2002 and 2008 future year simulations.

The initial conditions are specified in CAMx at 0500 PDT on August 3, 1997, for the August ozone episode. The initial conditions in all grid cells are set to the concentrations in Table 18. The first day of the CAMx simulation, August 3, is used to “spin up” the simulation from the "clean" background initial conditions. The simulation is run until 2300 PDT on August 7.

The initial conditions are specified in CAMx at 0500 PDT on September 24, 1997, for the September ozone episode. The initial conditions in all grid cells are set to the concentrations in Table 18. The first two days of the CAMx simulation, September 24 and 25, are used to "spin up" the simulation from the background initial conditions. The simulation is run until 0800 PDT on September 29, 1997.

Table 18. Clean initial and boundary conditions for SAPRC99 species.

Species	Concentration (ppm)	Species	Concentration (ppm)
NO	0.0000000	HC2H	0.0000000
NO2	0.0000000	CO2H	0.0000000
O3	0.0400000	CO3H	0.0000000
PAN	0.0000000	RC2H	0.0000000
PAN2	0.0000000	RC3H	0.0000000
MPAN	0.0000000	ACET	0.0000000
PBZN	0.0000000	MEK	0.0000000
NPHE	0.0000000	MEOH	0.0000000
RNO3	0.0000000	COOH	0.0000000
CRES	0.0000000	ROOH	0.0000000
DCB2	0.0000000	CO	0.2000000
DCB3	0.0000000	ETHE	0.0001800
HNO4	0.0000000	ALK1	0.0002000
BALD	0.0000000	ALK2	0.0007600
HONO	0.0000000	ALK3	0.0001900
XN	0.0000000	ALK4	0.0000000
HCHO	0.0009300	ALK5	0.0007400
CCHO	0.0006700	ARO1	0.0004200
RCHO	0.0010100	ARO2	0.0001400
BACL	0.0000000	OLE1	0.0003600
PROD	0.0000000	OLE2	0.0000000
DCB1	0.0000000	NOXY	0.0000000
PHEN	0.0000000	SO2	0.0000000
ISOP	0.0000000	SULF	0.0000000
ISPD	0.0000000	HC2H	0.0000000
MVK	0.0000000	CO2H	0.0000000
METH	0.0000000	CO3H	0.0000000
MGLY	0.0000000	RC2H	0.0000000
GLY	0.0000000	RC3H	0.0000000
TERP	0.0000000	ACET	0.0000000
HNO3	0.0000000	MEK	0.0000000
HO2H	0.0000000	MEOH	0.0000000

3.3.4 Ancillary Inputs

The Albedo/Haze/Ozone file specifies how these three photolysis-related parameters vary in time and space for the CAMx simulation. Version 2 (October 2005) of Environ's *ahomap* program was used to prepare the file. The surface albedo was calculated based on the gridded landuse data. The ozone column data were based on available satellite data from http://toms.gsfc.nasa.gov/ozone/ozone_v8.html.

The photolysis rates file determines the rates for chemical reactions in the mechanism that are driven by sunlight. The photolysis rates file was prepared using version 4 of the tropospheric ultraviolet-visible (TUV) radiative transfer model developed at NCAR with the Albedo/Haze/Ozone file as input.

3.3.5 CAMx Model Options

CAMx has several user selectable options that are specified for each simulation through the CAMx control file. The area preserving flux-form advection solver of Bott (BOTT option) was used as the horizontal advection solver. For the atmospheric chemistry the CAMx Chemical Mechanism Compiler (CMC) Fast Solver was used. The plume in grid option was not used for the simulations. Dry deposition was used, but wet deposition was not used. The chemical mechanism used is "mechanism 5" the SAPRC99 chemistry adapted for photochemical grid modeling by selecting a specific "fixed parameter" lumping scheme. The ozone source apportionment technology (OSAT) was used with most simulations.

4.0 EVALUATION OF MODEL PERFORMANCE

4.1 Emissions

The CAMx emission files are evaluated by graphical and tabular methods. Spatial plots of the distribution of the ROG and NOx emissions were examined. Grid cell emissions were summed to calculate total emissions for the domain. Changes in emission totals between August and September and between 1997, 2002, and 2008 were examined. No unexplained patterns or totals were found.

4.2 Evaluation of Meteorological Model Output

The model performance evaluation of MM5 focuses on the 5 km grid. We defined subregional groups of sites for statistical model performance evaluation. The observation sites are listed by mnemonic below. The locations of the stations are listed in an attachment to this document.

SDCW: San Diego County West

VLYC	VCEN	SOLM	SMPK	SDOV	SD12
SAND	REDM	RAMO	PEND	OCSD	OCEA
LSF	ESCO	ESCD	ECAJ	DMMC	CMPT
CASE	CARL	BLKM	ALPN	ALPM	

EAST: E San Diego/W Riverside
WSPR UCR TME2 THER TEME SRPL
RANC PERR PALM OASS OAKG MTLG
LOST LELS KEEN JULI JPFT INDO
FISH CMFS CATH BANN BANH APRT
ANZA

ORNG: Orange County
TUST LHAB IRVI ELTR ELCR CMMV
BELL ANAH

BORD: Mexican Border
TITT TIRP TIPL TILM SELY POTR
OTAY MEXU MEXT MEXI MEXA MELO
CLXE CLXC CHVT CALE BRWN

OFFS: Off Shore
SRIS SNI SCLM SCLH SCIS SBAR
CLEM CATM CATI CATA BY54 BY23

PROF: All Profilers
VNS VLC VAF USC TTN TML
TCL SMIP SCL SCE RSD PLM
PHE PDE ONT NTN LAX LAS
HPA GLA EMT ECO CBD BTW
BFD APE

MM5 predicted surface wind speed, surface temperature, and PBL height are compared to observed values and bias and error are calculated. Statistics are calculated for each day and for each subregion separately. The bias and error for wind speed and temperature are compared to some benchmarks proposed by Emery et al. (2001) for evaluating MM5 meteorological modeling for air quality simulations. These benchmarks are:

Wind Speed Error	≤2 m/s	Wind Speed Bias	≤ ±0.5 m/s
Temperature Error	≤2 K	Temperature Bias	≤ ±0.5 K

Benchmarks have not been proposed for evaluating mixing heights.

Adjustments were not made to wind speed or temperature to account for any discrepancies between the measurement heights and the MM5 model layer height. We compared MM5 predictions for the first layer with surface observations. Some studies, Boucouvala et al. (2003), for example, have adjusted the MM5 predictions to the actual measurement height. The mixing height observations are estimates from the Radar Wind Profiler/RASS systems. Wheeler (2003) explains how these estimates were determined.

4.2.1 August 4-7, 1997, Episode

A number of MM5 simulations were run for the August 3-7, 1997, period with various adjustments in the MM5 model parameters and inputs. Model performance differences between the runs were compared and used to make improvements to the simulation. In the end, outputs from two separate MM5 simulations were used to prepare the meteorological inputs to CAMx. The final MM5 simulation had a few areas in the domain which exhibited “anomalous” convection. This may be due to the FDDA of the surface temperature and moisture as discussed above. This “anomalous” convection caused excessive vertical velocities that created problems for CAMx. Our method to overcome this problem was to run MM5 without simulating water vapor. This eliminated the “anomalous” convection and also slightly improved the wind fields. The meteorological inputs to CAMx were prepared with the wind fields from the “dry” run and the cloud and water vapor fields from the “moist” run. So, although the momentum fields in CAMx are dynamically consistent, the meteorological fields are not hydrodyamically consistent since moisture is from a different MM5 simulation. This should not in itself cause any mass consistency problems in CAMx.

The MM5 output for the 5 km domain is used for the comparison of prediction to observation. The surface wind speed bias and error and the surface temperature bias and error are listed for both the “moist” MM5 simulation and the “dry” MM5 simulation in the tables below. Table 19 lists the bias and normalized bias for wind speed. Table 20 lists the error and normalized error for wind speed. Table 21 lists the bias and normalized bias for temperature. Table 22 lists the error and normalized error for temperature. The tables are stratified by sub-regions and by day of the episode. The mixing height bias and error are listed for the “moist” MM5 simulation, the “dry” MM5 simulation, and for the mixing heights calculated with the CALMET model. Table 23 lists the bias and normalized bias for mixing height. Table 24 lists the error and normalized error for mixing height. We used both these statistical measures and subjective examination of graphical output to judge model performance.

The performance benchmark for wind speed bias is met for most areas on all days, August 3-7. The “dry” simulation has the better model performance. The performance benchmark for wind speed error is also met. Again, the “dry” simulation has slightly better model performance. The surface temperature is mostly under predicted. Bias exceeds the benchmark, especially on August 5. Error also exceeds the 2K benchmark much of the time, although it rarely exceeds 4K. Performance for the “moist” and “dry” simulations is similar for temperature.

Table 19. Surface wind speed bias for August 3-7, 1997, for MM5 simulations.

Wind Speed Statistics							
3-Aug-97	Mean Bias (m/s)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	0.4		0.2		0.52		0.36
EAST	0.0		-0.1		0.33		0.22
ORNG	0.6		0.3		0.82		0.67
BORD	0.0		-0.2		0.33		0.26
OFFS	0.5		0.3		0.79		0.70
4-Aug-97	Mean Bias (m/s)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	0.4		0.2		0.46		0.34
EAST	0.6		0.4		0.68		0.61
ORNG	0.6		0.4		0.86		0.75
BORD	0.9		0.8		1.03		0.87
OFFS	0.1		-0.1		0.75		0.62
5-Aug-97	Mean Bias (m/s)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	0.2		0.0		0.41		0.27
EAST	0.5		0.5		0.58		0.58
ORNG	0.6		0.4		0.94		0.79
BORD	0.5		0.4		0.72		0.63
OFFS	0.2		-0.1		0.81		0.62
6-Aug-97	Mean Bias (m/s)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	0.1		0.0		0.21		0.22
EAST	0.5		0.5		0.85		0.82
ORNG	0.5		0.4		0.89		0.79
BORD	-0.1		-0.1		0.10		0.14
OFFS	0.1		-0.3		0.62		0.42
7-Aug-97	Mean Bias (m/s)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	0.3		0.2		0.41		0.29
EAST	0.3		0.4		0.39		0.44
ORNG	0.4		0.2		0.67		0.53
BORD	-0.3		-0.3		0.02		0.05
OFFS	0.0		-0.3		0.45		0.29

Table 20. Surface wind speed error for August 3-7, 1997, for MM5 simulations.

Wind Speed Statistics							
3-Aug-97	Mean Error (m/s)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	0.7		0.6		0.68		0.57
EAST	1.3		1.2		0.81		0.73
ORNG	0.8		0.7		0.95		0.89
BORD	1.1		1.1		0.61		0.59
OFFS	1.6		1.6		0.94		0.89
4-Aug-97	Mean Error (m/s)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	0.7		0.6		0.65		0.55
EAST	1.3		1.2		1.04		1.00
ORNG	0.8		0.8		0.98		0.95
BORD	1.1		1.0		1.09		0.98
OFFS	1.7		1.7		0.97		0.87
5-Aug-97	Mean Error (m/s)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	0.7		0.6		0.66		0.57
EAST	1.3		1.2		0.89		0.89
ORNG	1.0		1.0		1.13		1.08
BORD	1.0		0.9		0.91		0.84
OFFS	1.7		1.6		1.06		0.91
6-Aug-97	Mean Error (m/s)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	0.6		0.6		0.50		0.51
EAST	1.4		1.4		1.22		1.15
ORNG	1.0		0.9		1.04		1.03
BORD	1.0		0.9		0.49		0.47
OFFS	1.5		1.5		0.96		0.87
7-Aug-97	Mean Error (m/s)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	0.7		0.7		0.65		0.58
EAST	1.2		1.2		0.79		0.83
ORNG	0.8		0.8		0.88		0.84
BORD	1.0		1.0		0.46		0.45
OFFS	1.1		1.1		0.86		0.82

Table 21. Surface temperature bias for August 3-7, 1997, for MM5 simulations.

Temperature Statistics							
3-Aug-97	Mean Bias (K)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	-1.7		-1.8		-0.05		-0.06
EAST	-1.9		-1.6		-0.05		-0.04
ORNG	-1.6		-1.4		-0.05		-0.04
BORD	-0.2		0.1		0.00		0.01
OFFS	-0.2		-0.2		0.05		0.05
4-Aug-97	Mean Bias (K)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	-1.1		-1.7		-0.03		-0.05
EAST	-0.5		-0.3		0.01		0.02
ORNG	-0.8		-0.9		-0.02		-0.03
BORD	0.0		-0.9		0.00		-0.03
OFFS	-0.3		-0.1		0.03		0.05
5-Aug-97	Mean Bias (K)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	-1.8		-2.3		-0.04		-0.07
EAST	-1.7		-1.3		-0.02		-0.01
ORNG	-1.7		-1.8		-0.04		-0.06
BORD	-1.0		-1.8		-0.02		-0.05
OFFS	-2.6		-2.4		-0.06		-0.05
6-Aug-97	Mean Bias (K)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	-0.9		-1.6		-0.02		-0.05
EAST	-0.5		-0.4		0.00		0.01
ORNG	-1.5		-2.2		-0.04		-0.07
BORD	-0.3		-1.4		-0.01		-0.04
OFFS	-1.4		-1.7		-0.01		-0.02
7-Aug-97	Mean Bias (K)				Normalized Bias		
Area	Moist		Dry		Moist		Dry
SDCW	1.2		0.2		0.05		0.01
EAST	-0.1		-0.2		0.02		0.02
ORNG	0.7		-0.2		0.03		0.00
BORD	0.7		-0.2		0.02		-0.02
OFFS	1.5		1.6		0.10		0.11

Table 22. Surface temperature error for August 3-7, 1997, for MM5 simulations.

Temperature Statistics							
3-Aug-97	Mean Error (K)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	2.2		2.3		0.08		0.08
EAST	3.4		3.4		0.11		0.12
ORNG	2.4		2.3		0.08		0.08
BORD	2.9		3.2		0.09		0.10
OFFS	3.5		3.6		0.19		0.19
4-Aug-97	Mean Error (K)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	2.2		2.3		0.08		0.08
EAST	3.3		3.3		0.12		0.13
ORNG	2.3		2.3		0.08		0.08
BORD	1.9		1.9		0.07		0.06
OFFS	3.4		3.6		0.17		0.18
5-Aug-97	Mean Error (K)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	2.9		3.0		0.10		0.10
EAST	3.9		3.8		0.13		0.13
ORNG	2.7		2.8		0.09		0.10
BORD	2.4		2.6		0.07		0.08
OFFS	4.6		4.5		0.18		0.17
6-Aug-97	Mean Error (K)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	2.5		2.5		0.09		0.09
EAST	3.2		3.2		0.11		0.12
ORNG	2.7		3.1		0.09		0.11
BORD	2.2		3.2		0.07		0.10
OFFS	4.1		4.2		0.17		0.17
7-Aug-97	Mean Error (K)				Normalized Error		
Area	Moist		Dry		Moist		Dry
SDCW	1.7		1.6		0.07		0.07
EAST	3.3		3.0		0.12		0.11
ORNG	2.1		2.1		0.08		0.08
BORD	1.7		2.1		0.06		0.07
OFFS	2.3		2.3		0.13		0.14

Mixing heights are under predicted by both the “moist” and “dry” MM5 simulations. Both MM5 simulations predict approximately the same mixing heights. MM5 mixing heights range from a 168m under prediction bias on the 3rd to a 327m under prediction bias on the 5th. CALMET is successful in reducing the bias in the mixing heights. Bias is reduced to less than 100m on the 3rd and 6th and to less than 25m on the 4th, 5th, and 7th. However, the CALMET mixing height errors are somewhat larger than the MM5 mixing height errors. Where MM5 mixing heights have errors ranging from 300m to 400m, the CALMET mixing height errors are generally between 400m and 500m. MM5 mixing heights are near zero near the coast and Salton sea. This does not agree with the observations and does not allow for sufficient vertical mixing of emissions in the CAMx model. Figure 4 shows a spatial plot of MM5 predicted mixing height for 1000 PDT on August 5, 1997. CALMET estimates higher mixing heights along the coast and near the Salton sea as seen in Figure 5.

The examination of the spatial and temporal plots of the wind speeds, wind directions, surface temperature, and mixing heights shows patterns that generally agree with the observations.

Table 23. Mixing height bias for August 3-7, 1997, for MM5 simulations.

Mixing Height Statistics											
3-Aug-97	Mean Bias (m)						Normalized Bias				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	-172.4		-168.4		84.7		-0.39		-0.39		0.25
4-Aug-97	Mean Bias (m)						Normalized Bias				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	-259.2		-256.4		-12.3		-0.6		-0.59		0.04
5-Aug-97	Mean Bias (m)						Normalized Bias				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	-327.2		-322.4		-22.1		-0.66		-0.66		0.11
6-Aug-97	Mean Bias (m)						Normalized Bias				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	-311.1		-315.6		-98.2		-0.61		-0.63		-0.10
7-Aug-97	Mean Bias (m)						Normalized Bias				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	-186.6		-187		21.9		-0.49		-0.49		0.11

Table 24. Mixing height error for August 3-7, 1997, for MM5 simulations.

Mixing Height Statistics											
3-Aug-97	Mean Error (m)						Normalized Error				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	291.8		305.6		404.6		0.7		0.74		1.00
4-Aug-97	Mean Error (m)						Normalized Error				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	319.5		318.4		401.4		0.76		0.75		0.99
5-Aug-97	Mean Error (m)						Normalized Error				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	375		380.5		484.6		0.8		0.81		1.13
6-Aug-97	Mean Error (m)						Normalized Error				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	392.6		387.4		406.5		0.81		0.8		0.90
7-Aug-97	Mean Error (m)						Normalized Error				
Area	Moist		Dry		CALMET Dry		Moist		Dry		CALMET Dry
PROF	308.2		294.4		378.9		0.82		0.78		1.04

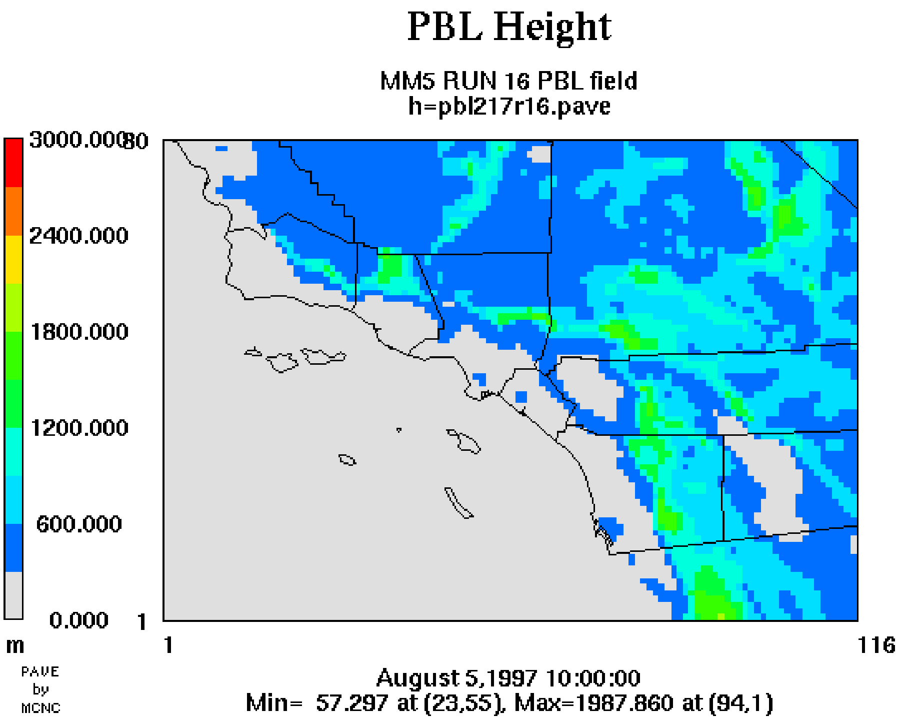


Figure 4. Mixing height (meters) from MM5 output.

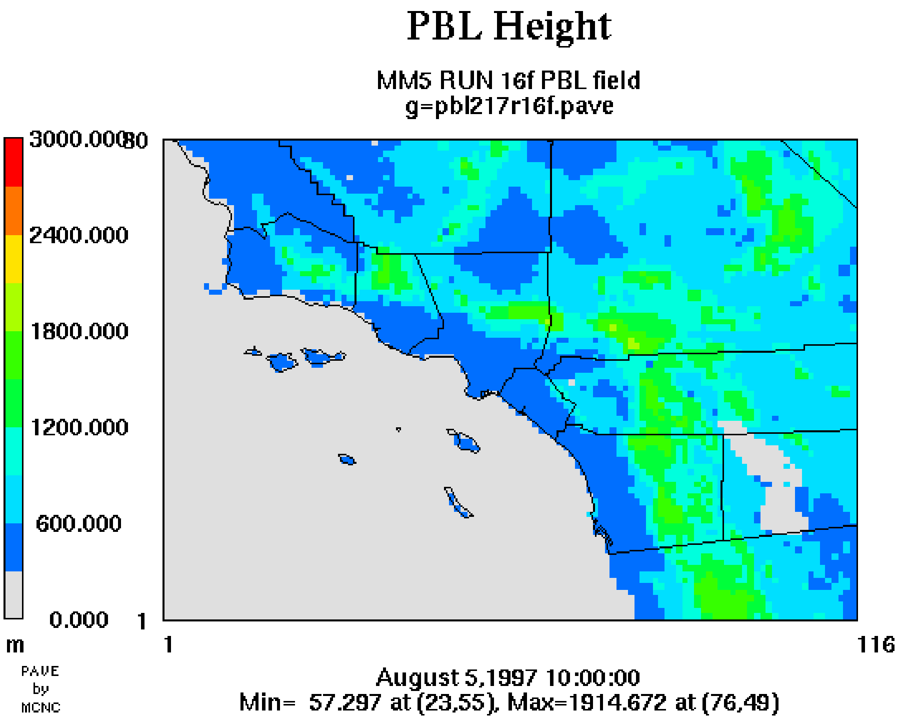


Figure 5. Mixing height (meters) from CALMET output.

4.2.2 September 27-28, 1997, Episode

Several MM5 simulations were made for the September 24-30, 1997, period with various adjustments in the MM5 model parameters and inputs. Unlike the August episode MM5 simulation, “anomalous” convection was not present which may be due to no “nudging” toward surface moisture and temperature. A single MM5 simulation is used to prepare CAMX meteorological inputs.

Statistical model performance is discussed below. The tables are stratified by the sub-regions defined in Section 4.2. Table 25 lists the bias and normalized bias for surface wind speed. Table 26 lists the error and normalized error for wind speed. Table 27 lists the bias and normalized bias for surface temperature. Table 28 lists the error and normalized error for temperature. Table 29 lists the bias and normalized bias for mixing height. Table 30 lists the error and normalized error for mixing height for both the MM5 simulation and the CALMET mixing height estimates.

Except for September 25 most of the sub-regions meet the performance benchmarks for wind speed bias. Wind speed is mostly over predicted. All days and sub-regions meet the benchmark for wind speed error.

Surface temperature is generally over predicted with only a few instances of meeting the benchmark. Surface temperature errors are from 2K to 4K with only a few instances of meeting the benchmark.

MM5 underestimates the mixing heights with bias ranging from -235m to -303m. CALMET mixing height estimates have lower bias, with under predictions ranging from -58m to -77m. MM5 mixing height errors range from 282m to 358m. CALMET mixing height errors are slightly larger than for MM5 with the CALMET mixing errors ranging from 341m to 380m. As with August 3-7, 1997, for September 24-29, 1997, CALMET does better with estimating the coastal area mixing heights than MM5

Table 25. Surface wind speed bias for September 24-29, 1997, MM5 simulations.

Wind Speed Statistics		
24-Sep-97		
Area	Mean Bias (m/s)	Normalized Bias
SDCW	1.3	0.74
EAST	0.5	0.29
ORNG	0.1	0.37
BORD	0.5	0.36
OFFS	0.1	0.54
25-Sep-97		
Area	Mean Bias (m/s)	Normalized Bias
SDCW	0.6	0.41
EAST	-0.1	0.11
ORNG	0.6	0.28
BORD	1.4	0.61
OFFS	0.9	0.64
26-Sep-97		
Area	Mean Bias (m/s)	Normalized Bias
SDCW	0.4	0.44
EAST	0.6	0.82
ORNG	0.6	0.63
BORD	0.4	0.37
OFFS	0.0	0.37
27-Sep-97		
Area	Mean Bias (m/s)	Normalized Bias
SDCW	0.2	0.39
EAST	0.4	0.47
ORNG	0.2	0.22
BORD	0.3	0.42
OFFS	0.2	0.82
28-Sep-97		
Area	Mean Bias (m/s)	Normalized Bias
SDCW	-0.1	0.13
EAST	0.7	0.67
ORNG	0.4	0.37
BORD	0.3	0.33
OFFS	-0.1	0.46
29-Sep-97		
Area	Mean Bias (m/s)	Normalized Bias
SDCW	0.1	0.10
EAST	0.1	0.33
ORNG	0.2	0.22
BORD	0.1	0.13
OFFS	-0.2	0.41

Table 26. Surface wind speed error for September 24-29, 1997, MM5 simulations.

Wind Speed Statistics		
24-Sep-97		
Area	Mean Error (m/s)	Normalized Error
SDCW	1.7	0.84
EAST	1.4	0.58
ORNG	0.9	0.84
BORD	1.1	0.58
OFFS	1.2	0.87
25-Sep-97		
Area	Mean Error (m/s)	Normalized Error
SDCW	1.2	0.56
EAST	1.4	0.54
ORNG	0.8	0.37
BORD	1.4	0.62
OFFS	1.3	0.72
26-Sep-97		
Area	Mean Error (m/s)	Normalized Error
SDCW	0.7	0.62
EAST	1.2	1.05
ORNG	0.9	0.77
BORD	0.9	0.61
OFFS	1.5	0.61
27-Sep-97		
Area	Mean Error (m/s)	Normalized Error
SDCW	0.7	0.66
EAST	1.1	0.80
ORNG	0.7	0.55
BORD	0.7	0.62
OFFS	1.1	1.10
28-Sep-97		
Area	Mean Error (m/s)	Normalized Error
SDCW	0.6	0.54
EAST	1.2	0.91
ORNG	0.7	0.60
BORD	0.6	0.70
OFFS	1.0	0.83
29-Sep-97		
Area	Mean Error (m/s)	Normalized Error
SDCW	0.6	0.46
EAST	0.9	0.77
ORNG	0.8	0.54
BORD	0.6	0.55
OFFS	0.9	0.78

Table 27. Surface temperature bias for September 24-29, 1997, MM5 simulations.

Temperature Statistics		
24-Sep-97		
Area	Mean Bias (K)	Normalized Bias
SDCW	0.8	0.05
EAST	-0.7	0.04
ORNG	2.7	0.11
BORD	0.6	0.03
OFFS	1.1	0.06
25-Sep-97		
Area	Mean Bias (K)	Normalized Bias
SDCW	3.8	0.20
EAST	1.0	0.06
ORNG	2.4	0.11
BORD	3.1	0.14
OFFS	0.4	0.03
26-Sep-97		
Area	Mean Bias (K)	Normalized Bias
SDCW	0.4	0.03
EAST	0.8	0.05
ORNG	0.4	0.02
BORD	1.4	0.06
OFFS	0.0	0.05
27-Sep-97		
Area	Mean Bias (K)	Normalized Bias
SDCW	0.2	0.03
EAST	1.6	0.14
ORNG	-0.4	0.00
BORD	0.6	0.04
OFFS	-0.5	0.03
28-Sep-97		
Area	Mean Bias (K)	Normalized Bias
SDCW	0.4	0.03
EAST	0.2	0.05
ORNG	-0.5	-0.01
BORD	0.1	0.02
OFFS	-2.2	-0.06
29-Sep-97		
Area	Mean Bias (K)	Normalized Bias
SDCW	0.8	0.05
EAST	1.2	0.11
ORNG	-0.6	-0.02
BORD	0.6	0.05
OFFS	-1.2	-0.03

Table 28. Surface temperature error for September 24-29, 1997, MM5 simulations.

Temperature Statistics		
24-Sep-97		
Area	Mean Error (K)	Normalized Error
SDCW	3.7	0.15
EAST	4.2	0.23
ORNG	2.8	0.11
BORD	3.6	0.13
OFFS	3.3	0.14
25-Sep-97		
Area	Mean Error (K)	Normalized Error
SDCW	3.9	0.21
EAST	2.2	0.11
ORNG	2.6	0.11
BORD	3.2	0.15
OFFS	1.6	0.08
26-Sep-97		
Area	Mean Error (K)	Normalized Error
SDCW	1.1	0.06
EAST	2.0	0.11
ORNG	1.3	0.06
BORD	1.8	0.08
OFFS	3.2	0.15
27-Sep-97		
Area	Mean Error (K)	Normalized Error
SDCW	1.8	0.09
EAST	3.2	0.20
ORNG	1.8	0.08
BORD	1.8	0.08
OFFS	3.6	0.16
28-Sep-97		
Area	Mean Error (K)	Normalized Error
SDCW	2.1	0.09
EAST	3.9	0.17
ORNG	2.3	0.10
BORD	2.3	0.09
OFFS	4.0	0.16
29-Sep-97		
Area	Mean Error (K)	Normalized Error
SDCW	1.9	0.09
EAST	3.8	0.20
ORNG	2.1	0.09
BORD	2.2	0.10
OFFS	2.9	0.12

Table 29. Mixing height bias for September 26-29, 1997, MM5 simulations.

Mixing Height Statistics							
26-Sep-97	Mean Bias (meters)				Normalized Bias		
Area	MM5		CALMET		MM5		CALMET
PROF	-260.9		-58		-0.57		-0.03
27-Sep-97	Mean Bias (meters)				Normalized Bias		
Area	MM5		CALMET		MM5		CALMET
PROF	-235.2		-59.7		-0.63		-0.16
28-Sep-97	Mean Bias (meters)				Normalized Bias		
Area	MM5		CALMET		MM5		CALMET
PROF	-303		-76.8		-0.72		-0.08
29-Sep-97	Mean Bias (meters)				Normalized Bias		
Area	MM5		CALMET		MM5		CALMET
PROF	-258.5		-66.7		-0.65		-0.18

Table 30. Mixing height error for September 26-29, 1997, for MM5 simulations.

Mixing Height Statistics							
26-Sep-97	Mean Error (meters)				Normalized Error		
Area	MM5		CALMET		MM5		CALMET
PROF	357.7		358.6		0.77		0.92
27-Sep-97	Mean Error (meters)				Normalized Error		
Area	MM5		CALMET		MM5		CALMET
PROF	281.9		303.2		0.72		0.83
28-Sep-97	Mean Error (meters)				Normalized Error		
Area	MM5		CALMET		MM5		CALMET
PROF	340		380		0.8		0.98
29-Sep-97	Mean Error (meters)				Normalized Error		
Area	MM5		CALMET		MM5		CALMET
PROF	317.7		340.8		0.79		0.85

4.3 Evaluation of Air Quality Model Outputs for the Base Year August 4-7, 1997, Episode

EPA guidance recommends statistical and other analytical techniques to be part of an operational evaluation of ozone model performance. The guidance recommends three statistical measures be calculated for hourly ozone and 8 hourly ozone over the episode days in an attainment demonstration. Model predictions are paired in time and space with observations for these statistical measures. The model predictions at the observational site are bi-linearly interpolated from the four grid cells surrounding the station location.

- Mean Normalized Bias - EPA (2005, Equation 15.1)
- Mean Normalized Gross Error - EPA (2005, Equation 15.2)
- Average Peak Prediction Bias and Error - as above except applied to daily maxima at each monitoring location

In addition we evaluated the ability of the model to predict the unmatched peak ozone in San Diego County: $Model_{max}/Observed_{max}$, where the modeled value occurred anywhere in the county and the observed value occurred at the location of the observed daily maximum in San Diego County. The statistics were calculated with a threshold value of 60 ppb to avoid undue weighting of low ozone concentrations.

The modeling protocol established the following goals for the statistical model performance. The same performance goals are used for both one-hour and eight-hour averaged ozone.

- unpaired peak accuracy to within ±20%
- paired normalized bias to within ±15%
- paired normalized error to within 35%

Sixteen surface ozone monitoring stations operated in San Diego County during SCOS97. The names and mnemonics of these sites are listed in Table 31 and shown in Figure 6. The more densely populated areas of San Diego County are shown with shading in the figure. Supplemental sites that are not part of the normal monitoring network are indicated in Table 31.

Table 31. Ozone monitoring sites in San Diego County.

Site	Mnemonic		Site	Mnemonic
Alpine	ALPN		12th Street	SD12
Chula Vista	CHVT		Black Mountain*^	BLKM
Del Mar	DMMC		Camp Pendleton	PEND
El Cajon	ECAJ		Red Mountain*^	REDM
Escondido	ESCO		San Marcos Peak*^	SMPK
Oceanside	OCEA		Soledad Mountain*^	SOLM
Otay Mesa	OTAY		Valley Center*	VCEN
Overland	SDOV		Warner Springs*	WSPR

*Supplemental monitoring site.
^Site located on elevated terrain.

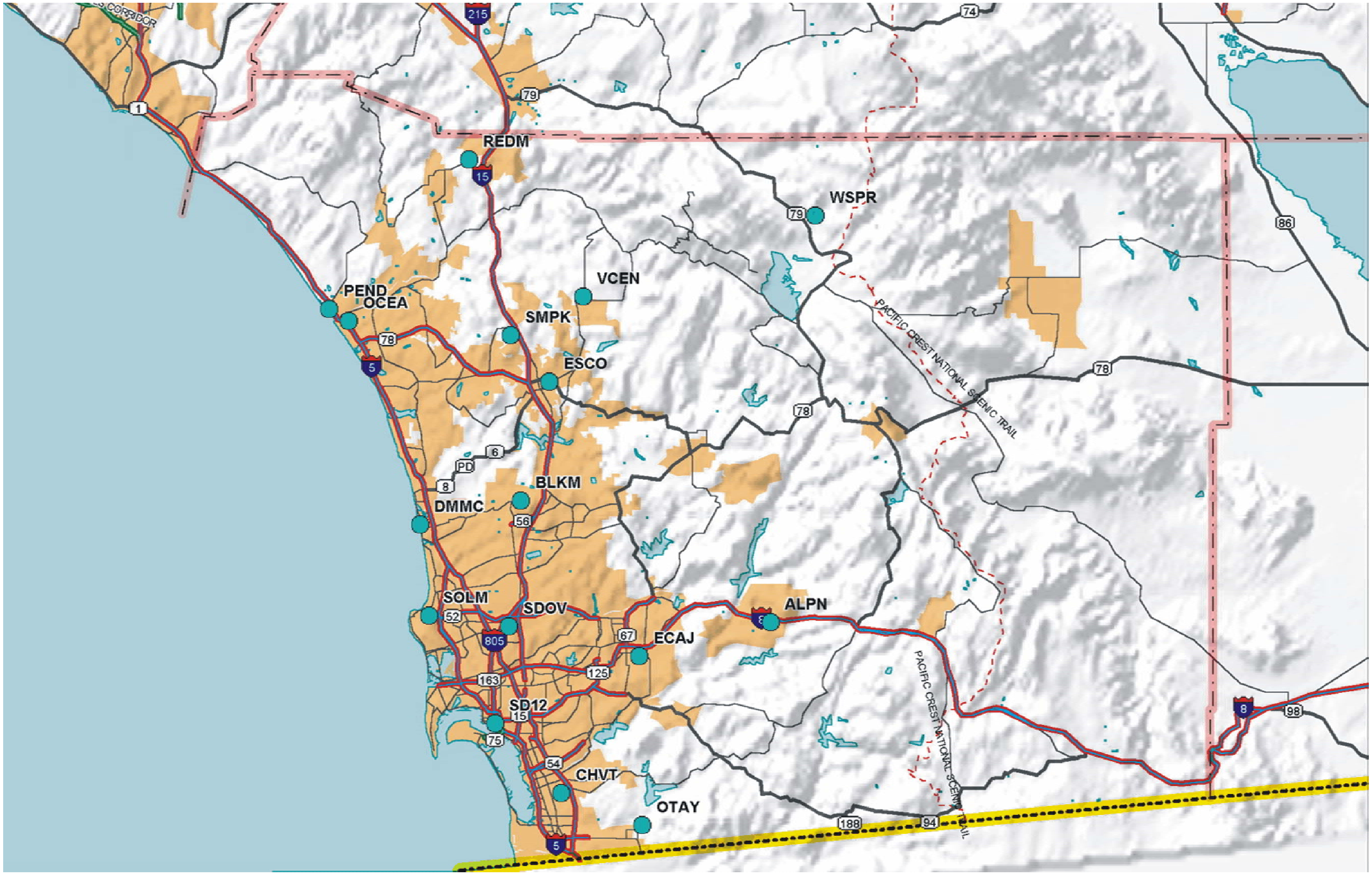


Figure 6. Ozone monitoring sites in San Diego County, SCOS97.

4.3.1 Evaluation of One-Hour Ozone Predictions

One-hour predicted ozone in San Diego meets many of the performance goals except for over predicting peak ozone on August 6 and 7 and on August 4 the one-hour averaged ozone is under predicted so the bias misses the performance goal. Table 32 lists the statistical model performance measures for August 4 to 7.

Table 32. One-hour averaged ozone model performance for San Diego County for the August 4-7, 1997, ozone episode.

Episode Day	Unpaired Normalized Peak (%)	Normalized Bias (%)	Normalized Error (%)	Normalized Peak Bias (%)	Normalized Peak Error (%)
August 4 (Peak location)	-14 Black Mtn	-21	28	-9	18
August 5 (Peak location)	-1 Otay Mesa	-4	23	-5	15
August 6 (Peak location)	22 Valley Center	4	16	-1	11
August 7 (Peak location)	30 Warner Springs	14	19	30	31

Figures 7a and 7b show time series of one-hour averaged ozone and NO_x predictions and observations at 16 monitoring sites in San Diego County for August 3 to 7. Figures 8a to 8d show the daily one-hour maximum grid cell predicted values and the daily maximum observed ozone for August 4 to 7.

Alpine is the location of the only monitoring in San Diego County not in attainment of the 8 hour averaged ozone standard. At Alpine hourly ozone is reasonably well predicted on August 4 and 5 and on August 6 until about noon. After that time hourly ozone is over predicted at Alpine. Ozone at the coastal sites of Camp Pendleton, Oceanside, and Del Mar is slightly over predicted during August 4 to 7. The San Diego 12th Street and Chula Vista sites' ozone is predicted on all days. The San Diego Overland site ozone is under predicted on the 4th, predicted on the 5th and over predicted on the 6th and 7th. Ozone at Otay Mesa is predicted through August 5, then over predicted at night and on August 7. The inland site Escondido ozone is predicted well on the 3rd to 6th, but over predicted on the 7th. The inland site El Cajon ozone is predicted well on the 3rd to 5th, but over predicted on the 6th and 7th. The Valley Center site ozone is over predicted at night and on the 7th, but predicted during the day on August 4, 5, and 6. The ozone predictions at Warner Springs are out of phase with the predicted peaks, which occur six to eight hours after the observed ozone peaks. At the elevated sites Black Mountain and Red Mountain the nocturnal ozone peak which occurs between August 3 and 4 is not predicted. Ozone is predicted fairly well on the remaining days at Red Mountain. Ozone at Black Mountain is predicted well on August 4 and 5, but is over predicted on August 6 and 7. Ozone is predicted fairly well at San Marcos Peak and Soledad Mountain on August 3 to 5, but is over predicted on August 6 and 7.

The spatial plot of peak ozone for August 4 shows the observed lower ozone concentrations near the coast and higher values inland in San Diego County are predicted by the simulations. The peak predicted values extend south from Alpine into Mexico. On August 5 there are two areas of observed maximum ozone in San Diego County; one in the northwest part of the county and another in the southwest part. The northwest area is predicted well. The predicted ozone in the southwest part of the county does not extend westward far enough toward the coast so that Chula Vista, Otay Mesa, and 12th Street are under predicted. Peak predicted ozone on August 6 in San Diego County is located northeast of Alpine with higher concentrations extending north and south from that area. This area of predicted peak ozone is not located far enough eastward, which causes the observed ozone maxima to be over predicted. The same pattern is seen in the ozone predictions on August 7, with the predicted maximum not far enough east of the coast, so again, the inland observed ozone maxima are over predicted.

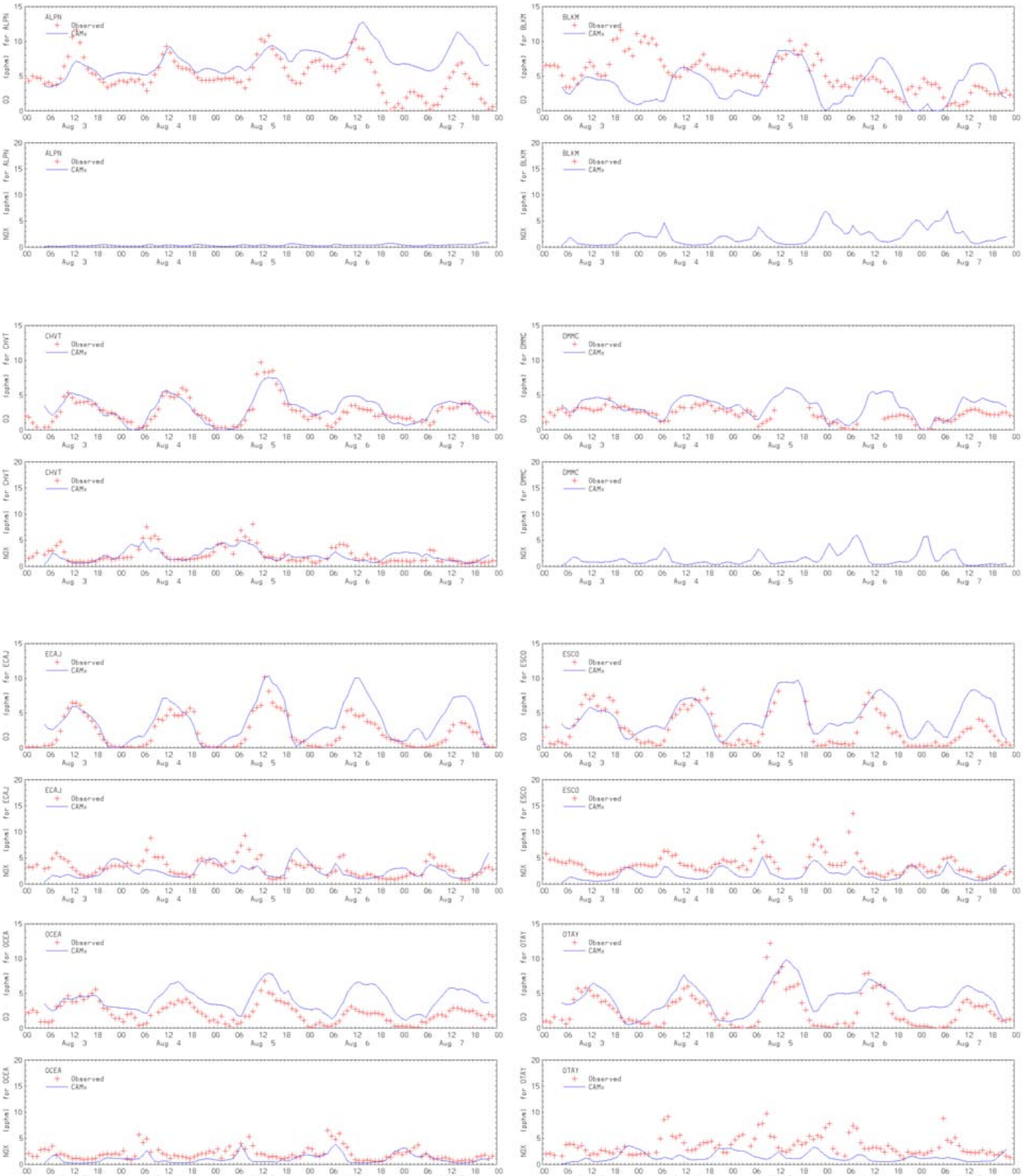


Figure 7a. Time series of one-hour averaged ozone and NOx in San Diego County, August 3-7, 1997.

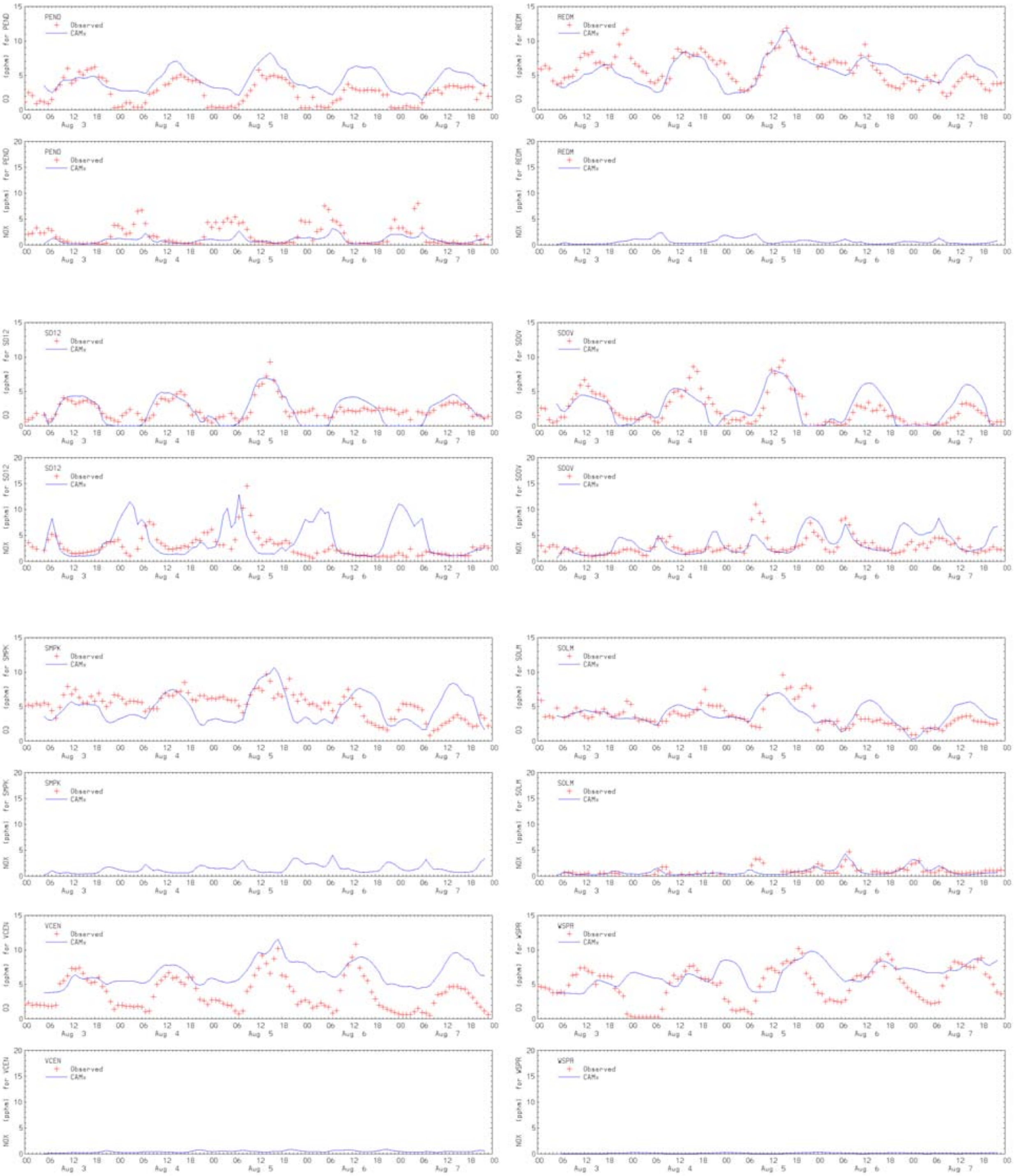


Figure 7b. Time series of one-hour averaged ozone and NOx in San Diego County, August 3-7, 1997.

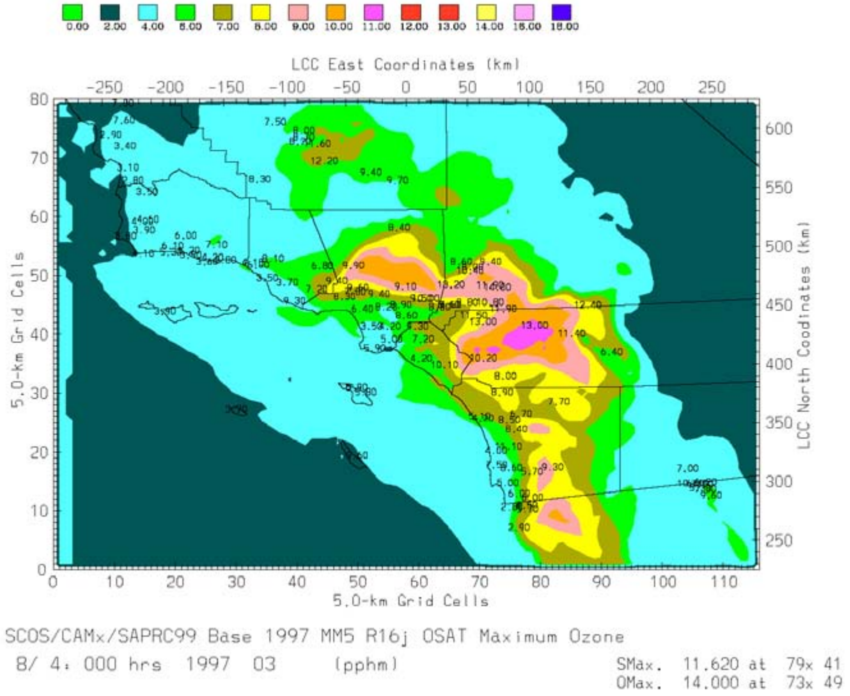


Figure 8a. Plot of maximum predicted one-hour averaged ozone for August 4, 1997.

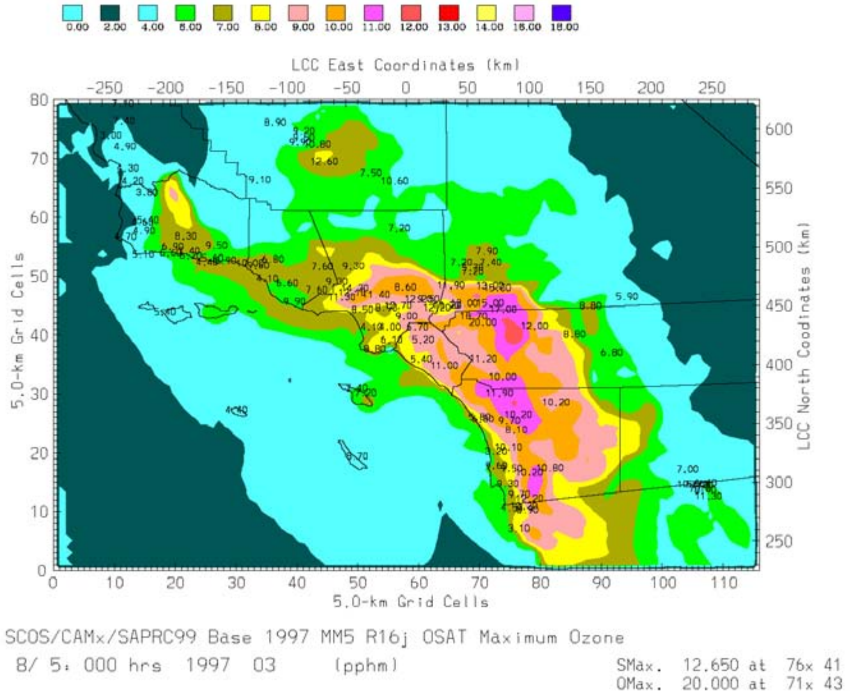


Figure 8b. Plot of maximum predicted one-hour averaged ozone for August 5, 1997.

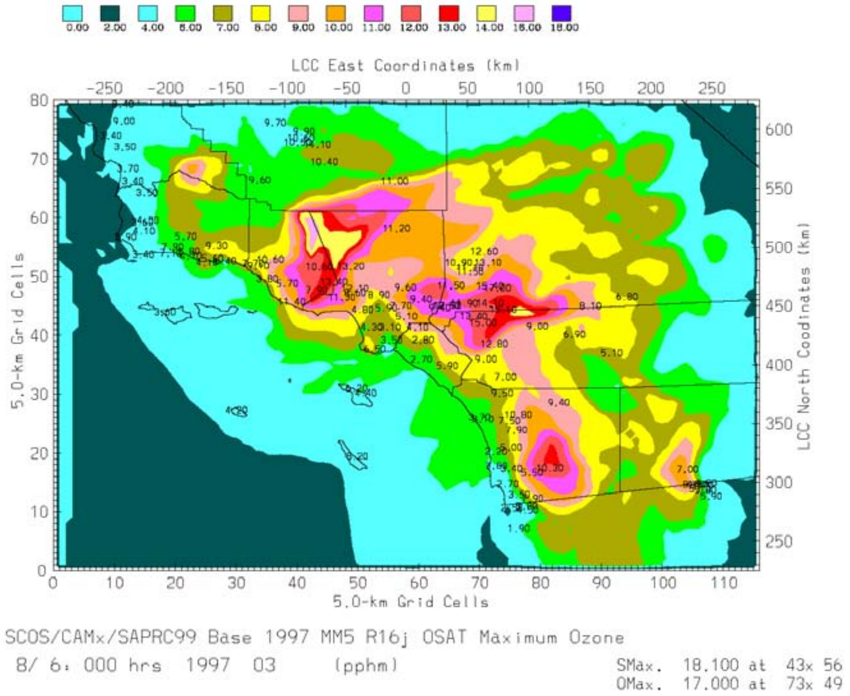


Figure 8c. Plot of maximum predicted one-hour averaged ozone for August 6, 1997.

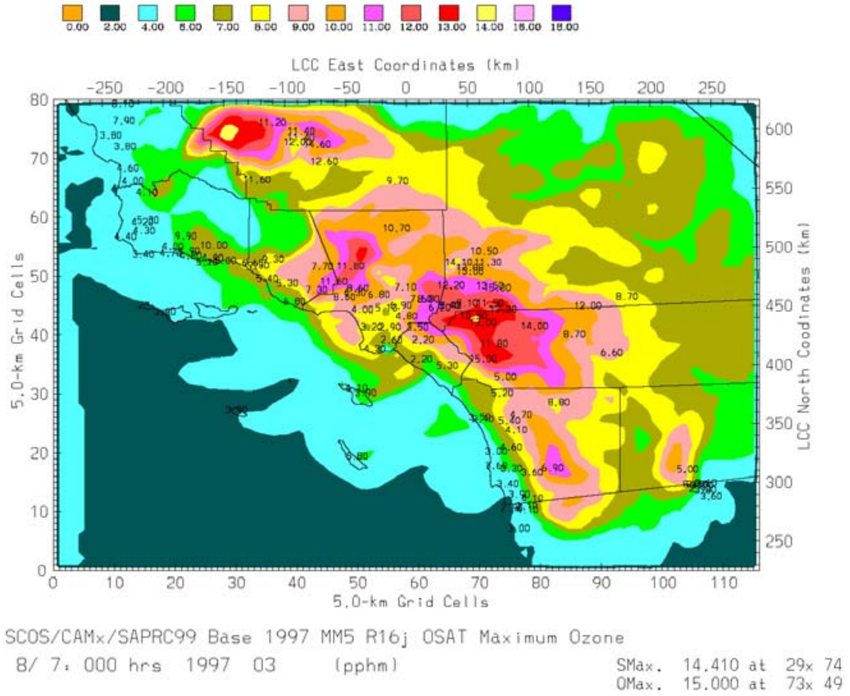


Figure 8d. Plot of maximum predicted one-hour averaged ozone for August 7, 1997.

4.3.2 Evaluation of Eight-Hour Ozone Predictions

Eight-hour predicted ozone in San Diego meets many of the performance goals except for over predicting peak ozone on August 6 and 7 and on August 4 eight-hour averaged ozone is under predicted and the bias misses the performance goal. Table 33 lists the statistical model performance measures for August 4 to 7.

Table 33. Eight-hour averaged ozone model performance for San Diego County for the August 4-7. 1997, ozone episode.

Episode Day	Unpaired Normalized Peak (%)	Normalized Bias (%)	Normalized Error (%)	Normalized Peak Bias (%)	Normalized Peak Error (%)
August 4 (Peak location)	-12 Black Mtn	-20	23	-6	13
August 5 (Peak location)	7 Red Mtn	1	16	6	11
August 6 (Peak location)	26 Alpine	9	15	11	11
August 7 (Peak location)	27 Warner Springs	7	7	4	4

Figures 9a and 9b show time series of eight-hour averaged ozone predictions and observations at 16 monitoring sites in San Diego County for August 3 to 7. Figures 10a to 10d show the daily eight-hour maximum predicted and observed ozone in the modeling domain for August 4 to 7.

Alpine is the location of the only monitoring in San Diego County not in attainment of the eight-hour averaged ozone standard. Eight-hour averaged ozone is reasonably well predicted on August 4 and 5. After that eight-hour averaged ozone is over predicted at Alpine. Nearer the coast, El Cajon ozone is over predicted, especially on August 6 and 7. The San Diego Overland site ozone is predicted on August 4 and 5, but over predicted on August 6 and 7. Ozone at the San Diego 12th Street is predicted on August 4 and 5, but the flat trend on August 6 is not predicted. At the coastal sites of Del Mar, Oceanside and Pendleton ozone is over predicted. Escondido ozone is predicted on August 4, but is over predicted on August 5, 6, and 7. Red Mountain ozone is predicted well from the 4th through noon on the 6th and then over predicted. At Black Mountain nocturnal ozone peaks are not predicted. The August 5 afternoon ozone peak is predicted, but the afternoon peaks on August 6 and 7 are over predicted. Ozone at Chula Vista is predicted on August 4, 5, and 7, but is over predicted on August 6. At Otay Mesa afternoon ozone is predicted on August 5 and 6, but over predicted on August 4 and 7 and at night on August 5 and 6. At San Marcos Peak ozone is under predicted at night August 4 to 5, but out of phase for the observed nocturnal peak ozone August 5 to 6 and August 6 to 7. Ozone at Valley Center is over predicted. Predicted zone at Warner Springs is out of phase with observed ozone.

The same spatial pattern seen in the one-hour averaged ozone is observed in the eight-hour averaged ozone. The spatial plot of peak ozone for August 4 shows the observed lower ozone concentrations near the coast and higher values inland are predicted by the simulation. The peak predicted values extend south from Alpine into Mexico. On August 5 there are two areas of maximum ozone in San Diego County; one in the northwest part of the county and another in the southwest part. The northwest area is slightly over predicted. The predicted ozone in the southwest part of the county is predicted well. Peak predicted ozone on August 6 in San Diego County is located northeast of Alpine with higher concentrations extending north and south from that area. This area of predicted peak ozone is not located far enough eastward which causes the observed ozone maxima to be over predicted. The same pattern is seen in the ozone predictions on August 7 with the predicted maximum not far enough east of the coast, so again, the inland observed ozone maxima are over predicted.

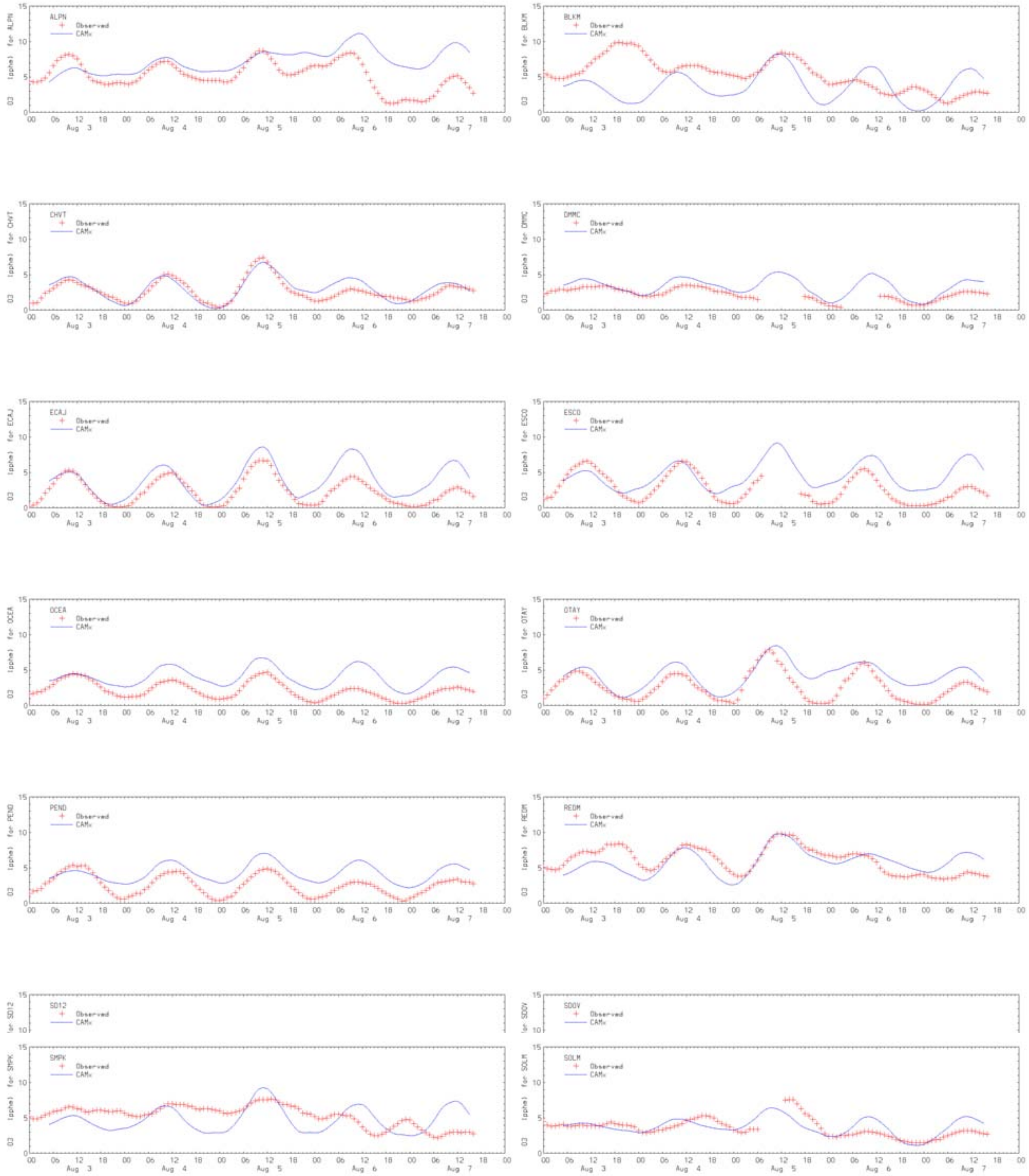


Figure 9a. Time series of eight-hour averaged ozone in San Diego County, August 3-7, 1997.

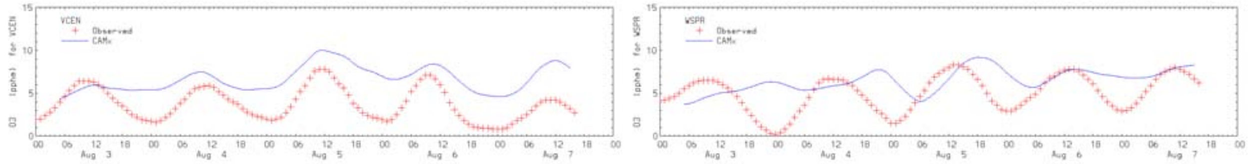


Figure 9b. Time series of eight-hour averaged ozone in San Diego County, August 3-7, 1997.

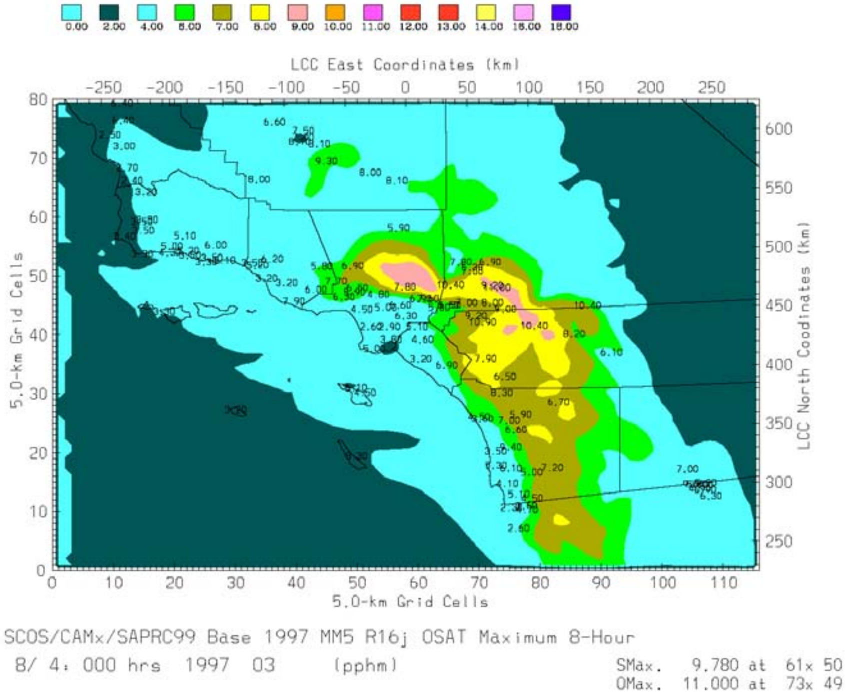


Figure 10a. Plot of maximum predicted eight-hour averaged ozone for August 4, 1997.

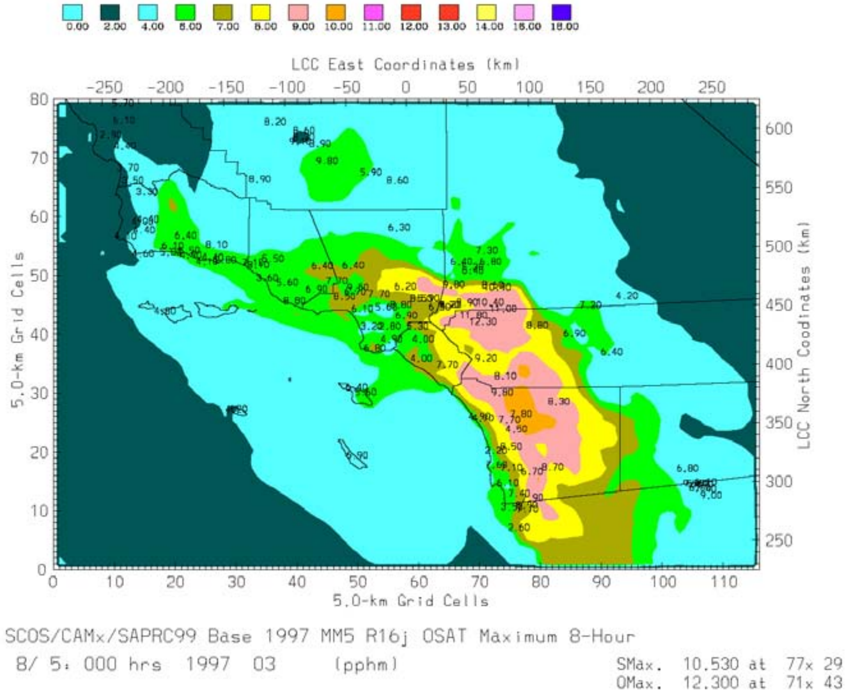


Figure 10b. Plot of maximum predicted eight-hour averaged ozone for August 5, 1997.

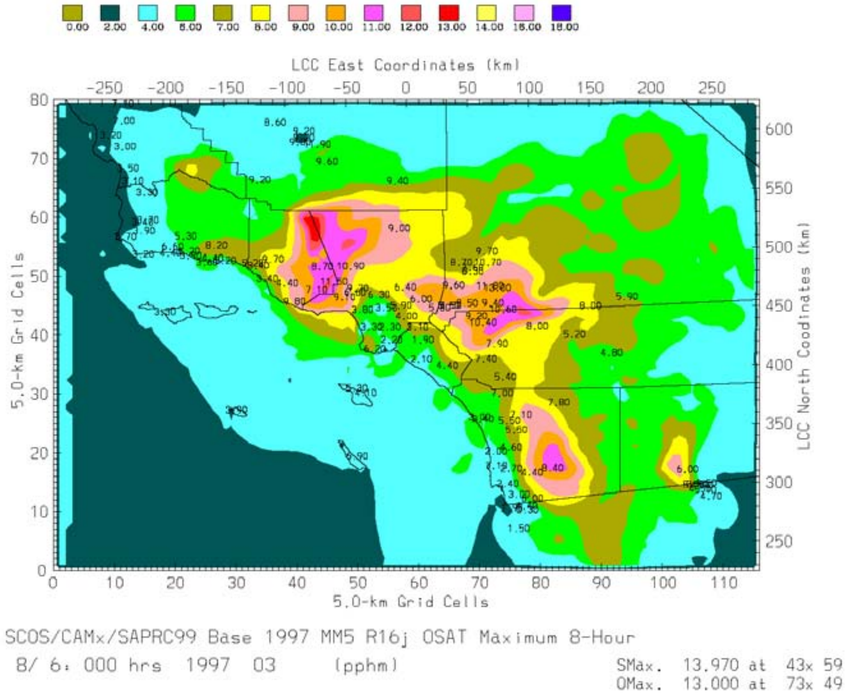


Figure 10c. Plot of maximum predicted eight-hour averaged ozone for August 6, 1997.

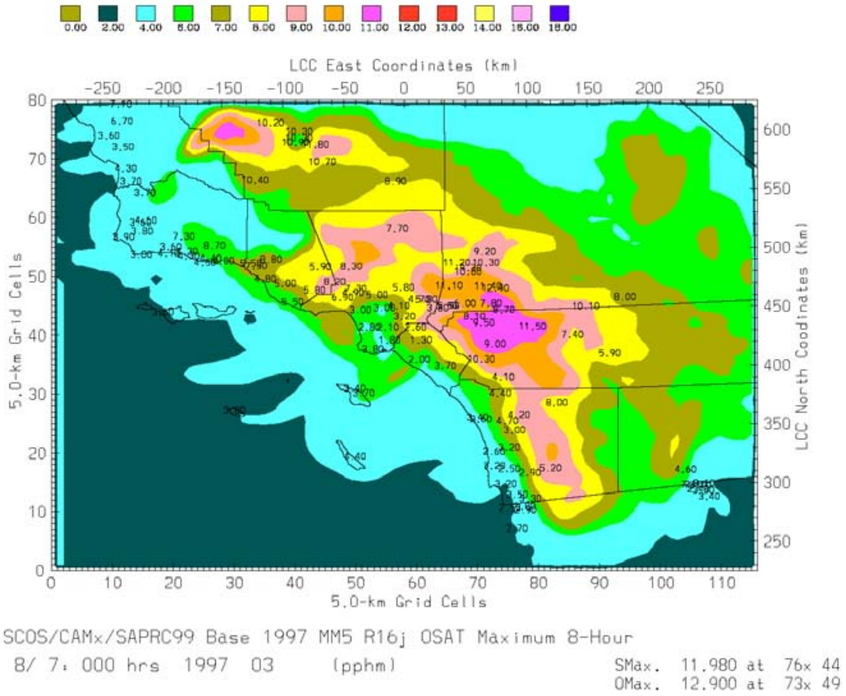


Figure 10d. Plot of maximum predicted eight-hour averaged ozone for August 7, 1997.

4.4 Evaluation of Air Quality Model Outputs for the Base Year September 27-28, 1997, Episode

4.4.1 Evaluation of One-Hour Ozone Predictions

One-hour predicted ozone in San Diego County meets most of the performance goals except bias on both September 27 and 28 when ozone is under predicted. Table 34 lists the statistical model performance measures for September 27 and 28. Model performance is improved if the supplemental monitoring sites on elevated terrain are excluded. These would be sites: Black Mountain, Red Mountain, San Marcos Peak, and Soledad Mountain. These sites are impacted by ozone aloft, which remains high at night in the observations, but is lower in the simulation. Statistical performance for the remaining set of monitoring sites is shown in Table 35.

Statistical model performance for one-hour averaged ozone with all monitoring sites does not meet the performance goals for bias with both September 27th and 28th ozone under predicted. When the sites on elevated terrain are excluded most of the performance goals are met except for an under prediction bias on September 28, which misses the performance goal.

Table 34. One-hour averaged ozone model performance for San Diego County for the September 27-28, 1997, ozone episode.

Episode Day	Unpaired Normalized Peak (%)	Normalized Bias (%)	Normalized Error (%)	Normalized Peak Bias (%)	Normalized Peak Error (%)
September 27 (Peak location)	-11 San Marcos Pk	-18	21	-16	16
September 28 (Peak location)	-13 Black Mtn	-26	31	-16	21

Table 35. One-hour averaged ozone model performance for San Diego County for the September 27-28, 1997, ozone episode excluding elevated sites.

Episode Day	Unpaired Normalized Peak (%)	Normalized Bias (%)	Normalized Error (%)	Normalized Peak Bias (%)	Normalized Peak Error (%)
September 27 (Peak location)	6 Overland	-7	11	-11	12
September 28 (Peak location)	-13 Alpine	-19	26	-12	20

Figures 11a and 11 b show time series of one-hour averaged ozone and NO_x predictions and observations at 16 monitoring sites in San Diego County for September 26-28. Figures 12a to 12c show the daily one-hour maximum predicted and observed ozone in the modeling domain for September 26 to 29.

Alpine is the location of the only monitoring in San Diego County not in attainment of the 8 hour averaged ozone standard. Hourly ozone is reasonably well predicted on September 27 but is under predicted on September 28. At night ozone is over predicted from the 26th to the 27th. El Cajon ozone is predicted on the 26th and 27th, but the peak is predicted late on the 28th. At the coastal site of Del Mar ozone is predicted on the 26th and 27th, but is over predicted on the 28th. At coastal sites Oceanside and Pendleton ozone is predicted during the day, but over predicted at night. In southern San Diego County at Otay Mesa and Chula Vista, ozone is predicted on the 26th and 27th, but under predicted on the 28th. Ozone at Escondido is predicted on the 26th and 27th, but under predicted on the 28th. At the San Diego 12th Street site ozone is predicted except for an under prediction during the night between the 27th and 28th. The San Diego Overland site ozone is predicted during the day, but over predicted at night. At the elevated site Black Mountain ozone is predicted until noon on the 27th, then is under predicted. At Red Mountain and San Marcos Peak ozone is predicted on the 26th, but under predicted on the 27th and 28th. Predicted ozone at Valley Center and Warner Springs has little diurnal variation while the observed ozone shows a nocturnal minimum which is over predicted.

The spatial pattern of observed one-hour averaged peak ozone on September 26 is fairly uniform across San Diego County except for Warner Springs which has higher ozone. The pattern of predicted ozone is an area of higher ozone offshore and a second area in mid San Diego County. The predicted values are close to the observed values except for Warner Springs. On September 27 observed ozone is higher at the elevated sites. Predicted ozone shows a ridge line of higher ozone extending south from the Escondido into Mexico. The predicted values along this ridge are similar to the observed values. Observed ozone on September 28 has higher concentrations inland. The predicted ozone has a region of higher concentrations just offshore and a second region of higher ozone near Alpine. The region near Alpine is not as large in extent as the region of observed peak ozone.

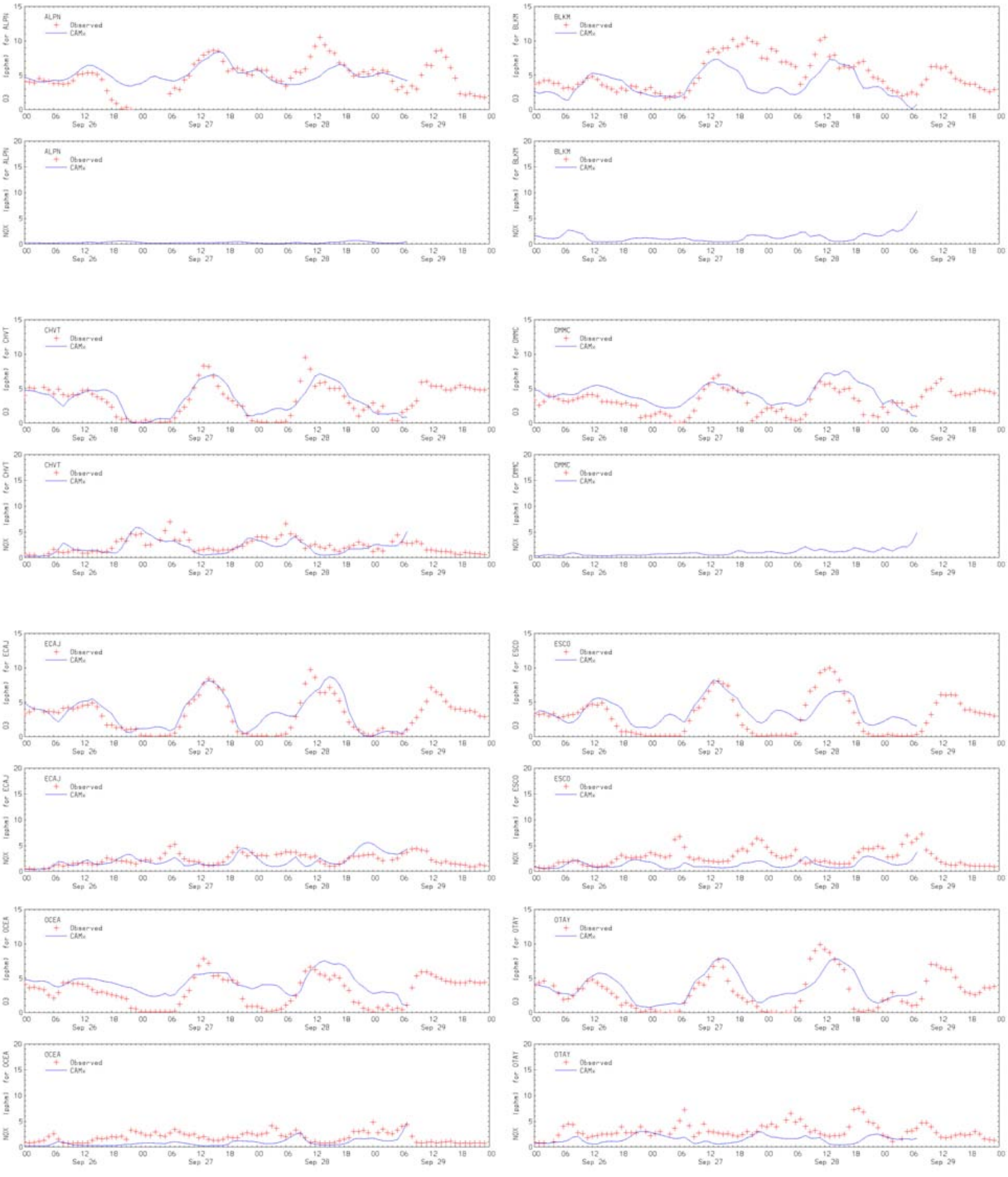


Figure 11a. Time series of one-hour averaged ozone and NOx in San Diego County, September 26-29, 1997.

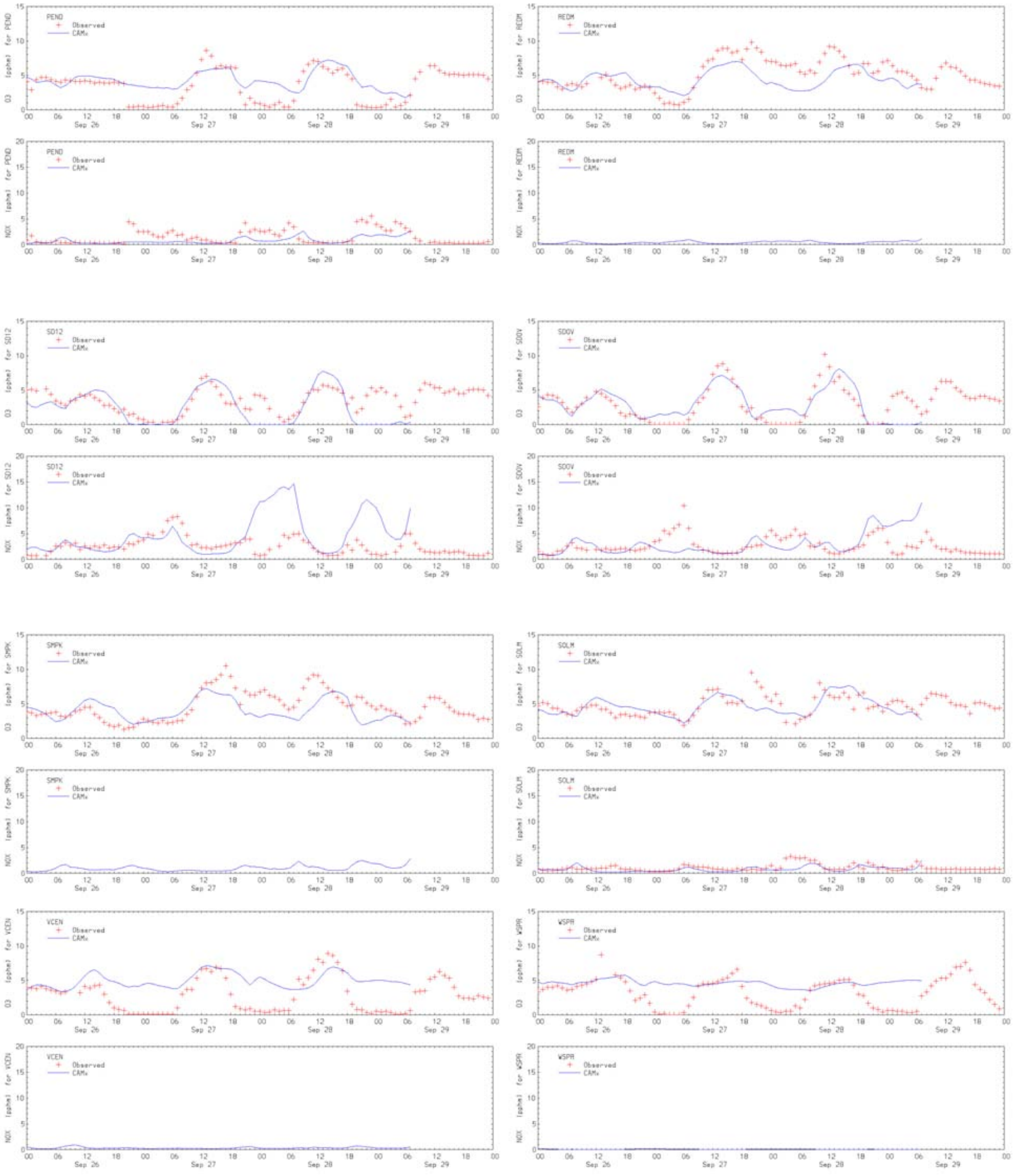


Figure 11b. Time series of one-hour averaged ozone and NOx in San Diego County, September 26-29, 1997.

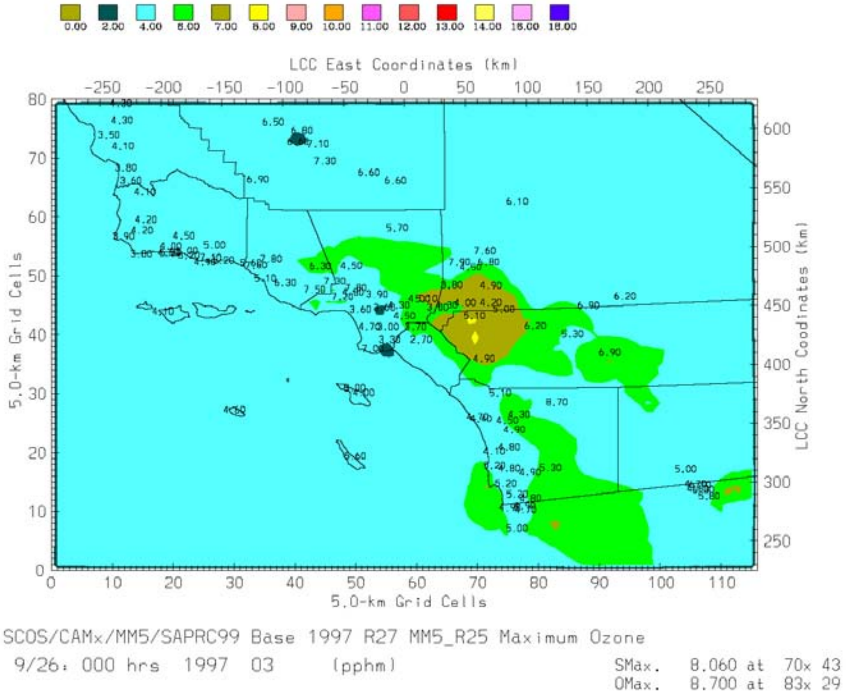


Figure 12a. Plot of maximum predicted one-hour averaged ozone for September 26, 1997.

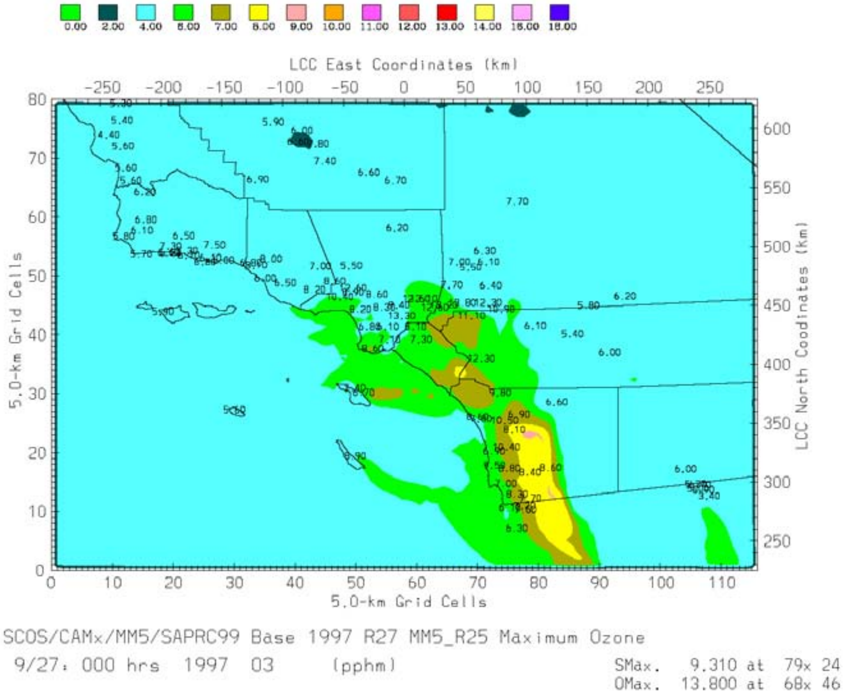


Figure 12b. Plot of maximum predicted one-hour averaged ozone for September 27, 1997.

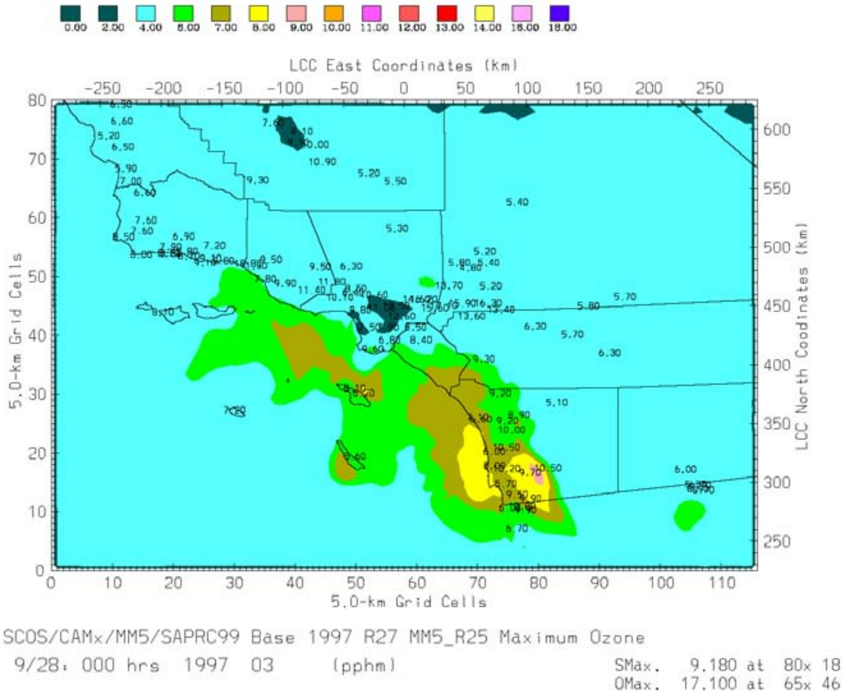


Figure 12c. Plot of maximum predicted one-hour averaged ozone for September 28, 1997.

4.4.2 Evaluation of Eight-Hour Ozone Predictions

Eight-hour predicted ozone in San Diego meets most of the performance goals except bias on both September 27 and 28 when ozone is under predicted. Table 36 lists the statistical model performance measures for September 27 and 28. Model performance is improved if the supplemental monitoring sites on elevated terrain are excluded. All of the performance goals are met except for bias on September 28 if the elevated sites are excluded as seen in Table 37.

Table 36. Eight-hour averaged ozone model performance for San Diego County for the September 27-28, 1997, ozone episode.

Episode Day	Unpaired Normalized Peak (%)	Normalized Bias (%)	Normalized Error (%)	Normalized Peak Bias (%)	Normalized Peak Error (%)
September 27 (Peak location)	-18 Black Mtn	-24	25	-9	12
September 28 (Peak location)	-6 Alpine	-23	25	-11	15

Table 37. Eight-hour averaged ozone model performance for San Diego County for the September 27-28, 1997, ozone episode excluding elevated sites.

Episode Day	Unpaired Normalized Peak (%)	Normalized Bias (%)	Normalized Error (%)	Normalized Peak Bias (%)	Normalized Peak Error (%)
September 27 (Peak location)	5 Alpine	-2	5	-2	6
September 28 (Peak location)	-6 Alpine	-18	20	-10	14

Figures 13a and 13b show time series of eight-hour averaged ozone predictions and observations at 16 monitoring sites in San Diego County for September 26-28. Figures 14a to 14c show the daily eight-hour maximum predicted and observed ozone in the modeling domain for September 26 to 28.

Alpine is the location of the only monitoring in San Diego County not in attainment of the 8 hour averaged ozone standard. Eight-hour averaged ozone is reasonably well predicted on September 27 but is under predicted on September 28 and over predicted at night September 26 to 27. To the west, at El Cajon and San Diego Overland ozone is predicted except for over prediction during the night September 27-28. Ozone at the San Diego 12th Street site is predicted except for under prediction during the night September 27 to 28. At the coastal sites of Oceanside and Pendleton ozone is predicted during the day, but over predicted at night. At the coastal site in Del Mar, ozone is predicted September 26 and 27, but over predicted on September 28. Inland at Escondido ozone is over predicted at night and under predicted on the 28th. At Otay Mesa ozone is over predicted on September 26 and 27 and under predicted on the 28th. Ozone at the elevated sites of Red Mountain, Black Mountain and San Marcos Peak is under predicted on the 27th and 28th. The northern sites of Valley Center and Warner Springs show little diurnal variation in the ozone predictions, which causes over prediction at night.

The spatial pattern of observed daily peak eight-hour averaged ozone on September 26 is an area of ozone with little variation ranging between 40 ppb and 60 ppb in San Diego County. The predicted ozone shows the same pattern with concentrations between 40 ppb and 60 ppb. On September 27th the observed maximum eight-hour ozone is highest at Alpine and the elevated supplemental sites. The predicted ozone shows an area of highest concentration south of Alpine. Peak observed eight-hour ozone on September 28 is highest inland. Predicted peak ozone has an area of maximum concentration immediately offshore San Diego County and a second area of maximum concentration south of Alpine. The observed maximum area in northern San Diego County is under predicted.

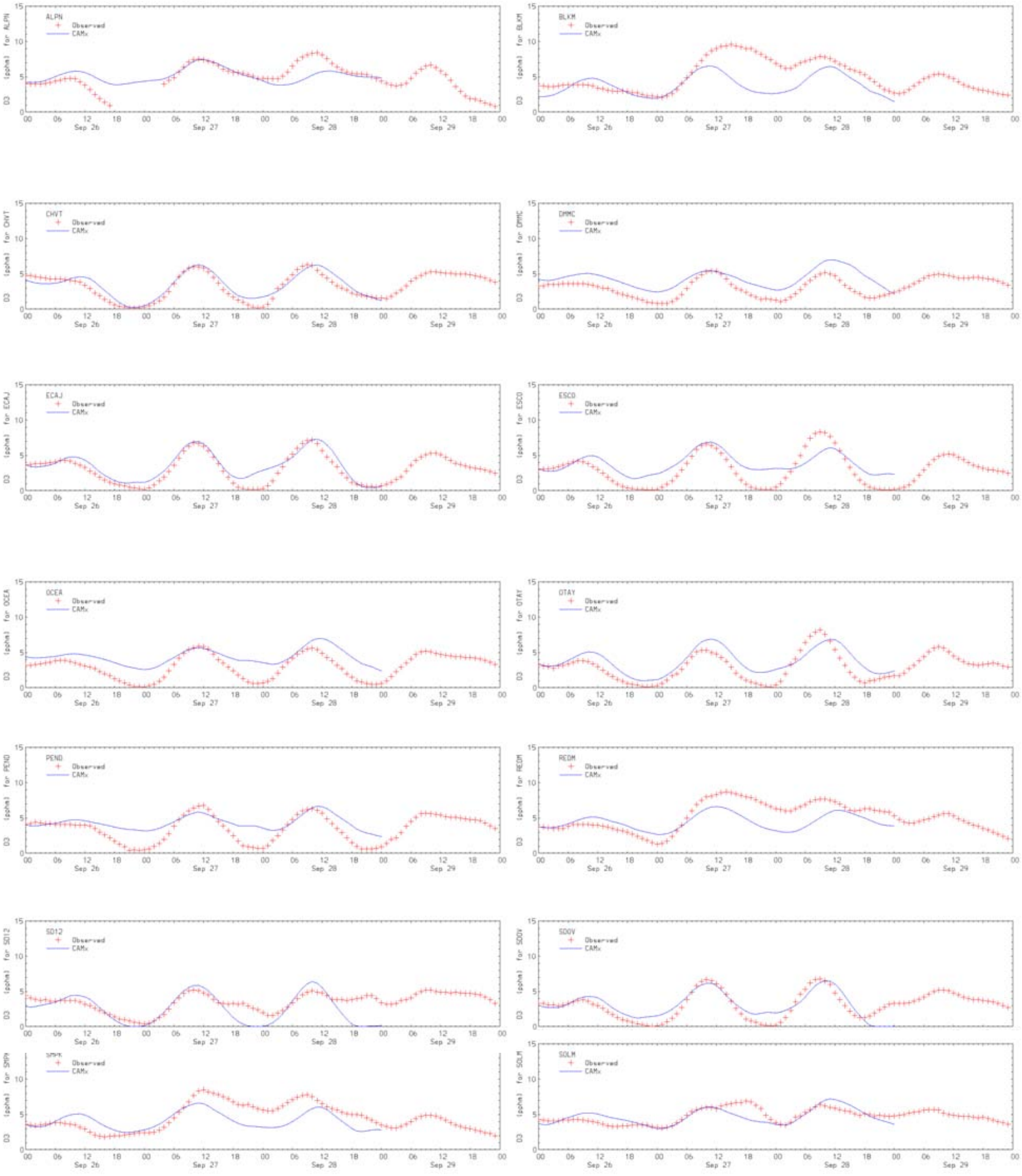


Figure 13a. Time series of eight-hour averaged ozone in San Diego County, September 26-29, 1997.

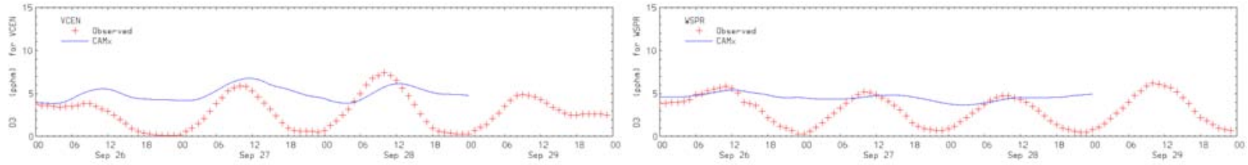


Figure 13b. Time series of eight-hour averaged ozone in San Diego County, September 26-29, 1997.

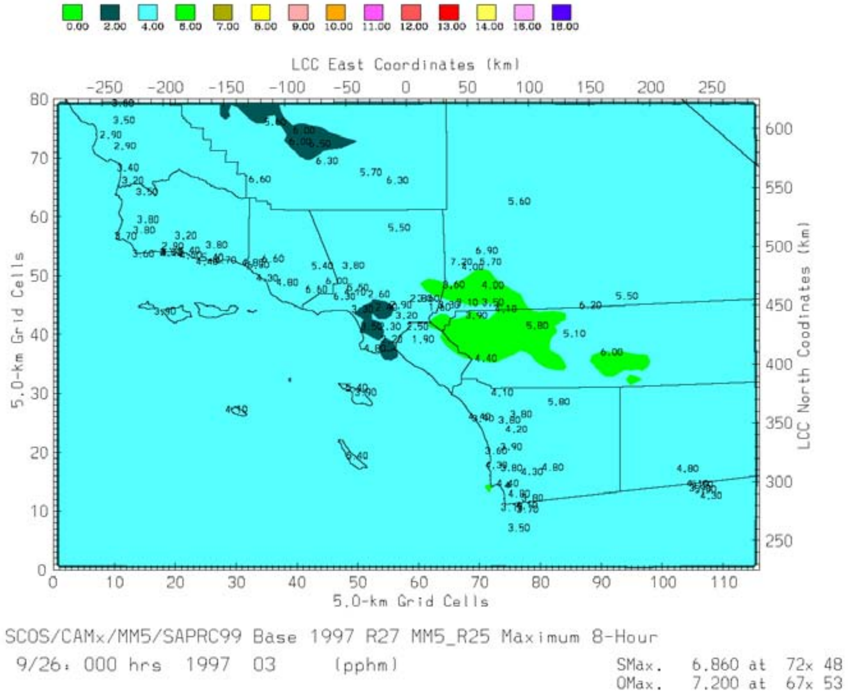


Figure 14a. Plot of maximum predicted eight-hour averaged ozone for September 26, 1997.

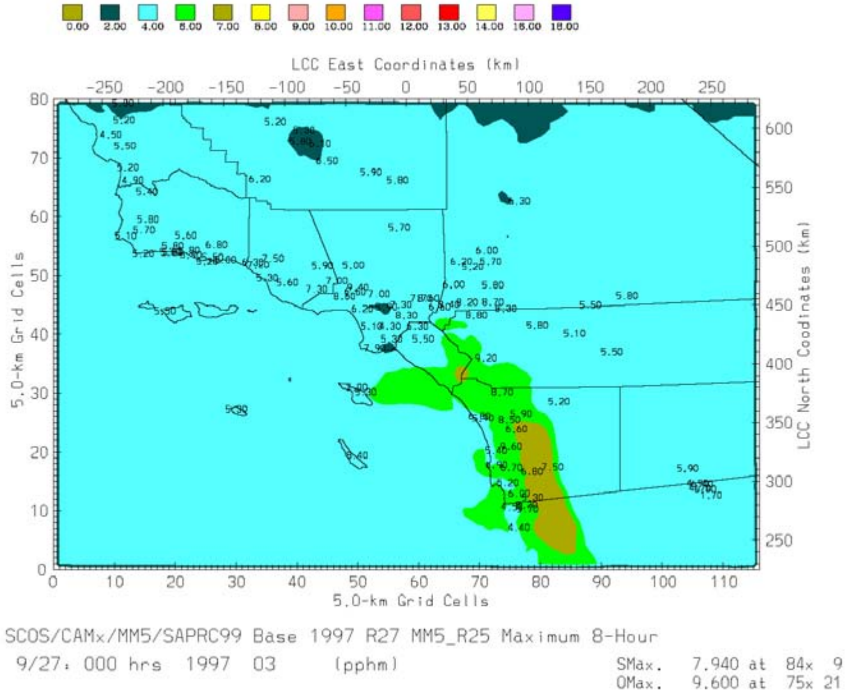


Figure 14b. Plot of maximum predicted eight-hour averaged ozone for September 27, 1997.

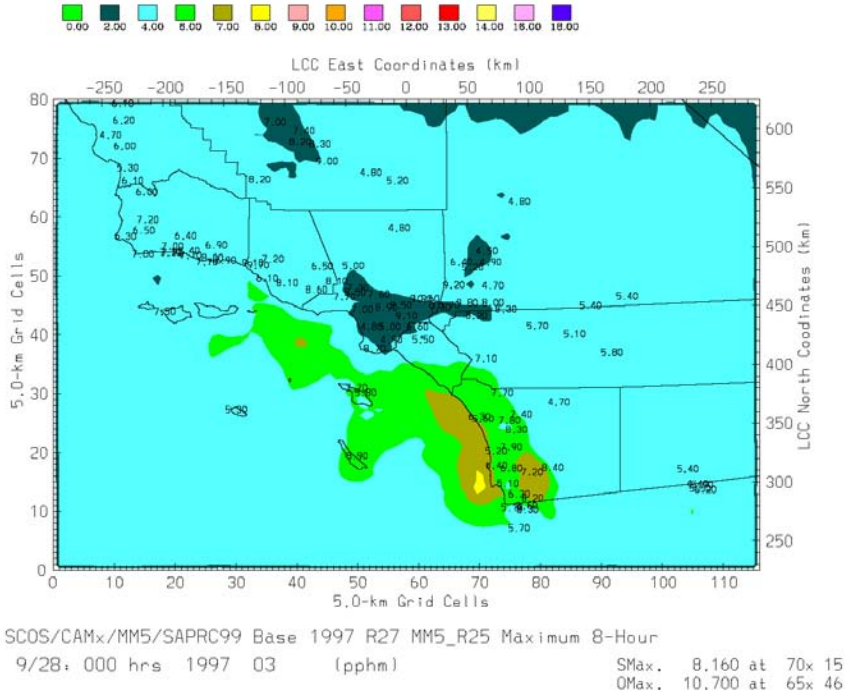


Figure 14c. Plot of maximum predicted eight-hour averaged ozone for September 28, 1997.

4.5 Source Apportionment

The CAMx simulations for the August 4-7, 1997, and September 27-28, 1997, ozone episodes were made using the Ozone Source Apportionment Technology (OSAT) (Environ 2005) in the CAMx model. OSAT provides information about the sources of ozone production that lead to predicted ozone at a designated receptor. Fourteen source regions are defined in the modeling domain. These source regions listed in Table 38 are mostly defined by the county boundaries. Sixteen point receptors are defined which are located at the SCOS97 San Diego County monitoring sites. These receptors are listed in Table 39.

Table 38. Source apportionment source regions.

Region	CAMx ID	Region	CAMx ID
Ocean	1	San Luis Obispo County	2
Kern County	3	San Bernardino County	4
Santa Barbara County	5	Ventura County	6
Los Angeles County	7	Riverside County	8
Orange County	9	San Diego County	10
Imperial County	11	Mexico	12
Outer Continental Shelf	13	State of Nevada	14

Table 39. San Diego Receptors for source apportionment.

Alpine	Chula Vista	Del Mar	El Cajon
Escondido	Oceanside	Otay Mesa	Overland
Downtown 12th St.	Black Mountain	Camp Pendleton	Red Mountain
San Marcos Peak	Soledad Mountain	Valley Center	Warner Springs

The source apportionment tracks the contribution to ozone at a receptor from initial and boundary conditions and from emissions. Ozone created from emissions is further separated into that portion formed during VOC (volatile organic compound)-limited conditions and that portion formed during NO_x-limited conditions. The apportionment is tracked each hour of the simulation.

Table 40 shows the results of the source apportionment for August 5. The apportionment is listed by receptor for the hour when the peak ozone occurred at that receptor. This means that the time of the apportionment is different for each receptor. The peak predicted ozone for the grid cell containing the receptor is listed in the second column of Table 40. This peak value will differ from the peak values used to calculate the model performance statistics which was a bi-linearly interpolated value. Column three is the contribution to the peak value from initial conditions; column four is the contribution to the peak value from boundary conditions; columns five and six are the contributions to the peak value from the chemical reactions. Column five lists the contribution from ozone created during VOC-limited conditions; column six, the contribution from ozone created during NO_x-limited conditions. Columns 3-6 add up to the peak predicted ozone. Columns seven and eight show the percentage of ozone formed from local emissions and from transported emissions. Local emissions are from the San Diego County source region. Transported emissions are the total from all other source regions in the modeling domain.

As an example, look at the Alpine receptor in Table 40. The peak ozone predicted for the surface grid cell that includes Alpine is 98.5 ppb. Initial and boundary conditions contributed 27.2 ppb to that peak value. Emissions contributed 71.3 ppb to that peak value. So initial and boundary conditions contribute 28% (27.2/98.5) to the peak ozone. Emissions contribute 72% (37% + 35%) to the peak ozone. Ozone created under VOC-limited conditions is 57% (40.9/71.3) of the emission contribution.

On August 5 initial conditions contribute 8 ppb or less to the peak ozone. Boundary conditions contribute 21 ppb or less to the peak ozone. At the coastal sites of Oceanside and Pendleton, the inland sites of Escondido, Valley Center, and Warner Springs, and at the elevated sites of Red Mountain, Black Mountain, and San Marcos Peak transported emissions contribute considerably more than local emissions to peak ozone. The slightly inland sites of San Diego 12th Street, San Diego Overland, and Chula Vista have transported emissions contributing more than local emissions to peak ozone. Further inland at El Cajon local emissions contribute equally with transported emissions to peak ozone. At Alpine local emissions contribute slightly more than transported emissions to peak ozone.

Table 41 lists the ozone source apportionment for September 27. On September 27, initial conditions contribute less than 3 ppb to the peak ozone except at Warner Springs. Boundary conditions contribute 29 ppb or less to the peak ozone. At the coastal sites of Pendleton and Oceanside transported emissions contribute considerably more to peak ozone than local emissions. At the coastal site of Del Mar transported emission contribute more to peak ozone than local emissions. Peak ozone at the elevated sites of Red Mountain, Black Mountain, and San Marcos Peak is contributed to more from transported emissions than local emissions. At the inland stations of Chula Vista, San Diego 12th St., San Diego Overland. and Otay Mesa, transported emissions contribute slightly more than local emissions to peak ozone. Further inland at El Cajon, and Alpine local emissions contribute slightly more than transported emissions to peak ozone.

Table 42 shows the ozone source apportionment for Alpine peak ozone for August 4 to August 7, and September 27 and 28. Alpine is the only San Diego County site not meeting the eight-hour ozone standard. August 4 is the only day when initial conditions contribute significantly (32%) to peak ozone. Boundary conditions contribute little on that day. Boundary conditions contribute approximately 21 ppb to peak ozone on the remaining days of the August episode. Boundary conditions contribute approximately 30 ppb to peak ozone during the

September episode. On August 4 and 7 local emissions contribute more than transported emissions to peak ozone at Alpine. On August 5 and 6 the contributions are about equal. On both September 27 and 28 local emissions contribute more than transported emissions to peak ozone at Alpine. More ozone contributing to peak ozone at Alpine is formed under VOC-limiting conditions than NOx-limiting conditions for all of the August and September episode days.

Table 40. Ozone source apportionment for August 5, 1997.

Receptor	Predicted Peak Ozone (ppb)	Initial Conditions (ppb)	Boundary Conditions (ppb)	NOx limited (ppb)	VOC limited (ppb)	Local Emissions	Transported Emissions
Alpine	98.5	6.3	20.9	30.4	40.9	37.5%	34.8%
Chula Vista	87.5	6.4	18.2	23.9	39.0	26.5%	45.4%
Del Mar	69.1	4.2	20.1	24.3	20.5	6.9%	58.1%
El Cajon	110.2	7.7	18.1	22.5	61.8	38.4%	38.2%
Escondido	99.7	5.6	20.3	29.8	43.9	3.9%	70.0%
Oceanside	89.3	4.5	18.3	18.1	48.4	1.7%	72.9%
Otay Mesa	99.8	7.4	19.0	23.8	49.6	31.8%	41.7%
Overland	78.8	6.3	18.7	20.9	32.9	19.8%	48.5%
12th Street	75.6	6.1	17.9	20.5	31.1	20.8%	47.4%
Black Mtn.	86.7	6.0	19.0	27.0	34.8	11.3%	60.0%
Pendleton	74.1	3.3	19.6	17.1	34.0	1.3%	67.7%
Red Mtn.	115.7	6.5	18.7	21.3	69.1	3.5%	74.7%
San Marcos Pk.	99.0	5.8	19.3	25.7	48.1	4.8%	69.8%
Soledad Mtn.	68.3	4.4	19.9	25.0	18.9	8.2%	56.2%
Valley Center	118.3	6.5	20.5	27.4	63.9	4.7%	72.5%
Warner Springs	97.2	5.4	21.2	23.2	47.5	1.2%	71.5%

Table 41. Ozone source apportionment for September 27, 1997.

Receptor	Predicted Peak Ozone (ppb)	Initial Conditions (ppb)	Boundary Conditions (ppb)	NOx limited (ppb)	VOC limited (ppb)	Local Emissions	Transported Emissions
Alpine	86.8	1.4	27.9	19.2	38.4	37.1%	29.1%
Chula Vista	74.9	1.8	26.5	20.4	26.3	26.7%	35.6%
Del Mar	64.5	2.1	25.1	16.0	21.3	22.2%	35.6%
El Cajon	83.2	1.6	26.6	14.3	40.6	33.7%	32.3%
Escondido	79.2	1.8	24.0	12.4	40.9	25.8%	41.6%
Oceanside	61.9	0.9	27.1	16.9	17.0	1.0%	53.8%
Otay Mesa	79.5	1.7	26.7	18.3	32.7	31.0%	33.2%
Overland	69.8	1.8	25.4	21.0	21.6	23.5%	37.5%
12th Street	67.9	1.8	24.7	19.9	21.5	23.2%	37.8%
Black Mtn.	71.8	1.9	25.1	14.7	30.1	25.0%	37.5%
Pendleton	57.9	2.4	28.9	18.6	8.0	2.2%	43.9%
Red Mtn.	68.6	0.9	27.8	19.0	20.9	4.8%	53.4%
San Marcos Pk.	74.8	1.8	24.4	14.5	34.1	23.3%	41.6%
Soledad Mtn.	66.1	2.1	25.8	18.3	19.9	21.4%	36.4%
Valley Center	70.0	1.2	26.7	21.7	20.4	15.6%	44.6%
Warner Springs	54.4	5.6	25.9	6.4	16.4	1.5%	40.6%

Table 42. Ozone source apportionment for the Alpine monitoring site for the August and September episodes.

Alpine Receptor	Predicted Peak Ozone (ppb)	Initial Conditions (ppb)	Boundary Conditions (ppb)	NOx limited (ppb)	VOC limited (ppb)	Local Emissions	Transported Emissions
August 4	91.0	29.4	5.9	15.2	40.6	37.7%	23.5%
August 5	98.5	6.3	20.9	30.4	40.9	37.5%	34.8%
August 6	121.6	2.9	20.4	45.2	53.2	39.0%	41.9%
August 7	105.8	0.9	21.8	33.4	49.7	53.8%	24.8%
September 27	86.8	1.4	27.9	19.2	38.4	37.1%	29.1%
September 28	81.8	0.1	33.7	6.8	41.2	36.9%	21.8%

5.0 MODELED OZONE ATTAINMENT TEST

5.1 Procedures for Design Values and Relative Reduction Factors

The modeled attainment test for 8 hour averaged ozone (EPA 2005) is based on using the model results in a relative sense rather than an absolute sense. The absolute sense would be comparing the actual model predicted concentration against the standard of 80 ppb (in practice ≤84 ppb). The relative sense relies on multiplying design values from monitored data by the relative reduction factors from model predictions. The steps to make the modeled attainment test are:

- Calculate a site-specific current design value from monitored data.
- Calculate a site-specific relative reduction factor as the ratio of the predicted future 8 hour average daily maximum concentration near a monitoring site to the predicted base year 8 hour average daily maximum concentration near the same site.
- Multiply the site-specific design value times the relative reduction factor for that site to calculate the predicted site-specific future design value.
- If the predicted future design values is ≤ 84 ppb, then the modeled attainment test is passed.

The base case August 4-7, 1997, and September 27-28, 1997, ozone episodes have been simulated with future year emissions. The base year for the site specific eight-hour ozone design values is 2002. The future year for the modeled attainment demonstration is 2008. CAMx simulations have been made with the 2002 and 2008 future year emissions. Relative reduction factors (RRF) are calculated for each of the SCOS97 monitoring sites in San Diego County.

The guidance (EPA 2005) for selecting the predicted concentration to use in calculating the RRF recommends selecting the highest predicted value for the day from a grid cell in the vicinity of the monitoring site. Vicinity is considered to be a grid cell with any part of its area within 15 km of the monitoring site. For this modeling domain the daily maximum is selected from grid cells within a 7 by 7 grid cell array with the monitoring site located within the center grid cell of the array. The 7 by 7 array has 49 grid cells. On each side of the center grid cell are 3 grid cells of 5 km size.

The guidance recommends using the eight-hour average daily maximum of each modeled day excluding the "ramp-up" day. For the August 4-7, 1997, ozone episode, August 3 is the "ramp-up" day. For the September 27-28, 1997, ozone episode, September 25 and 26 are "ramp-up" days. The RRF for a monitoring site is the arithmetic mean of the 2008 predicted daily maximum for all modeled days divided by the 2002 predicted average daily maximum for the modeled days. In additions to excluding the "ramp-up" days, days with the predicted 8 hour ozone significantly below the standard may also be excluded.

The monitored design values are calculated from the fourth highest daily maximum eight-hour averaged ozone for the year at each monitoring site. Table 43 lists the fourth highest eight-hour averaged concentrations for each year from 1995 to 2005. Table 44 lists the three year arithmetic mean of the fourth highest value for each of the three year periods from 1995 to 2005. Table 45 lists year eight-hour ozone design values which are the truncated values from Table 44, the convention for establishing the eight-hour averaged ozone design values. For the modeled attainment test the guidance recommends using the average of the three design values which center on the baseline year, 2002. For a 2002 baseline year the design values for 2000-2002, 2001-2003, and 2002-2004 are averaged. For Alpine the 2002 average design value is (95+93+89)/3 = 92.3 ppb.

Table 43. San Diego County eight-hour averaged ozone 4th highest concentration (ppb).

Site	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Alpine	107	99	93	114	92	95	96	96	89	83	87
Chula Vista	78	75	81	75	70	72	71	70	54	70	70
Del Mar	84	79	79	73	70	70	72	71	65	81	64
El Cajon	80	90	76	86	70	77	74	73	69	71	71
Escondido	83	90	83	87	70	81	76	69	77	73	69
Oceanside	77	84	73	75	70	69	71	*	*	*	*
Otay Mesa	81	79	79	67	63	56	60	69	69	69	59
Overland	75	78	74	73	73	73	83	76	74	82	68
12th St	71	75	72	65	64	64	65	64	62	65	53
Pendleton	**	**	83	88	76	75	76	70	81	80	68

* - Monitoring at Oceanside site ended in March, 2002.

** - Monitoring at Camp Pendleton site began in April, 1997 (replacement site for Oceanside).

Table 44. San Diego County three year average of the 4th highest eight-hour ozone (ppb).

Site	1995-1997	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005
Alpine	99.7	102.0	99.7	100.3	94.3	95.7	93.7	89.3	86.3
Chula Vista	78.0	77.0	75.3	72.3	71.0	71.0	65.0	64.7	64.7
Del Mar	80.7	77.0	74.0	71.0	70.7	71.0	69.3	72.3	70.0
El Cajon	82.0	84.0	77.3	77.7	73.7	74.7	72.0	71.0	70.3
Escondido	85.3	86.7	80.0	79.3	75.7	75.3	74.0	73.0	73.0
Oceanside	78.0	77.3	72.7	71.3	70.0	70.0	71.0	*	*
Otay Mesa	79.7	75.0	69.7	62.0	59.7	61.7	66.0	69.0	65.7
Overland	75.7	75.0	73.3	73.0	76.3	77.3	77.7	77.3	74.7
12th St	72.7	70.7	67.0	64.3	64.3	64.3	63.7	63.7	60.0
Pendleton	**	**	82.3	79.7	75.7	73.7	75.7	77.0	76.3

* - Monitoring at Oceanside site ended in March, 2002.

** - Monitoring at Camp Pendleton site began in April, 1997 (replacement site for Oceanside).

Table 45. San Diego County eight-hour ozone design values (ppb).

Site	1995-1997	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005
Alpine	99	102	99	100	94	95	93	89	86
Chula Vista	78	77	75	72	71	71	65	64	64
Del Mar	80	77	74	71	70	71	69	72	70
El Cajon	82	84	77	77	73	74	72	71	70
Escondido	85	86	80	79	75	75	74	73	73
Oceanside	78	77	72	71	70	70	71	*	*
Otay Mesa	79	75	69	62	59	61	66	69	65
Overland	75	75	73	73	76	77	77	77	74
12th St	72	70	67	64	64	64	63	63	60
Pendleton	**	**	82	79	75	73	75	77	76

* - Monitoring at Oceanside site ended in March, 2002.

** - Monitoring at Camp Pendleton site began in April, 1997 (replacement site for Oceanside).

5.2 Eight-Hour Ozone Standard Attainment Demonstration Test

Table 46 lists the 2002 and 2008 daily maximum predicted eight-hour ozone for August 4, 5, 6, 7 and September 27 and 28. These concentrations are averaged to calculate the mean average eight-hour maximum for 2002 and 2008 shown in Table 47. The 2008 mean is divided by the 2002 mean to calculate the relative reduction factor (RRF) shown in the table. The RRF for Alpine is 0.940. This value is multiplied by the average design value at Alpine (92.3 ppb) to estimate the 2008 future year design value of 86 ppb. Since this value exceeds 84 ppb the modeled attainment demonstration test is not passed. However, since 86 ppb is close to 84 ppb, then "weight-of-evidence" analyses should be considered as part of an attainment demonstration.

Table 46. Daily maximum predicted eight-hour ozone near a monitoring site (ppb).

		Predicted Peak Ozone							Predicted Peak Ozone				
			2002							2008			
Site	4-Aug	5-Aug	6-Aug	7-Aug	27-Sep	28-Sep		4-Aug	5-Aug	6-Aug	7-Aug	27-Sep	28-Sep
ALPN	75.1	92.5	106.7	91.8	72.8	73.7		71.4	87.1	100.4	86.2	68.1	68.3
CHVT	67.5	90.6	85.8	69.7	68.8	72.2		65.3	85.8	82.6	67.3	65.8	67.3
DMMC	61.8	83.1	67.0	67.6	63.7	76.3		59.6	78.4	64.6	65.0	61.1	72.6
ECAJ	75.1	92.5	103.9	88.3	72.4	73.7		71.4	87.1	98.2	83.7	68.1	68.3
ESCO	77.4	94.5	90.3	85.8	70.5	62.6		73.7	88.3	85.8	81.3	66.5	59.7
OCEA	67.3	86.5	64.5	67.1	63.5	73.3		64.0	81.0	62.6	64.9	61.0	70.4
OTAY	73.7	92.5	89.3	81.0	72.4	73.7		70.2	87.1	86.8	77.3	68.1	68.3
SDOV	66.7	86.1	84.8	73.3	68.7	74.7		64.0	80.7	81.3	69.8	64.9	69.1
SD12	57.5	78.7	72.6	55.9	64.8	77.0		56.0	74.4	70.3	54.7	62.3	73.1
BLKM	75.6	94.4	84.8	79.6	69.8	71.0		71.9	88.3	81.3	75.7	66.2	66.6
PEND	69.9	88.3	64.5	67.1	65.5	73.3		66.4	82.7	62.6	64.9	62.9	70.4
REDM	76.6	94.7	79.0	85.6	65.0	64.4		71.4	88.0	76.0	80.0	62.4	61.7
SMPK	75.6	95.8	87.7	82.9	69.8	64.1		71.9	88.6	83.6	79.1	66.2	60.2
SOLM	55.2	77.9	61.2	58.1	62.0	77.9		53.3	73.3	59.9	56.7	59.4	74.0
VCEN	77.7	95.8	91.4	85.8	70.5	60.6		73.7	88.6	86.3	81.3	66.5	58.3
WSPR	75.9	93.2	91.0	89.7	62.8	50.7		71.3	86.1	86.2	82.8	59.5	49.6

Table 47. Future year eight-hour ozone design values.

Site	2002 Mean Predicted Concentration (ppb)	2008 Mean Predicted Concentration (ppb)	RRF	2002 Average Design Value (ppb)	2008 Future Year Design Value (ppb)
ALPN	85.4	80.3	0.940	92.3	86
CHVT	75.8	72.4	0.955	66.7	63
DMMC	69.9	66.9	0.957	70.7	67
ECAJ	84.3	79.5	0.943	72.3	68
ESCO	80.2	75.9	0.946	74.0	70
OCEA	70.4	67.3	0.956	70.5	67
OTAY	80.4	76.3	0.949	65.3	61
SDOV	75.7	71.6	0.946	77.0	72
SD12	67.8	65.1	0.960	63.3	60
BLKM*	79.2	75.0	0.947		
PEND	71.4	68.3	0.957	75.0	71
REDM*	77.6	73.3	0.945		
SMPK*	79.3	74.9	0.945		
SOLM*	65.4	62.8	0.960		
VCEN*	80.3	75.8	0.944		
WSPR*	77.2	72.6	0.940		

*Not an official ozone monitoring site for San Diego County.

6.0 REFERENCES

ARB, 1989: *Proposed Identification of Districts Affected by Transported Air Pollutants which Contribute to Violations of the State Ambient Air Quality Standards for Ozone.* Staff Report, Meteorology Section, Technical Support Division, California Air Resources Board, October 1989.

ARB, 1993: *Assessment and Mitigation of the Impacts of Transported Pollutants on Ozone Concentrations in California.* Staff Report, Technical Support Division, California Air Resources Board, June 1993.

ARB, 1996: *Second Triennial Review of the Assessment of the Impacts of Transported Pollutants on Ozone Concentrations in California (Revised).* Staff Report, Technical Support Division, California Air Resources Board, November 1996.

ARB, 2000: *Modeling Protocol for Regional 1-Hour and 8-Hour Ozone Modeling in Southern California for the 2003 State Implementation Plans (Draft #3).* Control Strategy Modeling Section, California Air Resource Board, September 18, 2000, Sacramento, CA, 46pp.

Boucouvala, D., R. Bornstein, J. Wilkenson, D. Miller, 2003: MM5 Simulations of a NARSTO-SCOS97 Episode, Atmospheric Environment, Supplement No. 2, S95-S117.

Boucouvala, D., and R. Bornstein, 2003: Analysis of transport patterns during a SCOS97-NARSTO episode, Atmospheric Environment, Supplement No. 2, S73-S94.

Croes, B.E, E.M. Fujita, 2003: Overview of the 1997 Southern California Study (SCOS97-NARSTO), Atmospheric Environment, Supplement No. 2, S3-S26.

Emery, C., E. Tai, and G. Yarwood, 2001: *Enhanced Meteorological Modeling and Performance Evaluation for Two Texas Ozone Episodes*. Environ International Corporation, Novato, CA, August 31, 2001, 235pp.

ENVIRON, 2005. "USER'S GUIDE, CAMx, Comprehensive Air Quality Model with Extensions, Version 4.20. June 2005. ENVIRON International Corporation, Novato, California, 236p.

EPA, 2005: Guidance on the Use of Models and Other Analyses in the Attainment Demonstration for the 8-hour Ozone NAAQS. U.S. Environmental Protection Agency, EPA-454/R-05-002, October 2005

Hayes, T.P., J.J.R. Kinney, and N.J.M. Wheeler, 1984: *California Surface Wind Climatology.* Staff Report, Aerometric Data Division, California Air Resources Board.

Rosenthal, J. S., R. A. Helvey, T. E. Bettalino, C. Fisk, and P. W. Greiman, 2003:Ozone transport by mesoscale and diurnal wind circulations across southern California, Atmospheric Environment, Supplement No. 2, S51-S71.

Scire, J. S., F. R. Robe, F. E. Fernau, and R. J. Yarmartino: *A User's Guide for the CALMET Meteorological Model (Version 5).* Earth Tech Inc., January 2000, 332pp.

SDAPCD, 2002: *Modeling Protocol for Regional 1-Hour and 8-Hour Ozone Modeling in Southern California for the 2003 State Implementation Plans, San Diego County Modeling Supplement.* Modeling & Meteorology Section, San Diego Air Pollution Control District, December 2, 2002, San Diego, CA, 14pp.

Seaman, N.L., D.R. Stauffer, and A.M. Lario. 1995. A Multi-Scale Four Dimensional Data Assimilation System Applied in the San Joaquin Valley During SARMAP. Part 1: Modeling Design and Basic Performance Characteristics. Journal of Applied Meteorology, 34:1739-1776.

Wagner, Kit K., Judith Lake, and Bill Brick, 2005. *Application of CAMx to a San Diego County Attainment Demonstration.* Paper 1079, Proceedings of the Air & Waste Management Association's (AWMA) 98th Annual Conference & Exhibition, June 21-24, 2005, Minneapolis, Minnesota.

Wheeler, N.J.M., 2003: *Quality Assurance, Review, and Optimization of Meteorological Modeling for the 1997 Southern California Ozone Study (Prepared for: The San Diego Air Pollution Control District).* Final Report STI-902220-2490-FR, Sonoma Technology Inc., August 29, 2003, Petaluma, CA, 121pp.

Modeling Protocols for a 2007 Modeling Attainment Demonstration for San Diego County

MODELING PROTOCOL FOR REGIONAL 1-HOUR AND 8-HOUR OZONE MODELING IN SOUTHERN CALIFORNIA FOR THE 2003 STATE IMPLEMENTATION PLANS

SAN DIEGO COUNTY MODELING SUPPLEMENT

December 2, 2002

Prepared for:

Southern California Modeling Stakeholders

Prepared by:

Modeling & Meteorology Section
Technical Services Division
San Diego Air Pollution Control District
9150 Chesapeake Drive
San Diego, CA 92123

CONTRIBUTORS

Kit Wagner
Bill Brick
Judy Lake
Carl Selnick

TABLE OF CONTENTS

INTRODUCTION

HORIZONTAL AND VERTICAL GRID RESOLUTION

INTRODUCTION

Background and Objectives

This document is a supplement to the modeling protocol, "Modeling Protocol For Regional 1-Hour And 8-Hour Ozone Modeling In Southern California For The 2003 State Implementation Plans (Draft #3)" dated September 18, 2000, (the Protocol) prepared by the California Air Resources Board (ARB) Staff. This supplement describes the modifications and additions to the modeling protocol for photochemical modeling of ozone for San Diego County.

In 2001, San Diego County attained the one-hour average National Ambient Air Quality Standard for ozone. The San Diego Air Pollution Control District (SDAPCD) is submitting a request for redesignation as attainment of this National one-hour ozone standard. In 2002, San Diego County remains non-attainment of the California one-hour average ozone standard and will likely be designated as non-attainment of the National eight-hour average ozone standard when those designations occur. San Diego County is also impacted by transport of ozone and ozone precursors from the South Coast Air Basin and from Mexico.

Photochemical modeling of ozone is needed to demonstrate that current and future emission control measures provide for attainment of the California one-hour ozone standard and the National eight-hour ozone standard in San Diego County. In the event that San Diego County becomes non-attainment of the National one-hour ozone standard, modeling will be used to demonstrate when attainment will be restored. Modeling will be used to assess the effectiveness of local emission control measures. Modeling will be used to evaluate the role of transport on ozone in San Diego County and the benefits of upwind emission reductions on ozone in San Diego County. The San Diego Air Pollution Control District will carry out the photochemical modeling for San Diego County in conjunction with modeling efforts of the California Air Resources Board and the South Coast Air Quality Management District (SCAQMD).

This supplement should be used in combination with the Protocol to understand the modeling procedures to be followed. Procedures not modified or appended in this document will be implemented as described in the Protocol. As with the Protocol this supplement will be updated as circumstances warrant.

MODELING DOMAIN

The modeling domain will be as described in the Protocol. Both Universal Transverse Mercator (UTM) coordinates and Lambert Conformal coordinates are used in the modeling. There will be some slight differences in domains for the different coordinate systems. The domain in UTM coordinates is defined by the UTM zone and the easting and northing coordinates. This domain is

UTM Zone 11, 150000m to700000m Easting, 3580000m to 3950000m Northing.

The domain in Lambert Conformal coordinates is defined by the latitudes where the conic projection intersects the sphere (standard parallels), the longitude of the center of the map (central meridian), the latitude of the projection origin, and the boundaries of the domain. The central meridian and latitude of origin define the center or origin of the projection. The boundaries of the domain are measured from this origin. This domain is

Standard parallels	30 degrees north	60 degrees north
Central meridian	-118 degrees (west)	
Latitude of origin	30 degrees north	
Extent	-290000m to +290000m east coordinate 225000m to 625000m north coordinate.	

EPISODE SELECTION

There are four SCOS97 ozone episodes that are of interest for modeling in San Diego County. Those episodes in priority order are:

1. August 3-7, 1997
2. September 26-29, 1997
3. October 30 - November 1, 1997
4. September 3-6, 1997

Table 1 on the following page lists the SCOS97 ozone episodes, episode types, and maximum one-hour and eight-hour ozone for the sub-regions.

August 3-7, 1997, is an ozone episode where both local contributions and transport contributed to exceedances of the standards in San Diego County. Peak one-hour ozone during this episode was 0.12 ppm on August 3 at Alpine and on August 5 at Otay Mesa. Exceedances of the California one-hour standard were wide spread on August 5. Alpine alone exceeded the California one-hour standard on August 6. The peak eight-hour averaged ozone in San Diego County during this episode was 0.099 ppm which occurred at a supplemental monitor. The highest eight-hour averaged ozone at an official monitor was 0.087 at Alpine on August 5.

September 26-29, 1997, is weekend episode. Peak ozone in San Diego County occurred on Sunday, September 28, with a concentration of 0.11 ppm at Alpine. Additional exceedances of the California one-hour standard occurred at other monitors in the County. Both local sources and transport contributed to the exceedances. Exceedances of the ozone standard on weekends are important in San Diego County. In 1997 forty-two percent of the days with exceedances of the California one-hour ozone standard were on Saturday or Sunday. In 2001 this had increased to fifty-two percent. In San Diego County during this episode 0.096 ppm was the peak eight-hour averaged ozone which occurred at a supplemental monitor. Eight-hour averaged ozone did not exceed 0.084 ppm at the official monitors during this episode.

October 30 to November 1, 1997, is an episode with off-shore transport of ozone and ozone precursors from Los Angeles to San Diego County. Peak one-hour ozone was 0.14 ppm on October 31, at San Marcos Peak, a supplemental monitor. Peak one-hour ozone at the official monitors was 0.12 ppm on October 31, at several sites and at Chula Vista on November 1. Exceedances of the California one-hour standard occurred at several monitors on October 30-31, and November 1. Although transport was overwhelming at many monitors, several monitors had local contributions to ozone standard exceedances. Eight-hour averaged ozone peaked at 0.119 ppm at a supplemental monitor. Peak eight-hour averaged ozone at official monitors was 0.099 at Chula Vista on November 1. Eight-hour averaged ozone exceeded 0.084 ppm at Camp Pendelton on October 30, and at Del Mar, Chula Vista, and Camp Pendelton on October 31.

September 3-6, 1997 is an episode with transport aloft that caused an ozone concentration of 0.13 ppm at a supplemental monitor at Black Mountain on September 4. Although, the 0.13 ppm at Black Mountain exceeded the ozone standards in San Diego County during the this episode, there were no exceedances of the State or National one-hour standards at the official monitors. For this reason this episode is not as well suited for emission control strategy development as the other episodes. The eight-hour averaged peak ozone was 0.090 ppm at a supplemental monitor. Eight-hour averaged ozone did not exceed 0.084 ppm at the official monitors during this episode.

Table 1. Characteristics of SCOS97 Episodes

Episode	Days of Week	Episode Type(s)	Maximum 1-Hour/8-Hour Ozone Concentration (pphm)							
			SCAB	Ventura	San Diego	Mojave Desert	Santa Barbara	Imperial County	Northern Mexico	
									Mexicali	Tijuana/ Rosarito
August 3-7, 1997	Sunday–Thursday	1-, 2-, 3-	19 / 13.0	13 / 11.5	12 / 9.9	14 / 11.3	10 / 8.7	10 / 9.3	9 / 7.5	10 / 8.0
September 3-6, 1997	Wednesday–Saturday	1-, 2, 3-	16 / 9.9	10 / 7.5	13 / 9.0	10 / 7.7	9 / 7.5	8 / 5.8	10 / 6.6	8 / 6.4
September 26-29, 1997	Friday–Monday	1-, 2-, 4-	17 / 10.7	12 / 9.7	11 / 9.6	10 / 7.7	11 / 9.3	11 / 7.0	13 / 9.8	11 / 8.5
October 30–November 1, 1997	Thursday–Saturday	5	10 / 6.3	11 / 8.1	14 / 11.9	8 / 7.2	9 / 7.6	12 / 8.3	21 / 11.4	12 / 9.6
National 1- and 8-Hour Design Values: 1997→			21.5 / 14.8	15.2 / 11.5	13.8 / 9.9	17.5 / 12.4	13.0 / 8.9	16.0 / 10.3		
1998→			21.7 / 15.4	14.4 / 11.2	13.5 / 10.2	16.7 / 12.7	13.0 / 8.7	14.0 / 9.3		
1999→			21.1 / 14.7	13.4 / 10.6	13.5 / 9.9	16.6 / 11.8	10.8 / 8.2	13.9 / 9.1		
State 1-Hour Design Value: 1997→			24	15	13	16	11	16		
1998→			22	14	13	18	11	18		
1999→			21	14	13	16	10	14		

Episode Types

1 South Coast Air Basin ozone maximum
2 upper level transport to San Diego
3 secondary South Coast Air Basin ozone maximum with transport into Mojave Desert
4 eddy transport to Ventura following episode in South Coast Air Basin
5 off-shore surface transport to San Diego

AIR QUALITY MODEL SELECTION

The Comprehensive Air Quality Model with Extension (CAMx) will be used for photochemical ozone modeling in San Diego County. Version 3.10 (ENVIRON, 2002) with the Carbon Bond IV chemical mechanism will be used. Alternate air quality models will be considered if modeling work by the ARB and SCAQMD demonstrate that another model may be more appropriate for southern California.

HORIZONTAL AND VERTICAL GRID RESOLUTION

Horizontal Grid Resolution

- Air Quality Modeling

The CAMx modeling will use a 5km horizontal grid resolution. Depending on the meteorological model used to prepare the meteorological inputs the domain will be in either the UTM coordinate system or the Lambert Conformal coordinate system. This grid resolution creates a 116 east-west by 80 north-south grid system within both coordinate systems.

- Meteorological Modeling

The meteorological modeling with MM5 also will use a 5km horizontal grid resolution in Lambert Conformal coordinates for the fine-scale domain. The fine-scale domain is coincident with the air quality modeling domain. Meteorological modeling with the CALMET meteorological model will use a 5km horizontal grid resolution in UTM coordinates.

- Emission Inventory

The 2km horizontal grid resolution emission inventory in UTM coordinates will be mapped into the 5km Lambert Conformal air quality model grid coordinates.

Vertical Resolution

- Air Quality Modeling

The air quality model will have sixteen (16) layers from the earth's surface to approximately 5000 m AGL. The specific vertical resolution depends upon the method used to create the meteorological inputs. If the meteorological inputs are created with a diagnostic model such as CALMET, the vertical resolution of CAMx will be the CALMET vertical resolution. When MM5 is used to create the meteorological inputs, the vertical resolution of CAMx will be the MM5 vertical resolution for the lower sixteen layers.

- Meteorological Modeling

The vertical resolution of the meteorological modeling for CALMET and MM5 for the sixteen layers are shown in Table 2.

Table 2. Vertical Domain for the Meteorological Modeling

Layer No.	CALMET layers+ (meters)	MM5 layers* (meters)
1	20	58
2	60	146
3	100	250
4	200	369
5	300	490
6	400	613
7	600	737
8	800	879
9	1000	1023
10	1500	1234
11	2000	1451
12	2500	1767
13	3000	2095
14	3500	2942
15	4000	3962
16	5000	4986

[+] Heights are for a constant height terrain following coordinate system.

[*] The vertical coordinate system for MM5 is based on a normalized pressure scales. The layer heights are approximate based on a standard atmosphere and are height above the terrain.

METEOROLOGICAL INPUTS

Proposed Approaches

The SDAPCD will sponsor an independent review of the CALMET and MM5 meteorological modeling efforts for the SCOS97 ozone episodes which are described in the Protocol. The review will evaluate the meteorological inputs that have been prepared by the ARB and SCAQMD for the SCOS97 domain as to their suitability for photochemical modeling of ozone in San Diego County. This study will make recommendations for any modifications or enhancements that may be required to address the specific concerns for modeling of San Diego County.

Meteorological Input Validation and Technical Review

Meteorological input validation and technical review will be carried out as described in the Protocol with specific emphasis on the region of San Diego County.

EMISSION INVENTORY

The 1997 base year emission inventory photochemical modeling inputs will be prepared as described in the Protocol and created by the ARB staff. Refer to the Protocol for a discussion of the following emission inventory topics and procedures.

Anthropogenic Emissions

- Point Sources
- Area Sources
- On-Road Mobile Sources
- Other Mobile Sources
- Day-Specific Emissions

Natural Emissions

- Biogenics
- Soil NOx Emissions
- Oil and Gas Seeps

Organic Gas Speciation

Gridding Surrogates

Northern Mexico Inventory

Quality Assurance Procedures

Emission Projections

The future year emissions will be projected as described in the Protocol.

INITIAL AND BOUNDARY CONDITIONS

Initial and boundary conditions for the photochemical ozone modeling will be prepared as described in the Protocol.

Initial Conditions

Boundary Concentrations

MODEL PERFORMANCE EVALUATION

The model performance evaluation will be carried out as described in the Protocol.

Statistical and Graphical Analyses

- Subregional Performance

Emphasis on subregional performance will be placed on model performance within San Diego County. The four subregions of the South Coast Air Basin listed in the Protocol will not be evaluated separately.

Supplemental air quality monitors were sited in San Diego County during SCOS97. Official monitoring sites along with the supplemental monitors are listed in Table 3. The locations of the monitors are shown in Figure 1. Several of the supplemental monitors were sited atop mountains. These sites are Black Mountain (BLKM), Red Mountain (REDM), San Marcos Peak (SMPK), and Mount Soledad (SOLM). These sites are not representative of the surrounding surface air quality. Their purpose for SCOS97 was to observe aloft transport. The air quality model scientific formulation with the 5 km grid resolution is not designed to resolve the large changes in terrain elevation over the small horizontal distances occurring at these sites. These sites will not be included in the statistical model performance evaluation.

Table 3. San Diego County air quality monitoring sites during SCOS97

Site	Identifer	Elevation MSL meters	Pollutants Sampled
Alpine	ALPN	603	O_3
Camp Pendelton	PEND	6	O_3, NO, NO_2, NO_X
Chula Vista	CHVT	56	O_3, NO, NO_2, NO_X, CO, SO_2
Del Mar	DMMC	35	O_3
El Cajon	ECAJ	143	O_3, NO, NO_2, NO_X, CO, THC, CH_4, NMHC
Escondido	ESCO	204	O_3, NO, NO_2, NO_X, CO
Oceanside	OCEA	37	O_3, NO, NO_2, NO_X, CO
Otay Mesa	OTAY	155	O_3, NO, NO_2, NO_X, CO, SO_2
San Diego Overland	SDOV	135	O_3, NO, NO_2, NO_X, CO
San Diego 12th Street	SD12	6	O_3, NO, NO_2, NO_X, CO, SO_2, THC, CH_4, NMHC
Supplemental Monitors			
Black Mountain	BLKM	473	O_3
Mount Soledad	SOLM	251	O_3, NO, NO_2, NO_X, NO_Y
Red Mountain	REDN	552	O_3
San Marcos Peak	SMPK	549	O_3
Valley Center	VCEN	414	O_3
Warner Springs	WSPR	945	O_3

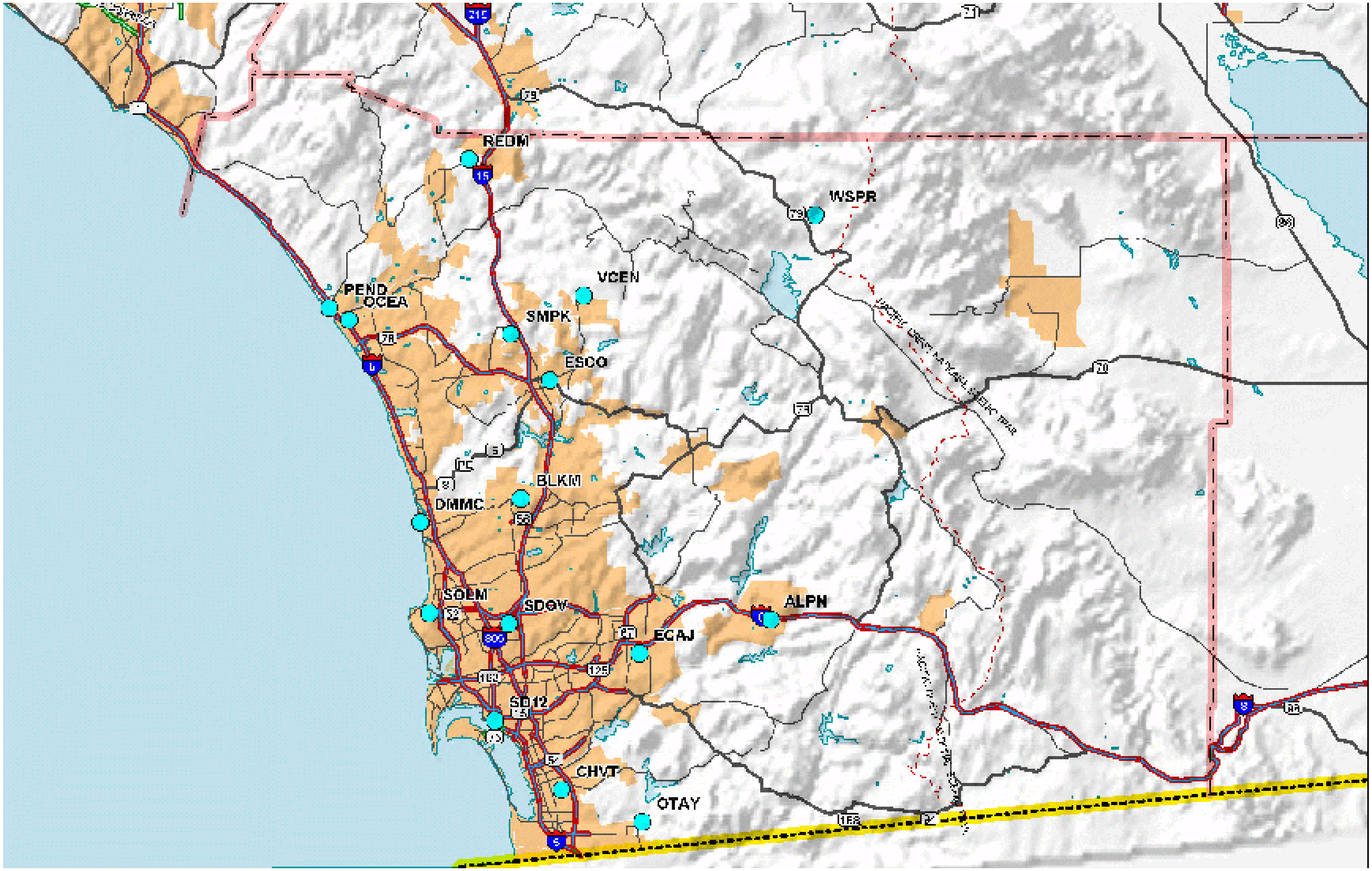


Figure 1 Air quality monitoring sites in San Diego County during SCOS97.

Multi-Species Evaluations

Ozone precursors and secondary species were not measured as extensively in San Diego County as they were in the South Coast Air Basin during SCOS97. To the extent that measurements are available, model performance for these species will be assessed with emphasis on San Diego County.

Aloft Comparisons

Qualitative comparisons will be made between model predictions and air quality measurements made aloft in San Diego County. This includes aircraft and ozone sonde measurements along with the mountain top supplemental sites in San Diego County, BLKM, REDM, SMPK, and SOLM.

Diagnostic Simulations

The diagnostic simulations proposed in the Protocol will made. The analysis of these diagnostic simulations will focus on impacts in San Diego County.

USE OF THE MODELING RESULTS

Carrying Capacity Estimation

An estimate of carrying capacity for San Diego County will be prepared if required by the ARB or U.S. EPA. The estimate will be made using the procedures in the Protocol.

Attainment Demonstration

Demonstrations of attainment of the ozone standards in San Diego County will be carried out as describe in the Protocol using relative reduction factors. Attainment will be demonstrated for the State one-hour and the National proposed eight-hour ozone standards. The specific years for future year simulations and attainment demonstrations will be chosen based on future guidance from the U.S. EPA and ARB.

If San Diego County fails to maintain attainment of the National one-hour ozone standard, modeling simulations will be used to demonstrate when attainment will be restored.

Transport Assessment

Transport of ozone and ozone precursors into San Diego County will be evaluated using the modeling simulations. Trajectory analysis using the meteorological inputs will be used to identify specific source-receptor relationships both at the surface and aloft. The photochemical ozone modeling simulations will be used to quantify the estimates of transport impacts.

One approach for transport assessment will use subregional modifications to the emission inventory model inputs. Anthropogenic emissions in the South Coast Air Basin, for example, will be set to zero for a simulation of a SCOS97 episode. The difference in model predictions between the base case and this sensitivity simulation will be analyzed to determine the impact of transport on ozone in San Diego County.

A second approach for transport assessment will use the Ozone Source Apportionment Technology (OSAT) capabilities within CAMx. Procedures will be created to use OSAT to estimate the relative contributions of transport and local emission sources to exceedances of the ozone standards. OSAT will also be used to examine the importance of low level over-water transport and transport aloft of ozone and ozone precursors to ozone measured in San Diego County.

TECHNICAL OVERSIGHT

This modeling project will seek review from the Southern California modeling stakeholders and the SCOS97 technical working groups.

SCHEDULE AND DELIVERABLES

Schedule

A preliminary schedule for photochemical ozone modeling for San Diego County is shown in Table 4.

Table 4. Schedule for San Diego County Photochemical Modeling

Activity	Begin Date	End Date
Prepare base case model inputs	October 2002	March 2003
Base case simulations and model performance evaluation	November 2002	May 2003
Diagnostic and sensitivity simulations	November 2002	July 2003
Source apportionment simulations	January 2003	July 2003
Future year and attainment demonstration simulations	March 2003	October 2003

Deliverables

San Diego County will provide interim summaries and graphics of the photochemical modeling to the stakeholders and technical working groups for review and comments. At the completion of the project the attainment demonstration and transport assessment along with documentation and electronic files will be made available.

REFERENCES

ENVIRON, 2002. "USER'S GUIDE, Comprehensive Air Quality Model with Extensions, Version 3.10. April 2002. ENVIRON International Corporation, Novato, California.

MODELING PROTOCOL FOR REGIONAL 1-HOUR AND 8-HOUR OZONE MODELING IN SOUTHERN CALIFORNIA FOR THE 2003 STATE IMPLEMENTATION PLANS

(DRAFT #3)

September 18, 2000

Prepared for:

Southern California Modeling Stakeholders

Prepared by:

Control Strategy Modeling Section
Modeling & Meteorology Branch
Planning & Technical Support Division
California Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

CONTRIBUTORS

Paul Allen
John DaMassa
Bruce Jackson
Don McNerny
Elliot Mulberg
Mena Shah
Southern California Stakeholders

TABLE OF CONTENTS

INTRODUCTION

HORIZONTAL AND VERTICAL GRID RESOLUTION

INITIAL AND BOUNDARY CONDITIONS

SCHEDULE AND DELIVERABLES

ACRONYMS

Several acronyms are used in the modeling protocol document. For convenience, the acronyms used are listed here to aid the reader.

AGL – Above Ground Level
AQMP – Air Quality Management Plan
ARB – Air Resources Board
AUSPEX – Atmospheric Utility Signatures, Predictions, and EXperiments
AVHRR – Advanced Very High Resolution Radiometer
CAMx – Comprehensive Air-Quality Model with Extensions
CBM – Carbon Bond Mechanism
CEFS – California Emission Forecasting System
CMAQ – Community Multi-scale Air Quality (model)
CO – Carbon Monoxide
EIWG – Emission Inventory Working Group
ICAPCD – Imperial County Air Pollution Control District
IOP – Intensive Operation Period
NOx Nitrogen Oxides
RECLAIM – Regional Clean Air Incentives Market
RRF – Relative Reduction Factor
SANDAG – San Diego Association of Governments
SAPRC – State Air Pollution Research Center
SAQM – SARMAP Air Quality Model
SARMAP – SJVAQS/AUSPEX Regional Model Adaptation Project
SCAG – Southern California Association of Governments
SCAQMD – South Coast Air Quality Management District
SCOS97 – Southern California Ozone Study (1997)
SDCAPCD – San Diego County Air Pollution Control District
SIP – State Implementation Plan
SJVAQS – San Joaquin Valley Air Quality Study
SOx – Sulfur Oxides
TOG – Total Organic Gases
UAM – Urban Airshed Model
USEPA – United States Environmental Protection Agency
VCAPCD – Ventura County Air Pollution Control District

SCOS97 SPONSORS

Several organizations provided financial and in-kind support to make the 1997 Southern California Ozone Study possible. These organizations were:

California Air Resources Board
Coordinating Research Council
Electric Power Research Institute
Mojave Desert Air Quality Management District
National Renewable Energy Laboratory
Pacific Merchant Shipping Association
Port of Los Angeles
Port of Long Beach
San Diego County Air Pollution Control District
South Coast Air Quality Management District
Steamship Association
United States Marines
United States Navy
United States Environmental Protection Agency
Ventura County Air Pollution Control District

INTRODUCTION

Background and objectives

During the Summer of 1997 a large-scale field measurement program was carried out in Southern California to collect sufficient aerometric data to allow data analysts and modelers to characterize and simulate ozone formation and fate in the region. Several agencies and others participated during the planning and operational phases of the field study, including the ARB, the USEPA, the local districts, the US Navy, the US Marines, and the marine industry. The specific goals and objectives of the 1997 Southern California Ozone Study (SCOS97) were two-fold:

1) To update and improve the existing aerometric and emission databases and model applications for representing ozone episodes in Southern California, with primary emphasis on high ozone concentrations in the South Coast Air Basin and secondary emphasis on high ozone concentrations in the San Diego Air Basin, the South Central Coast Air Basin, the Mojave Desert Air Basin, and the Salton Sea Air Basin.
2) To quantify the contributions of precursor emissions and of ozone generated from emissions in one Southern California air basin to federal and state ozone standard exceedances in neighboring air basins, and to apply modeling and data analysis methods to design regional ozone attainment strategies.

SCOS97 occurred over a four month period from June 15 – October 15, 1997, and captured several episodic ozone days. In addition to the SCOS97 data collected, a severe ozone episode with widespread ozone exceedances occurred during July 1998. This episode is also of planning interest to the regional agencies. Although data archival and quality assurance activities for the SCOS97 and July 1998 data are ongoing, it is now time to contemplate the ozone modeling that will be performed in support of planning needs.

Several ozone nonattainment air basins and regions fall within the planned modeling domain, and include several potential stakeholder agencies:

Air Basin/Region	Stakeholder Agencies/Region
Mojave Desert Air Basin	Mojave Desert Air Quality Management District; South Coast Air Quality Management District
Northern Mexico	Border Region
Salton Sea Air Basin	Imperial County Air Pollution Control District; South Coast Air Quality Management District
San Diego County	San Diego County Air Pollution Control District
South Coast Air Basin	South Coast Air Quality Management District
South Central Coast Air Basin	Santa Barbara County Air Pollution Control District; San Luis Obispo County Air Pollution Control District; Ventura County Air Pollution Control District

Each of the stakeholder agencies is a potential user of the modeling results; all have been involved to some extent in the planning of the measurement program and subsequent inventory collection efforts.

The model results are intended to provide technical support to the local agencies in support of planning needs, primarily the development of comprehensive and regionally coordinated emission control strategies for attainment of the national ozone standards. Transport assessment is another planned objective of the modeling results. Because of the large number of stakeholder agencies, there is a need for ongoing involvement by all of the agencies to ensure that the modeling analyses meet their needs in a timely fashion.

This protocol document provides a proposed modeling methodology to be used for regional 1-hour and 8-hour ozone modeling in Southern California. It describes the procedures, tools, and analyses that will be used to investigate ozone formation and transport within the region and, ultimately, to develop and evaluate control strategies. Although the emphasis of the 2003 State Implementation Plan (SIP) revision will clearly be on the 8-hour ozone standard, a review of the impact on the 1-hour standard will be performed as resources permit. SIP revisions for the 1-hour standard may or may not be considered.

We intend for the protocol document to be dynamic, and will update it in response to reviewer comments and to reflect the results of the modeling analyses.

MODELING DOMAIN

Previous ozone modeling results in Southern California, such as those in support of the 1994 State Implementation Plan (SIP), proved sensitive to boundary concentrations of air pollutants. This reflected the physical processes of recirculation of pollutants within Southern California and the transport of pollutants from one air basin to another. However, because of the three-dimensional nature of transport and recirculation, it is difficult to take field study measurements that are adequate to determine boundary conditions. Thus the boundary conditions used in previous studies were uncertain.

The photochemical modeling studies done for the 1994 SIP for the South Coast Air Basin, the San Diego Air Basin, and the South Central Coast Air Basin defined the upper domain boundary at a height of 2,000 m above ground level (AGL) or less. There were few air quality measurements above this height. However, terrain elevations in Southern California often exceed 2,000 m AGL and recirculation and transport above this height are possible. Ozonesonde measurements made during the 1997 Southern California Ozone Study (SCOS97) have shown high concentrations of ozone at heights above 3,000 m AGL.

The proposed SCOS97 modeling domain will minimize the influence of boundary conditions on simulation results and allow the effects of recirculation and interbasin transport to be better represented by meteorological and photochemical model simulations. The SCOS97 modeling domain will completely encompass the South Coast Air Basin and San Diego County, almost all of the South Central Coast Air Basin (excepting a small piece of San Luis Obispo County),the California-Mexico border regions, and includes most of the inland desert areas (Figure 1) to eliminate the need to define boundary concentrations between them. The domain will extend far enough offshore to contain wind flow patterns conducive to overwater recirculation. Specifically, the UTM Zone 11 coordinates of the domain are 150-700 km UTM East and 3580-3950 km UTM North. Vertically, the modeling domain will extend to a height of at least 5,000 m AGL for a more complete representation of atmospheric processes. This will contain observed high ozone concentrations aloft and allow three-dimensional wind flow patterns near elevated terrain features to be represented better than in previous simulations, providing more accurate representation of pollutant transport and recirculation.

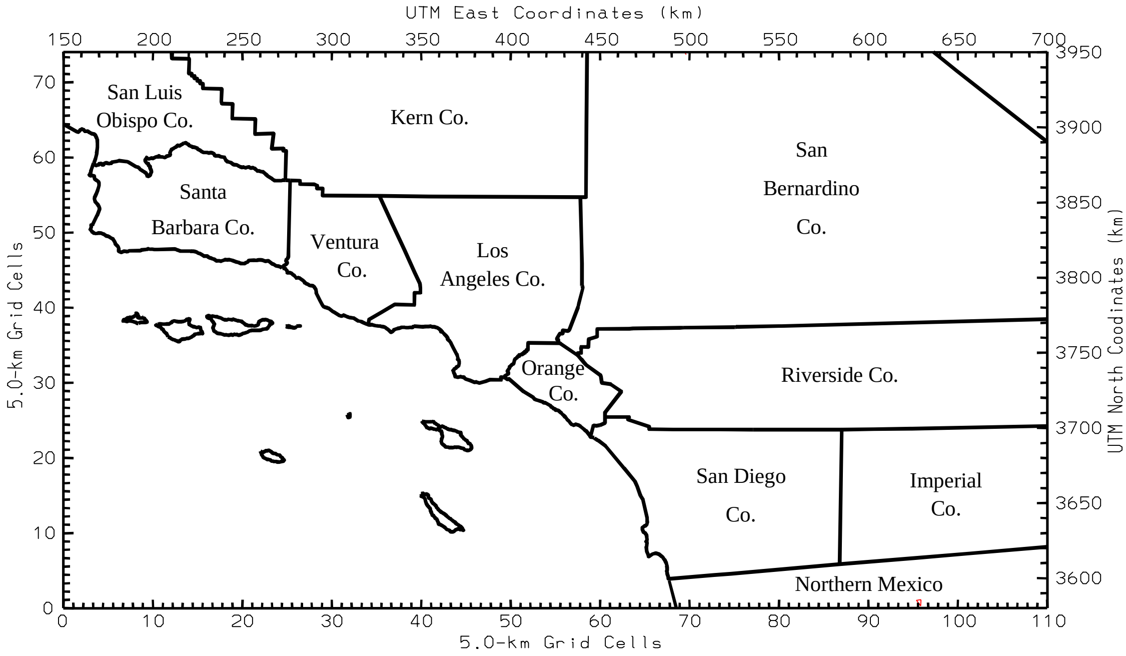


Figure 1. The 1997 Southern California Ozone Study photochemical modeling domain.

EPISODE SELECTION

Decisions regarding which episode days to model depend on a number of factors, including peak ozone concentrations and their locations, the type of meteorology, exceptional events such as large wildfires, and the availability of air quality and meteorological data. Another consideration is the availability of field measurements from special studies such as offshore tracer releases.

During the 4 month field study period, the peak observed ozone concentration within the SCOS97 domain was 21 pphm. There were 13 Intensive Operation Period (IOP) days during which additional measurements were taken, such as speciated hydrocarbons and air quality aloft. The peak ozone concentration measured on an IOP day was 19 pphm. Because of the unique meteorological patterns during SCOS97 associated with the El Niño phenomenon, there is a concern that the peak ozone concentrations measured during SCOS97 may not represent actual design values for Southern California. In July 1998 a severe regional ozone episode occurred in Southern California with a peak observed one-hour ozone concentration in the SCOS97 domain of 24 pphm. Although intensive field study data are not available for this episode, there were approximately 10 radar wind profilers operating during that period, thereby providing aloft meteorological data.

Table 1 summarizes the episodes under consideration for regional modeling, including peak observed ozone concentrations, design values, and other attributes:

Table 1

Characteristics of SCOS97 and Other Episodes Under Consideration for Modeling

Episode	Days of Week	Episode Type(s)	Maximum 1-Hour/8-Hour Ozone Concentration (pphm)							
			SCAB	Ventura	San Diego	Mojave Desert	Santa Barbara	Imperial County	Northern Mexico	
									Mexicali	Tijuana/ Rosarito
August 3-7, 1997	Sunday–Thursday	1-, 2-, 3-	19 / 13.0	13 / 11.5	12 / 9.9	14 / 11.3	10 / 8.7	10 / 9.3	9 / 7.5	10 / 8.0
September 3-6, 1997	Wednesday–Saturday	1-, 2, 3-	16 / 9.9	10 / 7.5	13 / 9.0	10 / 7.7	9 / 7.5	8 / 5.8	10 / 6.6	8 / 6.4
September 21-23, 1997	Sunday–Tuesday	4	11 / 8.8	10 / 8.8	10 / 7.9	7 / 6.1	14 / 10.8	16 / 9.2	17 / 9.7	10 / 7.9
September 26-29, 1997	Friday–Monday	1-, 2-, 4-	17 / 10.7	12 / 9.7	11 / 9.6	10 / 7.7	11 / 9.3	11 / 7.0	13 / 9.8	11 / 8.5
October 30–November 1, 1997	Thursday–Saturday	5	10 / 6.3	11 / 8.1	14 / 11.9	8 / 7.2	9 / 7.6	12 / 8.3	21 / 11.4	12 / 9.6
July 14-19, 1998 *	Tuesday–Sunday	1	24 / 20.6	17 / 15.2	16 / 14.2	20 / 14.8	12 / 9.8	12 / 10.1	17 / 10.3	12 / 7.7
National 1- and 8-Hour Design Values: 1997→			21.5 / 14.8	15.2 / 11.5	13.8 / 9.9	17.5 / 12.4	13.0 / 8.9	16.0 / 10.3		
1998→			21.7 / 15.4	14.4 / 11.2	13.5 / 10.2	16.7 / 12.7	13.0 / 8.7	14.0 / 9.3		
1999→			21.1 / 14.7	13.4 / 10.6	13.5 / 9.9	16.6 / 11.8	10.8 / 8.2	13.9 / 9.1		
State 1-Hour Design Value: 1997→			24	15	13	16	11	16		
1998→			22	14	13	18	11	18		
1999→			21	14	13	16	10	14		

Episode Types

1 South Coast Air Basin ozone maximum
2 upper level transport to San Diego
3 secondary South Coast Air Basin ozone maximum with transport into Mojave Desert
4 eddy transport to Ventura following episode in South Coast Air Basin
5 off-shore surface transport to San Diego

* There is no aloft air quality data available for the July 1998 episode.

We propose to simulate several multi-day ozone episodes, as discussed below. Synopses of the meteorology associated with each of the 1997 episodes can be found in the summary of SCOS97 field operations (ARB et. al, 1998).

The following episodes are proposed as primary episodes for the regional modeling effort, pending further discussion with the stakeholders:

- The SCOS97 episode period of **August 3-7, 1997**. This episode was selected because the peak 1-hour ozone concentration of 19 pphm and the peak 8-hour concentration of 12.5 pphm measured in the South Coast during this period were the highest not associated with an exceptional event during SCOS97. High ozone concentrations were also observed in other areas, as indicated in Table 1.

- The SCOS97 episode period of **September 26-29, 1997** was selected because it includes the second highest ozone concentrations measured during an IOP, and it represents a weekend episode. The peak 1-hour (17 pphm) and 8-hour (10.7 pphm) ozone concentrations were both observed at Upland. The 17 pphm value represents the second highest episodic ozone concentration observed during a SCOS97 intensive operating period.

- The SCOS97 episode period of **September 3-6, 1997** was selected because it includes the highest 1-hour ozone concentration (13 pphm) measured during an IOP in San Diego, and because of the availability of offshore tracer release data for windfield validation.

- The non-SCOS **July 14-19, 1998** episode was selected because it represents a severe, widespread high ozone event in the region. The peak observed 1-hour ozone concentration in the South Coast Air Basin was 24 pphm; an 8-hour peak of 20.6 pphm was also observed. Other areas also experienced elevated ozone peaks, including San Diego (1-hour peak of 16 pphm), Ventura (1-hour peak of 17 pphm, 8-hour peak of 15 pphm), and Mojave Desert (1-hour peak of 20 pphm, 8-hour peak of 14 pphm).

In addition to the primary episodes listed above, the September 21-23, 1997 and the October 30-November 1, 1997 episodes are also of potential planning interest, and will be considered based upon stakeholder input and the availability of resources.

AIR QUALITY MODEL SELECTION

The Urban Airshed Model (UAM-IV) is the only Eulerian photochemical modeling tool that has been previously approved by the USEPA for ozone modeling studies. However, the UAM-IV (USEPA 1990) is widely acknowledged to have characteristics which limit its utility when applied to large modeling domains, or to domains that are not geographically uniform. In addition, much of the science in the model is not up to date, and both the USEPA and the ARB are contemplating removing that model's recommended status. A number of photochemical models have been developed over the last decade to improve upon the UAM-IV; these include:

- CALGRID (Yamartino et. al, 1989). The CALGRID model was developed for the ARB in the late 1980's. The model has been applied by various air pollution agencies around the world. It is modular to allow the user to substitute various types of wind fields and chemical mechanisms. CALGRID incorporates refined treatments of numerical advection, vertical transport and dispersion, and dry deposition. The model can be exercised with either the Carbon Bond IV or SAPRC chemical mechanisms, and contains highly efficient chemical integration routines. The vertical structure of the atmosphere can be optionally defined relative to a mixing height field, similar to the UAM, or can be based on fixed layer heights and a derived mixing height.

- The Comprehensive Air-Quality Model with Extensions (ENVIRON 1997). CAMx contains a number of advanced features, including grid nesting, sub-grid-scale plume-in grid simulation, alternative numerical advection solvers, and the ability to use alternative chemical mechanisms. In addition it has the ability to tag emissions so that at the end of the simulation one can determine the sources of emissions impacting a particular receptor. Since CAMx is a relatively new model, there is a relatively short history of experience applying the model.

- Models-3 (USEPA 1998a). Models-3 is a flexible software system designed for applications ranging from regulatory and policy analysis to understanding the complex interactions of atmospheric chemistry and physics. The MODELS-3 system allows the user to go from developing model inputs to visualizing results all in one package. At the heart of the current version of MODELS-3 is the Community Multi-scale Air Quality (CMAQ) model. Its capabilities include urban to regional scale air quality simulation of ozone, acid deposition, visibility, and fine particles. CMAQ is a modular system capable of using output from the MM5 prognostic meteorological model, along with the CBIV or RADM-2 chemical mechanism. The CMAQ model also includes a plume-in-grid module, vertical and horizontal growth due to turbulence and shear, a choice of advection schemes, and a cloud- module to simulate precipitating and non-precipitating clouds. A forthcoming aerosol module will allow simulation of $PM_{2.5}$ and PM_{10}. Since the Models-3 system is new, some implementation and application problems are likely.

- <u>S</u>ARMAP <u>A</u>ir <u>Q</u>uality <u>M</u>odel (J.S. Chang et. al, 1997). SAQM is a three-dimensional non-hydrostatic model based upon the Regional Acid Deposition Model (Chang et. al 1987, 1990). However, SAQM includes a number of improvements over RADM, including: a fixed vertical coordinate system that is compatible with MM5; a horizontal coordinate system defined in a Lambert-Conformal projection that accounts for curvature of the Earth; a mass conservation module for compatibility with non-hydrostatic meteorological inputs; the Bott advection scheme (Bott 1989a, 1989b) to reduce numerical diffusion and increase numerical accuracy; two-way nesting, and the capability to use either the CBM-IV or SAPRC chemical mechanisms. A version of SAQM with plume-in-grid treatment is also available.

- <u>U</u>rban <u>A</u>irshed <u>M</u>odel-<u>F</u>lexible <u>C</u>hemical <u>M</u>echanism (Kumar et. al, 1995). The UAM-FCM is an alternate version of the UAM-IV that has been enhanced to allow the flexibility to incorporate any Carbon Bond- or SAPRC-type chemical mechanism. The FCM allows incorporation of reaction-specific photolysis rates. In addition, the UAM-FCM has a generalized methodology to solve the set of differential equations that is mechanism independent.

- <u>U</u>rban <u>A</u>irshed <u>M</u>odel-<u>V</u> (SAI 1996). The UAM-V (UAM-V) is an updated version of the Urban Airshed Model (UAM-IV) which incorporates many state-of-the-art enhancements in chemical mechanisms, meteorological models, and representation of emissions. Perhaps the most significant additions are: an updated CB-IV mechanism to include aqueous phase chemistry; plume-in-grid capabilities; an improved dry deposition algorithm; and an improved plume rise algorithm. Other enhancements over UAM-IV include allowing the user a fixed vertical structure as opposed to one that is relative to the diffusion break, the ability to use three dimensional inputs from prognostic models, and two-way grid nesting. However, the present non-public domain status of UAM-V precludes regulatory usage.

As part of their joint preparation of a year 2000 AQMP, the staffs of the ARB and the SCAQMD have agreed to begin the testing of a number of the available models for the SCOS97 domain: CALGRID, UAM-V, CAMx, UAM-FCM, Models-3 and SAQM. This testing will provide experience using each model. The experience gained during this exercise will allow us to narrow the list of candidate models for application to 8-hour ozone modeling in the SCOS97 region. If appropriate, more than one air quality model will be used as the basis for attainment planning activities in the region.

The models will be run using the Carbon Bond IV chemical mechanism (Gery et. al, 1989), which is the most widely used mechanism. However, the ARB anticipates making additional simulations with the SAPRC mechanism (Carter1990; Carter et. al, 1993; Carter 1995; Carter et. al, 1996; Carter et. al, 1997; Carter et. al, 1999) for comparison purposes. The SAPRC chemical mechanism is the basis for chemical reactivity scales.

HORIZONTAL AND VERTICAL GRID RESOLUTION

Horizontal Grid Resolution

Over the past decade, photochemical models have been applied in California with horizontal grid resolutions in the range from 2 x 2 km to 8 x 8 km. The specific grid resolution chosen was primarily dependent on the size of the modeling domain, computer resources available, and the time and money available to carry out the simulations. In effect the final resolution was a compromise between the accuracy desired and the cost. However, the current generation of high-speed computers have minimized cost and resource constraints.

The horizontal grid resolution plays an important role in the modeling process. Large grid resolution tends to smooth emission gradients and meteorological inputs, which in turn leads to a smoothing of the resulting concentration fields. In general, the resolution should be sufficiently small to pick up emission gradients in urban areas and be consistent with the major terrain features which may affect the air flow.

- Air Quality Modeling

For the SCOS97 modeling, we propose to use a horizontal grid resolution of 5 km for the air quality modeling. No grid nesting is anticipated. This resolution is consistent with the grid resolution used in earlier photochemical modeling studies for the South Coast Air Basin (e.g., SCAQMD, 1994) and for San Diego. For the proposed SCOS97 modeling domain, use of a 5 km resolution results in a modeling grid with 110 cells in the east-west direction, and 74 cells in the north-south direction. The SAQM model will be based on a Lambert-Conformal map projection system, and thus will use a slightly different domain; all other air quality models will use a UTM-based horizontal coordinate system.

- Meteorological Modeling

Meteorological inputs to the air quality model will be provided for the same horizontal grid resolution and coordinate system (i.e., UTM or Lambert Conformal). More details of the meteorological modeling can be found in the section “METEOROLOGICAL INPUTS.”

- Emission Inventory

The emission inventory is based on a UTM coordinate system, with a horizontal resolution of 2 km. For SAQM, the emissions will be mapped from UTM into a Lambert Conformal coordinate system. More information on the inventory can be found in the section entitled "EMISSION INVENTORY."

Vertical Resolution

As with the selection of the horizontal grid resolution, the vertical resolution defined for photochemical modeling domains has been limited by computational resources. In addition, available aloft meteorological and air quality databases were not sufficient to characterize conditions aloft. As a result, simulation results have been limited by the relatively few number of vertical layers within the surface mixed layer, resulting in poor representation of the stratification of the atmosphere.

As enhanced aerometric databases have become available—such as the 1990 San Joaquin Valley Air Quality Study and 1997 SCOS97—more has been learned about the vertical structure of the atmosphere. The ability to better simulate the vertical structure of the atmosphere is emerging due to the availability of measurements aloft, the emergence of higher-speed computers, and our increased experience with diagnostic and prognostic meteorological models.

- Air Quality Modeling

To improve on the representation of the vertical structure of the atmosphere for the SCOS97 modeling, the number of vertical layers below 500 m (the nominal height of the afternoon mixing height within the Los Angeles coastal plain) will be increased over previous studies, and the modeling domain top will be set to a height of at least 5,000 m.

CALGRID – 16 vertical layers will be used, to a height of 5,000 m. The vertical layering will be the same as that used by the CALMET model (see Table 3).

CAMx – The fixed height vertical layers will be the same as for CALGRID.

UAM/FCM – As for the UAM, the vertical atmosphere is defined in two zones: that above the mixing height and that below. A total of 5-8 vertical layers are proposed for the SCOS97 simulations.

Models-3 – Since we are in the process of installing and implementing Models-3, its vertical structure has not yet been defined.

SAQM – 15 vertical layers will be used, to a height of 100 mb or approximately 15 km. Table 2 shows the proposed SAQM layering.

Table 2 Proposed vertical layer heights for SAQM

Layer #	Height (m)*	Layer #	Height (m)*	Layer #	Height (m)*
1	61	6	645	11	4,032
2	153	7	776	12	5,083
3	262	8	1,077	13	7,270
4	388	9	1,528	14	10,499
5	516	10	2,207	15	15,634

* *These height estimates are based on sigma-level calculations at sea level using standard conditions. Height increments will decrease as terrain elevation increases.*

- Meteorological Modeling

For the terrain-following CALMET model, the proposed vertical layer definition is shown below.

Table 3

Proposed vertical layer heights for CALMET/CALGRID

Layer #	Height (m)*	Layer #	Height (m)*	Layer #	Height (m)*
1	20.0	7	600.0	12	2,500.0
2	60.0	8	800.0	13	3,000.0
3	100.0	9	1,000.0	14	3,500.0
4	300.0	10	1,500.0	15	4,000.0
5	400.0	11	2,000.0	16	5,000.0
6	400.0				

* *Heights are for a constant-height, terrain-following coordinate system*

For the MM5 prognostic model, the following vertical structure is proposed.

Table 4

Proposed vertical structure for MM5

Level	Height (m)*	Level	Height (m)*	Level	Height (m)*
30	61	20	1528	10	7270
29	154	19	1862	9	7981
28	263	18	2207	8	8773
27	389	17	2714	7	9624
26	516	16	3228	6	10499
25	646	15	3837	5	11371
24	776	14	4452	4	12230
23	926	13	5083	3	13227
22	1077	12	5816	2	14334
21	1300	11	6551	1	15635

** The vertical coordinate system for MM5 is based on a normalized pressure scale. The above layer heights were calculated from sea level using standard conditions. Layer heights are lower relative to ground level as terrain height increases.*

METEOROLOGICAL INPUTS

Air quality models require three-dimensional meteorological inputs. The key parameters are winds, mixing heights, temperature, and insolation. The windfields describe the transport and dispersion of pollutants. Mixing heights define the vertical extent of pollutant mixing near the surface. Temperature and insolation fields influence emission rates and the rates of chemical transformation. Because meteorological measurements can only be made at discrete locations, meteorological models are required to develop the 3-dimensional fields required by models.

The meteorological models used to generate these three-dimensional fields are generally of three types: objective, diagnostic or prognostic.

Objective models are the least sophisticated meteorological models. The analysis consists of interpolation of observations. Obtaining a reasonable field requires sufficient observations to accurately represent the observed pattern(s). This is especially true for windfields. In areas with complex terrain and bodies of water, such as the SCOS97 domain, the meteorology can be quite complex, and a successful objective analysis would require a large number of observations.

Diagnostic models rely on observations, yet apply constraints based on physical concepts such as the conservation of mass. A diagnostic wind model can simulate thermally induced circulations and the effects of surface friction. One example of this type of model is the Diagnostic Wind Model (DWM) distributed by the USEPA. For the DWM, the user defines first an initial guess mean wind field that can be representative of synoptic scale patterns. The domain mean wind is then adjusted for the effects of terrain. Available observations are then used to develop meteorological fields using objective analysis. The initial guess and the objective analysis are then merged. A criticism of diagnostic models is that the fields produced are not consistent from one hour to the next. Since the processes which create the wind, temperature, and mixing height fields are relatively independent, the model is criticized for not being thermodynamically consistent between the meteorological parameter fields.

Prognostic models are the most sophisticated of the meteorological models. They are based on first principles, i.e., conservation of mass, momentum, energy and moisture. As a result they are computationally intensive. The use of four dimensional data assimilation (FDDA)–where observations are introduced to the model as an additional forcing term–is typically used in areas of complex meteorology to improve the accuracy of the outputs. Another approach is objective combination, in which observations are introduced after the model has estimated a value. Prognostic models are capable of explicitly incorporating many of the physical flow processes important in the SCOS97 domain. However, prognostic models have historically had problems estimating fine-scale flow features due to the limited resolution of datasets used for describing geographic features

Previous Applications

In the past, the ARB and SCAQMD have utilized prognostic, diagnostic, and objective models to generate meteorological inputs for modeling. The National Center for Atmospheric Research's prognostic, non-hydrostatic Mesoscale Model (MM5) was applied for modeling in support of attainment planning in the San Joaquin Valley. The SCAQMD also has experience with the SAIMM prognostic model. Diagnostic models (WIND2D, WIND3D, DWM) have been applied in the Sacramento area and in Southern California to prepare meteorological input fields for the application of photochemical models in those areas. The ARB and the SCAQMD have also begun a review of CALMET, which may be viewed as an improved version of the DWM and which is being distributed through the USEPA for air quality modeling applications. The CALMET model has an added feature that allows a hybrid meteorological field to be developed by merging the results from a prognostic model, such as MM5, with an objective or diagnostic analysis characteristic of the CALMET model. This hybrid approach has the potential to take advantage of the prognostic capabilities of MM5 in areas of the domain where meteorological measurements are few, and utilizing measurements in an objective analysis where there are many.

Proposed Approaches

The SCOS97 field study generated a dataset with a relatively high spatial density of meteorological observations. While this dataset suggests that an objective/diagnostic model would be adequate to develop the meteorological parameter fields required for air quality modeling, there are large portions of the SCOS97 modeling domain—such as over the ocean or the inland desert—where there are few observations. Therefore, three approaches are proposed to develop the necessary meteorological fields. After the fields have been developed using each approach, they will be evaluated to determine which is the most suitable for air quality modeling.

- Diagnostic Modeling

The first approach will be to use the diagnostic meteorological model CALMET. As described previously, CALMET uses a fixed-height, terrain-following coordinate system. For the SCOS97 modeling, 16 vertical layers will be used to a height of 5,000 m above the ground (see Table 2).

- Prognostic Modeling

The second approach will be to use the MM5 prognostic model. The meteorological boundary conditions for MM5 are generated using the output from a Global Climate Model (GCM) with a relatively coarse grid scale of 45 km. Nested domains of 15 km and 5 km are then defined within MM5 to simulate meteorological fields for the fine grid scale of the SCOS97 modeling domain. The modeling domain for MM5 is defined in a Lambert-Conformal projection with two parallels to account for curvature of the Earth within the modeling domain over such a large region. Figure 2 shows the nested MM5 domains. Figure 3 shows the finest scale (interior) MM5 domain.

The vertical structure of MM5 is defined in a terrain-following, “sigma” coordinate system based upon a normalized pressure index. The 30 vertical layers defined for MM5 (see Table 3) can be transformed to fit the requirements of any air quality model.

- Hybrid Approach

The third approach for developing meteorological parameter fields will be to combine the results of the CALMET and MM5 models into a hybrid meteorological field. In this approach, the parameter fields will be overlaid using a weighting scheme that is based on the proximity to meteorological observations. The resultant fields benefit from the capabilities of the prognostic model in those areas of the modeling domain with few observations (such as offshore, in complex terrain, and in the desert areas), and benefit from the objective analysis component of the diagnostic model to force the fields to agree with observations. To develop the hybrid fields, the fields developed using CALMET and MM5 will need to be mapped into common horizontal and vertical coordinate domains. The CALMET model code is structured to facilitate this mapping.

Meteorological Input Validation and Technical Review

The meteorological inputs have a profound influence on the spatial and temporal resolution of ozone and other pollutant concentrations estimated by the air quality model. It is therefore essential that the products of meteorological models undergo a rigorous evaluation. By evaluating both offshore and onshore flow characteristics of the windfield and other key meteorological parameters we can minimize the uncertainty in the air quality simulations.

This process includes an evaluation of the gross circulation features in the modeling region to determine if the model is replicating those essential features (Mulberg, 1995, Lolk and Douglas, 1996). These features include areas of convergence and divergence, eddy circulations, land/sea breeze, slope flows, and transport corridors. Since the SCOS97 domain includes large overwater areas it is also necessary to evaluate offshore flows as well.

Key features of the windfield are areas of convergence and divergence. These features result in vertical velocities which can transport pollutants upward (in the case of convergence) or bring pollutants from aloft down to the surface (with divergence). The evaluation should include a review of the convergence and divergence zones in the simulated windfield to determine if they agree with measurements or conceptual models in terms of location, timing, and extent. The impact on vertical velocities should also be evaluated.

Converging flows can sometimes result in an eddy circulation. In the SCOS97 domain two key eddy features are prevalent: the Catalina eddy (centered near Catalina Island), and the Gaviota Eddy in the Santa Barbara Channel (Smith, et. al., 1984). Both eddy circulations are important transport mechanisms; they are capable of transporting precursors and aged ozone concentrations onshore. Exceedances of the ozone standards are often observed with the presence of an eddy circulation. The timing of the onset of eddy circulation, its persistence, and spatial extent should be considered as part of the windfield validation.

Land/sea breeze circulations are another important flow feature. The sea breeze is one method whereby pollutants generated in the Los Angeles Basin are transported eastward. That is, the strength of the sea breeze will determine how far precursors and ozone generated near the coast will be transported inland. Errors in the timing of the sea breeze can cause precursor emissions to be transported to the wrong locations instead of inland where peak concentrations are observed. It is thus essential that the onset of the sea and land breezes simulated by the model be compared to observations for reasonableness.

The onshore portion of the SCOS97 domain includes areas of complex terrain. Slope flows are important as a recirculation mechanism that may influence ozone concentrations. Slope flows are probably the most challenging feature for prognostic meteorological models, due to the sparse observational data in complex terrain. A proposed qualitative approach is to determine if wind speeds estimated by the model appear to be reasonable in areas of complex terrain.

Transport of ozone and precursors from the Los Angeles area to outlying areas is an obvious mechanism of interest to the regional stakeholders. Provided that the observational data support transport, the generated windfield(s) should allow us to evaluate transport couples of interest. Specifically we are interested in transport from Los Angeles to the desert areas, from Los Angeles to San Diego, from Los Angeles to Ventura and Santa Barbara, from Mexico to San Diego, and from San Diego to Mexico. These evaluations can be made by calculating trajectories both at the surface and aloft with the simulated windfield, and comparing to observations and conceptual models based on the observations.

As a qualitative and quantitative evaluation of the windfields, we propose to statistically summarize and plot wind speeds by site and globally throughout the SCOS97 domain (Seaman et. al., 1995, Bigler-Engler et. al., 1996). Temporal plots for agreed upon key sites will be examined to determine agreement with observations. Quantitative techniques will make use of statistical measures such as the mean gross error and mean bias to compare modeled and measured wind speeds (Mulberg, 1995).

The proposed approaches for generating meteorological inputs incorporate observations, thus we should expect good agreement near those observation sites where data was used as input to the model. In order to diagnose the impact that incorporation of the observations has on the meteorological models, it may be useful to consider withholding some observations when executing the models to have an independent set of observations for comparison. The sites withheld should have some relation to the sites used to provide some assurance in the results from the comparison. We propose to conduct this diagnostic evaluation once acceptable meteorological fields have been prepared.

Temperature fields will also be examined. At the surface, qualitative analyses will include an examination of the temporal and spatial variation of estimated and observed temperatures. The interface at the coastline will also be examined. Mean bias and mean gross error statistics will also be calculated to provide quantitative measures of performance.

In addition, the vertical temperature profiles generated by the models will be compared to those observed at rawinsonde sites, at wind profiler locations, and from aircraft spirals. The vertical temperature profile influences the stability characteristics of the modeling domain. One of the most notable affects is on mixing heights. The evaluation will include temporal and spatial evaluations of simulated mixing heights as compared to those estimated from observed soundings and profiler data. The timing of the onset and breakup of the inversion will also be evaluated, as this phenomenon has a profound effect on estimated ozone concentrations.

Figure 2
Nested MM5 Domains

The horizontal grid resolution of the outermost domain is 45 km, for the middle domain is 15 km, and for the fine scale domain is 5 km.

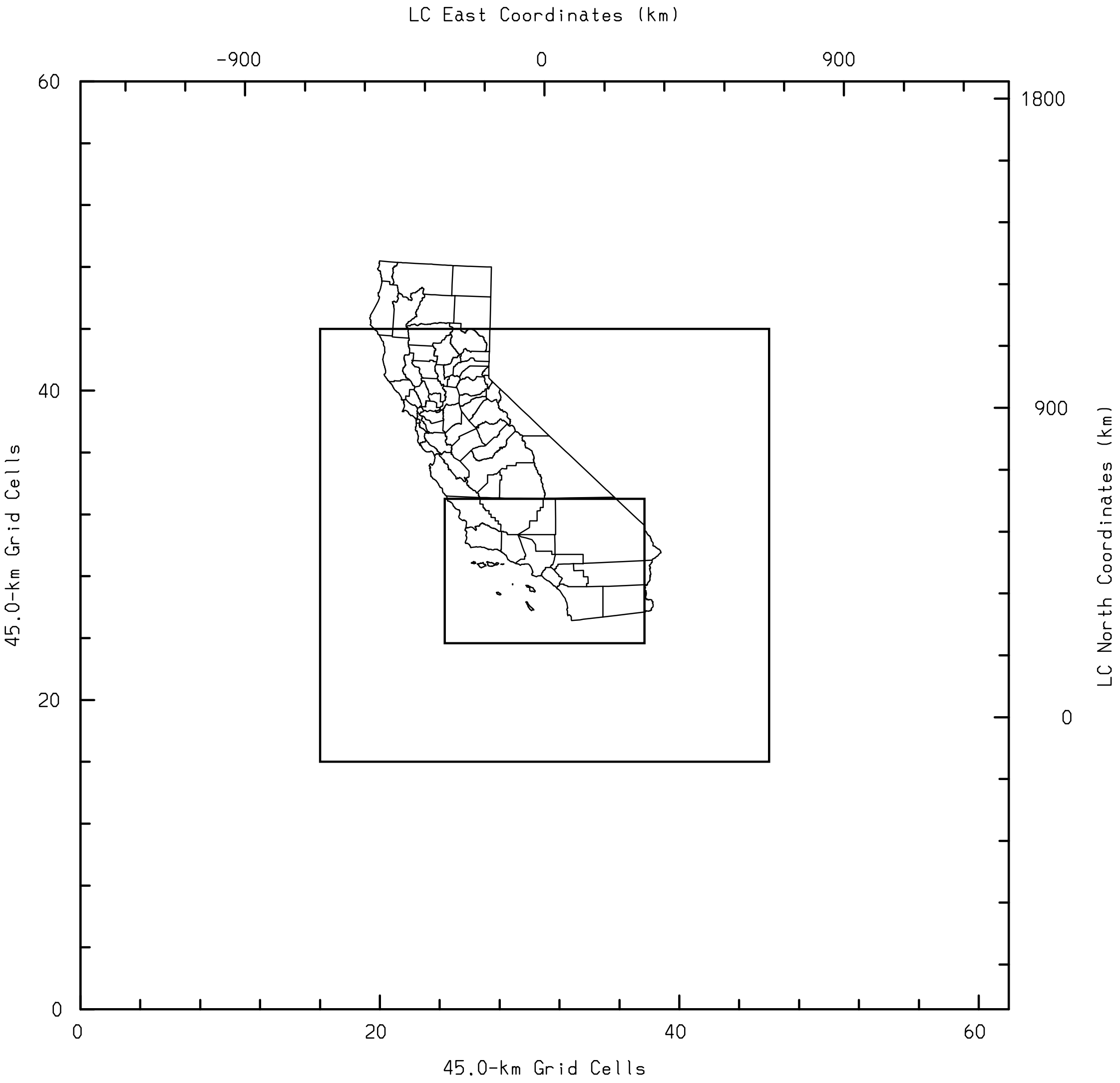
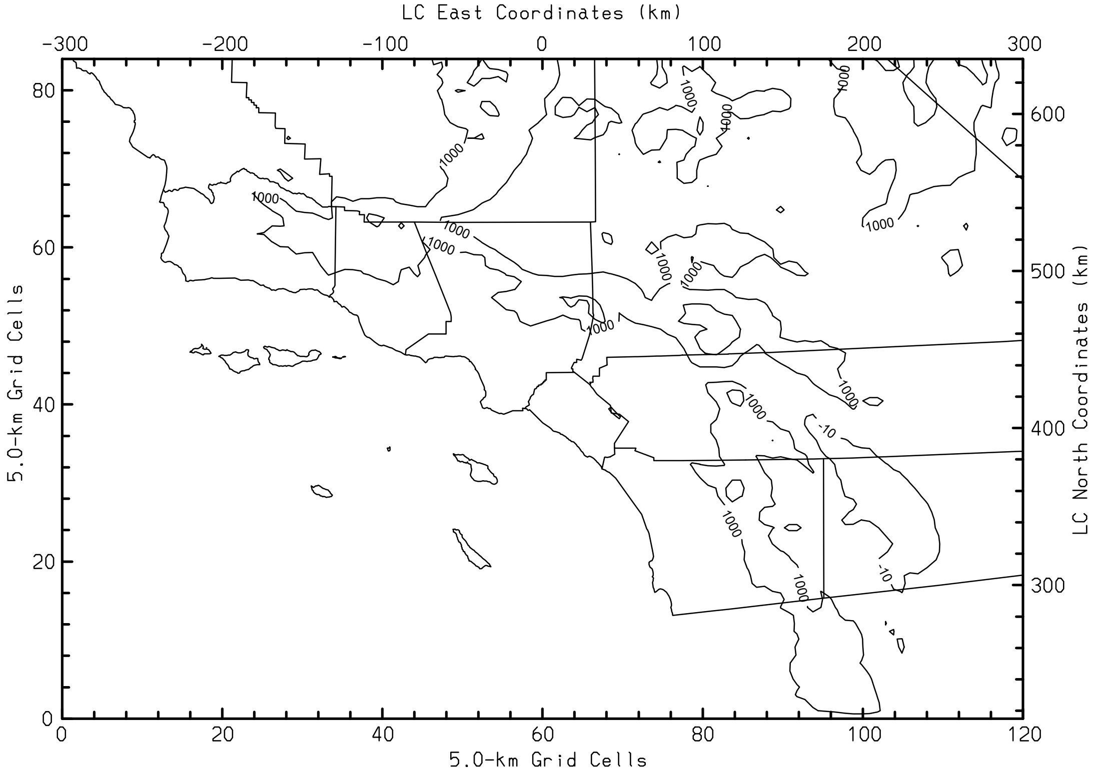


Figure 3
The Fine-Scale (5 km) MM5 Domain.



EMISSION INVENTORY

Ozone episodes occurring in both 1997 and 1998 will be simulated for the SCOS97 modeling domain. Base year inventories for CO, NOx, SOx, and TOG are needed for ozone modeling. PM is also included in the inventory in order to support inputs needed for aerosol modeling. Photochemical air quality models require gridded, hourly emissions. The information needed to complete the emission inventory for the SCOS97 modeling region is obtained from local air pollution control districts, transportation planning agencies, and the California Air Resources Board. In addition, contracts have been established with universities and the private sector to provide important inventory components.

To develop an emission inventory for SCOS97, an Emission Inventory Working Group (EIWG) was formed. The EIWG is comprised of members from the ARB, SCAQMD, SDCAPCD, VCAPCD, ICAPCD, MDAQMD, SBCAPCD, and US Navy (ARB 1997a).

Anthropogenic Emissions

- Point Sources

Emissions for point sources (including RECLAIM facilities) are inventoried by local districts and reported to the ARB. If annual emissions for a facility fall below 10 tons/year (this cutoff varies with district) the source is included in the area source inventory. Point sources are allocated to grid cells using the location that is stored as part of the point source emission database. Temporal codes which describe hours of operation are also included in the emission database. Factors are also stored to convert annual average emissions to a specific month and day of week.

Point sources have been inventoried for 1996. The SCAQMD is working on a point source inventory for 1997 which will include an update to locations (UTM coordinates) and stack parameters. Santa Barbara and Ventura Counties have submitted their 1997 annual average inventory; 1997 data from other districts will also be incorporated if available in time. Most other point source emissions will be “grown” to 1997 from 1996 emission values using ARB’s California Emission Forecast System (CEFS). Point source emissions for 1998 will also be estimated using the CEFS (M. Johnson, 1997).

- Area Sources

Area sources are comprised of emission source types that are difficult to inventory individually. Examples are architectural coatings, residential water heating, gasoline stations, and off-road mobile sources not included in the OFFROAD model. Districts and the ARB share responsibility for estimating area source emissions. Methodologies used to estimate emissions from area sources are described in several documents (ARB 1997b). Factors are also included that allow estimates of specific month and day of week emissions from annual average emissions. Temporal codes which describe hours of operation are also included in the area source emission database.

Area source categories have been inventoried for 1996. Emissions for 1997 and 1998 (except for eight ARB categories that were updated in 1997) will be grown using CEFS, except for Santa Barbara and Ventura Counties, since these counties have already submitted their 1997 annual average inventory.

- On-Road Mobile Sources

On-road mobile source inventories are prepared using vehicle activity data from transportation planning agencies. The majority of travel is reflected in transportation plans developed by:

1) Southern California Association of Governments (SCAG);
2) San Diego Association of Governments (SANDAG);
3) Santa Barbara County Association of Governments (SBCAG); and
4) Kern Council of Governments (Kern COG).

Travel for areas not covered by the transportation planning agencies is extracted from the California Statewide Planning Model maintained by the California Department of Transportation.

Emission factors for on-road mobile sources will be estimated using the ARB's EMFAC99 emission factor model. DTIM3 will use both the emission factors and travel activity data to produce hourly gridded emission estimates for the SCOS97 region. EMFAC7G, the current ARB emission factor model, is being updated and will be replaced by EMFAC99. DTIM3 has undergone testing with EMFAC7G but is not compatible with EMFAC99. The needed changes to DTIM3 are in progress. If delays are encountered, DTIM3 can be used to grid on-road mobile source emissions with EMFAC7G emission factors. The gridded inventory can then be scaled to be consistent with EMFAC99 using scaling factors specific to source category, time, and location.

The ARB has contracted with STI to acquire all travel data needed for this modeling study. STI will ensure that the digitized highways are consistent at the boundaries of the various planning areas. The network and travel activity data provided by transportation planning agencies is developed for peak and off-peak time periods, which will be processed into 24 hourly data sets. The results from a U.C. Davis project (that is nearing completion) to incorporate traffic count data from episode days will be used to calibrate DTIM3 inputs. STI will run the DTIM3 program to develop mobile source inventories for several episode days, including weekend days.

ARB staff will use the network and travel activity data to produce DTIM3 inventories for episode days not run by STI. One of STI's tasks is to provide training in processing inputs and executing the DTIM3 code.

- Other Mobile Sources

Area source emissions from most categories of off-road mobile sources will be estimated using ARB's off-road mobile source emission model (OFFROAD). OFFROAD covers more than 12 off-road categories, including lawn and garden equipment, small utility and construction equipment, as well as farm equipment. Categories not estimated by OFFROAD will be covered under "area sources". OFFROAD will produce countywide emission inventories for each calendar year desired. The OFFROAD model will have the capability to estimate exhaust, starting, and evaporative emissions for differing spatial and temporal conditions.

- Day-Specific Emissions

Emissions from many sources vary from day to day. Evaporative emissions from vehicles and vegetation increase with ambient temperature. Exhaust emissions are also a function of ambient temperature. Increased air conditioning demands on hot days also lead to increased emissions from electrical generation. Hourly surface temperatures for episode days are interpolated to each grid cell and are used in estimating emissions on-road mobile sources.

Criteria pollutant emissions from approximately 80 major point sources will also be estimated hourly for each specific episode day. Each district has acquired data from major point sources for 1997 episode days and has already finished or is developing day-specific point source inventories for that year. Day-specific data for the July 1998 episode have been solicited from the districts. Districts also collected information on variances, temporary breakdowns, and shutdowns.

Wildfire emissions occurring on 1997 and 1998 episode days have been compiled by ARB staff, and hourly emissions have been estimated for each wildfire. The type of information collected will allow development of temporally and spatially resolved emission estimates.

A computer model to estimate emissions from large ships in the SCOS97 modeling domain is being developed by ARB staff. Ship activity data (for commercial vessels) from shipping ports, ship-specific engine characteristics, and the latest emission factors will be used to estimate emissions for transit in the shipping lanes and at the ports.

The ARB has purchased aircraft activity data for the SCOS97 and July 1998 episode days. This data has one minute radar-derived locations for all aircraft in the SCOS97 region. Hourly landing, takeoff, approach, climbout, and cruise emissions can be determined from these data for each episode day. This database will be used to construct a three dimensional aircraft emissions array that can be input to photochemical models.

An analysis of air quality-related special events (such as air shows, sporting events, fires, and unusual traffic problems) has turned up an absence of such events.

<u>Natural Emissions</u>

- Biogenics

The derivation of a gridded biogenic emission inventory requires data sets describing the spatial distributions of plant species, biomass, and emission factors that define rates of hydrocarbon emissions for each plant species. The Biogenic Emission Inventory System (BEIS 2.3) (USEPA, 1995) model, distributed by the USEPA for this purpose, is one source of these data sets for areas throughout the United States. However, the BEIS model has been shown to have limited use in California because of poor spatial resolution within the referenced data sets and a simplified scheme for assigning emission factors (e.g., Jackson, et al., 1996). The development of a gridded biogenic emission inventory for the SCOS97 domain will benefit from research conducted within California that describes the needed data sets in more detail than is defined within the BEIS model (Benjamin et. al., 1998).

ARB staff in consultation with Dr. Arthur Winer of UCLA has developed a methodology to complete a gridded biogenics inventory for the SCOS97 region. The following paragraphs describe this approach.

Gridded Plant Species Maps

The distribution of plant species within the SCOS97 modeling domain will be determined using a composite of a number of data sets. Plant species as a function of urban land-use classifications were described by SCAQMD (1990) for the Los Angeles basin and updated by Benjamin et. al. (1996) and Arey et. al. (1995). These land-use classifications were extrapolated to other urban areas within the modeling domain. For the SCOS97 modeling domain, plant species distributions were taken from the GAP data base (Davis et. al. 1995), an inventory of biomass diversity for the United States.

Biomass Distribution

Plant biomass is difficult to measure and there are few descriptive data sets of biomass distribution for areas within the SCOS97 modeling domain. Therefore, estimates of biomass distribution were determined using published correlations between biomass and Normalized Difference Vegetative Index (NDVI). The NDVI is an index of relative "greenness" calculated from Advanced Very High Resolution Radiometer (AVHRR) data. Spatial distribution of NDVI from satellite remote sensing data sets were acquired from the United States Geological Survey EROS Data Center.

Emission Factors

The chemical species and rates of hydrocarbon emissions vary by plant species. Emission factors have been measured for only a relatively small subset of the more than 6,000 plant species known in California, and for only a few general categories of chemical species. However, research has shown that emission factors for various plant species can be correlated using taxonomic relationships between the plant species (Benjamin et. al., 1996). Using this “taxonomic model”, emission factors were assigned for all plant species known to exist within the SCOS97 modeling domain. However, because of the limited research results available, biogenic emission factors are available for only 2 classes of hydrocarbons: isoprene and monoterpenes.

Gridded Biogenic Inventory

The gridded plant species, biomass distribution, and emission factor databases will be combined with episode-specific ambient temperature and photosynthetically active radiation data using a Geographic Information System to produce gridded hourly emissions of isoprene, monoterpenes, and methylbutenol.

- Soil NOx Emissions

Soil emissions of NOx to the air have been associated with the use of nitrogen containing fertilizers. Emissions have been estimated from fertilizer usage in the San Joaquin Valley. The soil NOx emissions were seen to have insignificant impacts on ozone concentrations. As a result, a soil NOx inventory has not been planned for this study.

- Oil and Gas Seeps

There are substantial emissions from oil and gas seeps near the coast in the areas of Santa Barbara and Ventura counties. Estimates for these sources are provided to the ARB by the respective counties.

Organic Gas Speciation

Organic gas speciation profiles are applied to all categories of TOG emissions to obtain estimates for each organic gas species emitted in the modeling region. ARB maintains a database of current profiles that are routinely updated to reflect recent information. The most recent updates were for gasoline exhaust and evaporation, diesel exhaust and jet engine exhaust. These recent updates were presented at the September 10, 1998, VOC Speciation Workshop held in Sacramento. The ARB publication “Identification of VOC Species Profiles” (ARB 1991) documents the organic gas profiles; an update is planned by summer 1999 to reflect the recent workshop.

Gridding Surrogates

Area and OFFROAD emissions are estimated and stored in the emission inventory database at the county level. There are many types of data (with highly resolved spatial resolution) that can be used as surrogates for one or more emission categories. For example, census tract population can be used to allocate consumer product emissions to grid cells. Housing units, also available for census tracts, can be used to spatially allocate residential lawn and garden equipment emissions.

Maps are used to digitize and spatially allocate emissions for several categories of watercraft, locomotives, and airports.

The ARB has contracted with STI to provide gridded surrogates for all area and off-road mobile source emission categories. STI will seek inputs from the districts and the ARB on the appropriate gridding surrogates to use for each emission category for the SCOS97 region.

SCOS97 surrogates are being resolved to a 2 kilometer grid scale to allow high spatial resolution if needed. The 2 kilometer inventory can easily be aggregated to larger grid cells.

Northern Mexico Inventory

A portion of northern Mexico is included in the SCOS97 modeling region. A gridded inventory for this region was developed by SAI (SAI 1997) as part of a study to develop a 1990 gridded inventory for the region. Another contractor, STI, will review and recommend updates to the SAI gridded inventory for Northern Mexico. Organic gas emissions will be speciated using the most appropriate species profiles used for California emission categories.

Quality Assurance Procedures

ARB provided specific guidelines to assist state and local agencies in implementing uniform and systematic approaches for collecting, compiling, and reporting emission inventory data. A comprehensive quality control and quality assurance plan was prepared to ensure good quality practices during development of 1996, 1997, and future year emission inventories. These procedures include: quality control checks for collecting non-emission data, updating activity data, and using appropriate emission factors for calculating emissions; emission calculation methodology; quality assurance evaluation using the Data Attribute Rating System (DARS); and quality review of the entire inventory. The DARS program, originally developed by the USEPA, will be used as an additional quality assurance tool to quantify the relative accuracy of the annual emission inventories. ARB has also provided the districts with a variety of quality assurance reports to aid in the review of inventory data important for modeling. These reports were intended to provide checks on the accuracy of the emission calculations, stack data, facility location data, temporal data, devices data, process data, etc.

Emission Projections

Future year emissions form the basis for an air quality emission reduction target. Control measures and growth factors are applied to base year (1997) area and point source emissions to project future year emissions. Area source emissions are gridded using the appropriate surrogates as used for 1997. STI is also preparing gridded future year surrogates for the entire SCOS97 region for 2005, 2010, and 2020. Surrogates for other years can be interpolated as needed.

Future year traffic activity and network data are also prepared by local planning agencies. EMFAC99 will give estimates of future year emission factors. DTIM3 uses future year emission factors and network travel data to obtain gridded future year on-road mobile emissions. DTIM3 inputs for future years are being compiled and prepared (for DTIM3 input) by STI under contract to the ARB. Ambient temperatures that occurred during 1997 are also used in calculating future year emissions for each episode day.

Biogenic emissions will remain constant for each episode day for all future years. Even though there may be a shift in farm or landscaping plans and species, we do not have the capability to incorporate any potential changes into the inventory. Seep emissions will also remain constant in future year inventories.

INITIAL AND BOUNDARY CONDITIONS

Initial Conditions

Initial conditions define the spatial distribution of chemical species concentrations throughout the 3-dimensional modeling domain at the time at which the air quality model simulation begins. There are two problems inherent in defining initial conditions. The first is that chemical species concentrations are only measured at discrete locations and, for some species, for discrete time periods. Therefore, observed concentrations must be extrapolated to estimate concentrations throughout the modeling domain. The second problem is that observed chemical species concentrations may not represent chemical equilibrium, especially since not all important chemical species are measured explicitly.

To minimize the importance of initial conditions on air quality model simulation results, the simulation is frequently begun at some time interval before the period of interest. Historically, this "spinup" time interval has ranged between 8 and 72 hours. For the SCOS97 episodes, the spinup period will begin at between 0000 PDT and 0500 PDT of the day before the first day of interest (the difference in the begin time reflects the difference in time-base – GMT vs. local time – for some meteorological models). This spinup period will allow a full diurnal cycle of sunlight, prior to the period of interest, to enable the air quality model to reach chemical equilibrium.

Initial conditions will be determined by interpolation/extrapolation of the chemical species concentration measurements available from the SCOS97 field study archive. For the large areas of the study domain in which there are few such measurements, initial-conditions will be assigned "background" values based on the minimum concentrations measured from monitoring sites where measurements are available.

Boundary Concentrations

Boundary concentrations are chemical species concentrations on the study domain boundaries and represent the concentrations for the air mass moving into the domain. Unlike initial conditions which need to be defined only for the beginning of the simulation, boundary conditions must be defined for each hour of an air quality model simulation on the 2-dimensional, vertical planes on each of the horizontal boundaries of the domain, and at the top of the modeling domain.

Ideally, modeling domain boundaries are placed so remotely that simulation results are insensitive to boundary conditions. For the SCOS97 study domain, the influence of boundary conditions on the simulation results from an air quality model is problematic. Beyond the northern SCOS97 boundary, emissions from central California could have an impact on the domain. To the south, emissions from Mexico could have an impact. The western boundary is over the Pacific Ocean, where recirculation may be an issue. Boundary conditions will be determined from measured chemical species concentrations where they are available from the SCOS97 field study. Where measurements are not available, background chemical species concentrations will be assigned based on the lowest concentrations from sites where concentrations were measured. A part of the air quality model evaluation process will be to assess the influence of boundary and initial concentrations on simulation results.

MODEL PERFORMANCE EVALUATION

It is a well established tenet of the modeling community that for an air quality modeling simulation to give reliable results, it must be capable of giving the right answers *for the right reasons*. That is, not only must the model be capable of reproducing observed ozone measurements with a reasonable level of accuracy, but it must also pass a series of prescribed tests designed to ensure that the apparently accurate results are not produced by a combination of compensating errors. As discussed below, we propose to conduct several tests on the modeling simulations, both at the surface and aloft–for precursor and secondary species in addition to ozone–as part of the model performance process. The statistical tests will be performed for the domain, by district, and for several subregions to ensure that the domainwide statistics do not mask subregional problems. This information should allow a determination that the model is working properly. Much of the following information is taken from the ARB's photochemical modeling guidance (ARB 1992).

Statistical and Graphical Analyses

The evaluation will include both graphical and statistical analyses. Graphical analyses compare simulated pollutant concentrations with measured values. These will include time series plots showing temporal variations, contour plots showing spatial variations, scatter plots showing tendencies for over- or underestimation, and residual plots showing the distribution of the differences between observed and predicted concentrations. The statistical analyses will examine the accuracy of peak estimates (both paired and unpaired in time and space), mean normalized bias, mean absolute gross error, and mean absolute normalized gross error. The statistical performance criteria outlined in the ARB's guidance document for Class B or better ozone performance will be used to guide the determination of acceptable model performance. These statistical criteria will be used as a criterion for acceptable model performance. However, other analyses (graphical, multi-species, aloft comparisons, and the diagnostic simulations) will also be used to determine acceptable model performance, and ultimately a conclusion that the model is working properly must be made considering all of the analyses.

- SUBREGIONAL PERFORMANCE

In addition to the domainwide statistical analyses, we propose to conduct subregional analyses. The proposed subregions are San Diego County, the South Coast Air Basin, the Mojave Desert, and the South Central Coast.

Since the South Coast Air Basin is very large, we also propose to evaluate model performance for four subregions within that area:

- Coastal Los Angeles and Orange counties;
- the central basin including downtown LA, southeast Los Angeles and inland Orange county;
- the inland valley regions which include the San Gabriel Valley and the San Fernando Valley; and
- the portions of Riverside and San Bernardino counties within the South Coast Air Basin.

Since the modeling results may be used to support attainment demonstrations in several districts, we propose to use the same statistical acceptance criteria for the subregions as for the entire domain.

Multi-Species Evaluations

To be useful for planning or other purposes, an air quality model must be able to replicate measured ozone concentrations with reasonable accuracy. However, it is also important to compare estimated and measured concentrations of ozone precursors and secondary species, to establish confidence that the chemistry processes are being simulated properly. The important precursors are NO, NO_x, HONO, and organic gas species; important secondary species are HNO_3 and PAN. Organic gas concentrations will be lumped according to the scheme employed by each model's chemical mechanism. Comparisons will be made for each of the estimated precursor species and lumped organic gas species, for each monitoring location. In addition, comparisons will also be made for NO_x, and total ROG.

These comparisons may reveal problems not associated with those for ozone concentrations. Many of the precursor species have a secondary component as well. Concentrations of primary pollutants tend to have higher gradients than do secondary species. This makes it more difficult to assume that a measured concentration of a primary pollutant represents a grid cell average. For these reasons it is probably unreasonable to expect the same accuracy in replicating precursor concentrations as for ozone concentrations. Thus we don't recommend a specific statistical error or bias criterion. These comparisons should be viewed as qualitative, to uncover potential problems in precursor and secondary performance.

Aloft Comparisons

During the SCOS97 field study, concentrations of selected air pollutants were measured above the ground using aircraft, balloons, and LIDAR. The primary component of these measurements was oxidant concentrations measured with ozonesondes to a height of 5,000 m AGL. Ozonesondes were flown at 7 sites, at 6-hour intervals, for selected episode days. Also, 4 aircraft were flown up to 3 times per day and an ozone LIDAR was operated continuously on selected episode days.

The performance of air quality model simulations above the ground will be determined by comparing simulated oxidant and ozone concentrations with measurements, for the same times and locations. Measured concentration profiles will be averaged for the vertical layer increments corresponding to those of the air quality model. Because of the vertical spacing required for the air quality models, the vertical resolution of this comparison will be relatively poor. Therefore, initially this comparison will be of a qualitative nature only.

In addition to measuring ozone, three of the aircraft measured oxides of nitrogen and collected samples for later hydrocarbon analysis. Comparisons between these precursor data and concentrations simulated using the air quality models will also be made. However, there are relatively few samples and because an aircraft is not in one grid cell for an hour, comparisons may not be consistent with modeled concentrations. We will make the comparisons to see if any large discrepancies exist between modeled and measured concentrations aloft.

Diagnostic Simulations

Several diagnostic, or investigative, simulations are proposed to further determine the fidelity of the model results. These are anticipated to include the following:

- *Zero emissions* – all anthropogenic and biogenic emissions will be set to zero to test the model’s sensitivity to emissions and to ensure that the base case results are influenced appropriately by the emission inputs.
- *Double anthropogenic emissions* – all anthropogenic emissions will be doubled to test the model's sensitivity to increased man-made emissions.
- *Zero biogenics* – biogenic emissions will be set to zero to test the model’s sensitivity to biogenic emissions.
- *Zero and clean air boundary and initial conditions* – the initial (interior) and boundary (at the top and sides of the modeling domain) conditions will be set to zero and USEPA recommended clean air values to determine model sensitivity to these inputs.
- *Zero surface deposition* – deposition will be turned off for all species to examine the effects of dry deposition on ozone estimations.
- *Reduced wind speeds* – reducing the wind speeds by 50% is proposed to test the model’s sensitivity to that parameter. However, the feasibility of doing so in

the event that a dynamically consistent, prognostic model is used, has not yet been investigated.

- R*educed mixing heights* – reducing mixing heights by 50% is proposed to test the model's sensitivity to that parameter. However, the feasibility of doing so in the event that a dynamically consistent, prognostic model is used, has not yet been investigated.
- *Alternative meteorological inputs* – if an alternate procedure for preparing meteorological inputs provides acceptable fields, these will be simulated to test the model's response to similar but different fields. For example, if prognostic outputs are used as the primary meteorological fields, but diagnostic fields are available and are judged technically credible, they will be used as alternative inputs.

USE OF THE MODELING RESULTS

It is anticipated that the model results will be used for the following planning activities: carrying capacity estimation, attainment demonstration, and transport assessment. Other uses are dependent on the regulatory needs of the stakeholders, and will be coordinated via the agency stakeholder meetings with local, state, and Federal agency participation. All planning uses of the model results are contingent upon acceptable base case model performance for the episodes simulated. That is, only episodes which meet the model performance acceptance criteria will be used.

Carrying Capacity Estimation

A traditional use of models for planning has been the estimation of carrying capacities for ozone precursors. This is typically achieved by exercising the model with a series of across-the-board precursor emission reductions from the future year baseline, from which an ozone isopleth ("EKMA") diagram is constructed. The metric used for the isopleth diagram can be one of several, such as peak 1-hour or 8-hour ozone concentrations within the modeling domain (or subregion), number of grid cells above the standard, or one of many population exposure metrics. For the SCOS97 region, we propose to construct isopleth diagrams by episode for at least the following air quality metrics:

- Peak 8-hour ozone concentration for the domain, adjusted using USEPA's relative reduction factor (RRF) approach.
- Peak 1-hour ozone concentration for the domain, adjusted using RRFs.
- Air basin-specific peak 8-hour ozone concentration (adjusted using RRFs) for those of the following air basins which experienced 8-hour ozone violations during a given episode: the South Central Coast Air Basin; San Diego County; the SCAQMD; the Mojave Desert (including Antelope Valley); and Imperial County.
- Same as the preceding bullet but for RRF-adjusted peak 1-hour ozone concentrations.

Ozone design values for RRF application will be calculated based on monitoring from 1997 through 1999 for both the 1-hour and 8-hour standards. The resulting isopleth diagrams will be shared with the stakeholder agencies, from which additional simulations can be identified and coordinated.

Attainment Demonstration

As required by the USEPA in their draft 8-hour ozone guidance (USEPA 1998b), we propose to use relative reduction factors (RRFs) as part of the attainment demonstration process for the 8-hour ozone standard, assuming that satisfactory base year model performance is established. The RRF approach incorporates design period monitoring data directly into the attainment test along with the ratio of future to current year model estimations. This allows the model to be used in a relative, rather than absolute, sense to reduce uncertainty in the predictions.

We will also consider the use of an RRF type adjustment factor for the 1-hour standard. If properly applied, we believe that the use of RRFs can provide better estimates of the emission reductions needed for attainment. This is because they are capable of addressing two problems in model applications that tend to result in underestimation of emission reductions needed. The first problem is that modeled episodes usually have ozone concentrations lower than the design value. The second problem is that simulation results have historically exhibited a tendency towards underestimation of observed concentrations. By utilizing monitored data along with model estimations, RRFs address both problems.

As shown in the following table, it will be necessary to simulate multiple future attainment years to fully address planning needs in the region. Because of the staggered nature of the attainment years, it will be necessary to coordinate future year inventories within the region to facilitate the required simulations.

Probable Ozone Attainment Years in the Region

Area	1-Hour National Standard	8-Hour National Standard
Mojave Desert	2007	↓
San Diego	1999	↓
Santa Barbara	1999	2005-2010? for all areas**
South Coast	2010*	↑
Ventura	2005	↑

* The SCAQMD and the ARB are jointly preparing a year 2000 AQMP that will address the 1-hour ozone standard for the SCAQMD and the Mojave Desert. That process is on a separate schedule, however much of the work on and products from that process will be of use to the SCOS97 regional modeling.

** Appropriate attainment dates to be determined during the SIP development process.

Transport Assessment

Transport within the region is of obvious importance to the agency stakeholders. It is anticipated that, if acceptable model performance is established, the regional modeling may be useful to address some transport issues that are of concern to the local agencies. This assumes that the episodes simulated manifest the type(s) of meteorology conducive to transport between couples. We propose to work with the stakeholder agencies to identify and prioritize potential transport scenarios and simulations of interest within the region. This may involve simulations where anthropogenic emissions in one or more areas are turned off or reduced, or may take advantage of some of the newer models' (e.g., CAMx) ability to conduct source apportionment. However, modeling in support of the attainment demonstrations will remain our highest priority.

TECHNICAL OVERSIGHT

As with previous modeling efforts by the ARB, it is intended that the modeling process be an open one. That is, the involvement of all interested stakeholders and other technical experts is welcome throughout the process. Such involvement will allow comments and suggestions to be accommodated during the process, rather than foster disagreement at the end.

A SCOS97 Emission Inventory Working Group has already been established, and has met several times to discuss inventory-related issues and coordinate inventory preparation activities. The ARB has also hosted a series of ongoing agency stakeholder modeling meetings in Southern California to discuss the various aspects of the inventory, modeling, and planning processes. A meteorological working group has also been established to review the preparation of meteorological inputs. Members for other technical working groups will be solicited, and other peer review mechanisms considered, based on stakeholder input. As progress is made and products are available, interim results will be shared with the agency stakeholders in an agreed upon format and with the interested public at appropriate times and locations.

SCHEDULE AND DELIVERABLES

Schedule

Much of the work to prepare meteorological inputs, initial and boundary conditions, and to test and evaluate air quality models for the SCOS97 domain will be carried out as part of a joint effort by the staffs of the ARB and the SCAQMD to prepare that district's year 2000 AQMP. In addition, base year and future year baseline emission inventories will be prepared as part of the joint effort. The current schedule calls for that technical work to be completed by mid 2000.

The following table provides some preliminary milestones for the modeling process. Additional milestones will be developed in coordination with the agency stakeholders.

Tentative Milestones for 1- and 8-Hour SCOS97 Modeling

Task	Due Date
• Completion of technical work in support of SCAQMD year 2000 AQMP	Mid-2000
• Development of regional and air basin-specific carrying capacities.	Mid-2001

Deliverables

As discussed previously, all interim products and summaries will be provided to the individual technical working groups (emission inventory, meteorology, air quality, etc.). Comments and suggestions will be solicited from the working groups throughout the entire process.

In addition to the interim products, specific deliverables will be shared with the agency stakeholders via the regularly scheduled meetings of the local, state, and Federal agencies, and at public meetings convened at strategic times. These deliverables will include at least the following:

- Carrying capacity estimations. These are intended to provide an initial assessment of the emission targets for each region. Due to the large number of air basins included within the SCOS97 domain, and the potential for different attainment dates, the methodology for conducting these simulations will need to be worked out with the district stakeholders. However, we have proposed an initial methodology in the "USE OF THE MODELING RESULTS" section.

- The results of any 1-hour and 8-hour ozone attainment demonstration simulations carried out. As indicated above, the methodology for conducting these simulations will need to be worked out with the district stakeholders. Control measures for each district will need to be supplied by district staff.
- The results from any agreed upon transport assessments. The ARB will work with the local agencies via the regularly scheduled agency stakeholder meetings to identify appropriate and necessary transport simulations.

REFERENCES

Arey, J., D.E. Crowley, M. Crowley, M. Resketo, and J. Lester: 1995. "Hydrocarbon emissions from natural vegetation in California's South Coast Air Basin." Atmos. Environ. 21: 2977-2988.

Benjamin, M.T., M. Sudol, L. Bloch, and A.M. Winer. 1996. "Low-emitting urban forests: A Taxonomic methodology for assigning isoprene and monoterpene emission rates." Atmos. Environ. 30: 1437-1452.

Benjamin, M.T., A.M. Winer, J. Karlik, S. Campbell, B. Jackson, and A. Lashgari. 1998. "Assembling a biogenic hydrocarbon emissions inventory for the SCOS97-NARSTO modeling domain." Proceedings of the A&WMA 91st annual Meeting. Paper No. 98-WP75.08. A&WMA. Pittsburg, PA 15222.

Bigler-Engler, V., H. Brown, and K. Wagner, 1996. "A Hybrid Modeling Technique to Address Coastal Meteorology and Complex Terrain in the San Diego Photochemical Modeling Domain." Proceedings Ninth Joint Conference on Applications of Air Pollution Meteorology with A&WMA, Atlanta.

Bott, A. 1989a. "A Positive Definite Advection Scheme Obtained by Non-Linear Renormalization of the Advective Fluxes." Mon. Wea. Rev., 117:1006-1015.

Bott, A. 1989b. "Reply." Mon. Wea. Rev., 117:2633-2636.

California Air Resources Board. 1991. Identification of Volatile Organic Compound Species Profiles. August 1991.

California Air Resources Board: 1992. TECHNICAL GUIDANCE DOCUMENT: Photochemical Modeling. April, 1992.

California Air Resources Board. 1997a. The 1997 Southern California Ozone Study–NARSTO: Preparation of the 1997 Gridded Emission Inventory. A&WMA June 1998 Presentation.

California Air Resources Board. 1997b. Emission Inventory Procedures Manual: Methods for Assessing Area Source Emisions, Volume III. October 1997.

California Air Resources Board, and the SCOS97-NARSTO Technical Committee. 1998. SCOS97-NARSTO 1997 Southern California Ozone Study and Aerosol Study, Volume III: Summary of Field Operations. April 1998.

Carter, W.P.L. 1990. “A Detailed Mechanism for the Gas-Phase Atmospheric Reactions of Organic Compounds.” Atmos. Environ. 24A:481-518.

Carter, W.P.L., D. Luo, I.L. Malkina, and J.A. Pierce. 1993. An Experimental and Modeling Study of the Photochemical Ozone Reactivity of Acetone. Final Report to the Chemical Manufacturers Association. Contract No. KET-ACE-CRC 2.0. December 10, 1993.

Carter, W.P.L. 1995. “Computer Modeling of Environmental Chamber Studies of Maximum Incremental Reactivities of Volatile Organic Compounds.” Atmos. Environ., 29:2513-2527.

Carter, W.P.L., D. Luo, and I.L. Malkina. 1996. Environmental Chamber Studies for Development of An Updated Photochemical Mechanism for VOC Reactivity Assessment. December, 1996. Prepared by the University of California, Riverside for the California Air Resources Board.

Carter, W.P.L., D. Luo, and I.L. Malkina. 1997. Environmental Chamber Studies for Development of An Updated Photochemical Mechanism for VOC Reactivity Assessment. Final Report to the California Air resources Board, Coordinating Research Council, and National Renewable Energy Laboratory. November 26.

Carter, W. P. L. 1999. Documentation of the SAPRC-99 Chemical Mechanism for VOC Reactivity Assessment. Draft report to the California Air Resources Board, Contracts 92-329 and 95-308. September 13.

Chang, J.S., R.A. Brost, I.S.A. Isaksen, S. Madronich, P. Middleton, W.R. Stockwell, and C.J. Walcek. 1987. “A Three-Dimensional Eulerian Acid Deposition Model. Physical Concepts and Formulation.” J. Geophys. Res., 92:14681-14700.

Chang, J.S., P. Middleton, W.R. Stockwell, C.J. Walcek, J.E. Pleim, and H.H. Lansford. 1990. The Regional Acid Deposition Model and Engineering Model. Final Assessment Reports of the National Acid Precipitation Assessment Program. V. 4. Government Printing Office, Washington, D.C.

Chang, J.S., S. Jin, Y. Li, M. Beauharnois, C.L. Lu, and H. Huang. 1997. The SARMAP Air Quality Model. April, 1997. Prepared by the Atmospheric Sciences Research Center, State University of New York.

Davis, F.W., P.A. Stine, D.M. Stoms, M. I. Borchert, and A. D. Hollander. 1995. "GAP analysis of the actual vegetation of California 1. The southwestern region." Madrono. 42: 40-78.

ENVIRON. 1997. User's Guide to the Comprehensive Air Quality Model with Extensions. April, 1997.

Gery, M.W., G.Z. Whitten, J.P. Killus, and M.C. Dodge. 1989. "A Photochemical Kinetics Mechanism for Urban and Regional Scale Computer Modeling." J. of Geophys. Res. 94: 12,925-12,956.

Jackson, B.S., E. Mulberg, and N. Wheeler. 1996. "The application of biogenic emission inventory estimates to photochemical modeling in California." Proceedings of the 9th Joint Conference of the American Meteorological Society and A&WMA. January, 1996. Pages 575-579. American Meteorological Society. Boston, MA. 02108.

Johnson, M. 1997. Redesign of California's Emission Forecasting System (CEFS). California Air Resources Board. A&WMA Presentation October 1997 presentation.

Kumar, N., F.W. Lurmann, and W.P.L. Carter. 1995. Development of the Flexible Chemical Mechanism Version of the Urban Airshed Model. August, 1995. Prepared by Sonoma Technology, Inc. for the California Air Resources Board.

Lolk, N.K. and S.G. Douglas. 1996. "Evaluation of Meteorological Fields Generated by a Prognostic Mesoscale Model Using Data Collected During the 1993 GMAQS/Coast Field Study." Proceedings Ninth Joint Conference on Applications of Air Pollution Meteorology with A&WMA, Atlanta.

Mulberg, E. 1995. "A Comparison of Three Wind Models for the Broader Sacramento Area." Proceedings Regional Photochemical Measurement and Modeling Studies, A&WMA, San Diego.

SCAQMD. 1990. "Inventory of Leaf Biomass and Emission Factors for Vegetation in the South Coast Bain Basin." Technical Report III-C. Draft Air Quality Managenent Plan. South Coast Air Quality Management District. Diamond Bar, CA. 91765.

SCAQMD. 1994. “Ozone Modeling - Performance Evaluation.” Technical Report V-B. Air Quality Managenent Plan. South Coast Air Quality Management District. Diamond Bar, CA. 91765.

Seaman, N.L., D.R. Stauffer, and A.M. Lario. 1995. “A Multi-Scale Four Dimensional Data Assimilation System Applied in the San Joaquin Valley During SARMAP. Part 1: Modeling Design and Basic Performance Characteristics.” Journal of Applied Meteorology, 34:1739-1776.

Sonoma Technology, Inc. 1996. “Development of a Gridded Leaf Biomass Inventory for use in Estimating Biogenic Emissions for Urban Airshed Modeling”. Final Report STI-996086-1599-R. Ventura County APCD. Ventura, CA. 93003-5401. August 28, 1996.

Smith, T.B., W.D. Saunders, and D.M. Takeuchi. 1984. Application of Climatological Analysis to Minimize Air Pollution Impacts in California. Prepared for the California Air Resources Board, Sacramento. Report A2-119-32.

Systems Applications, Intl. 1996. User’s Guide to the Variable-Grid Urban Airshed Model (UAM-V). October 1996. SYSAPP-96-95/27r.

Systems Applications, Intl. 1997. Preparation of a Draft 1990 Gridded Emission Inventory for Southern California. March 1997. Prepared for the California Air Resources Board. SYSAPP-97/08.

United States Environmental Protection Agency. 1990. User’s Guide for the Urban Airshed Model, Volume I: User’s Manual for UAM (CB-IV). Office of Air Quality Planning and Standards. EPA-450/4-90-007A.

United States Environmental Protection Agency. 1995. Urban Airshed Model (UAM) Biogenic Emission Inventory System Version 2. (BEIS2) User's Guide. Final Report. EPA Contract No. 68-D3-0034. Work Assignment No. 1-9. EC/R Project No. AQM-108. United States Enviromental Protection Agency. Air Quality Modeling Group. RTP, NC 27711.

United States Environmental Protection Agency. 1998a. EPA Third-Generation Air Quality Modeling System: Models-3 Volume 9b User Manual. June 1998. Office of Research and Development. EPA-600/R-98/069(b).

United States Environmental Protection Agency. 1998b. Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS (Draft). October, 1998.

Yamartino, R.J., J.S. Scire, S.R. Hanna, G.R. Carmichael, and Y.S. Chang. 1989. CALGRID: A Mesoscale Photochemical Grid Model, Volume I: Model Formulation Document. June, 1989. Prepared for the California Air Resources Board by Sigma Research Corp.

Listing of the SCOS97 stations with their locations and mnemonics.

ID	Description	Lat-Deg	Lat-Min	Lat-Sec	Lon-Deg	Lon-Min	Lon-Sec	Elev (m)
29PL	MDAQMD TWENTY NINE PALMS-6078 ADOBE RD	34	8	31	116	3	28	65
ACTN	ACTION	34	26	45	118	12	0	79
AGRN	ARROYO GRANDE	35	11	31	120	25	54	18
ALPM	Alpine	32	51	53	116	48	27	46
ALPN	SDAQMD*ALPINE-2300 VICTORIA DR	32	49	58	116	45	0	60
ANAH	SCAQMD*ANAHIEM-1610 S HARBOR BLVD	33	49	11	117	54	46	4
ANZA	ANZA	33	33	18	116	40	23	119
APRT	USFS ANGELES PORTABLE	34	0	0	117	0	0	61
ARED	CIMIS ARVIN-EDISON	35	12	22	118	46	40	4
ARGR	XONTEC ARROYO GRANDE-RALCOA WAY	35	2	38	120	34	47	30
ARVN	CARB *ARVIN-20401 BEAR MTN BLVD	35	12	28	118	47	2	14
ATAS	SLOCO *ATASCADERO-6005 LEWIS AVE	35	29	27	120	40	4	86
AZSA	SCAQMD*AZUSA-803 N LOREN AVE	34	8	9	117	55	22	18
AZSM		34	9	37	117	54	17	23
BANH	SCAQMD*BANNING-135 N ALLESANDRO	33	55	40	116	52	26	72
BANN	SCAQMD*BANNING-135 N ALLESANDRO	33	55	40	116	52	26	72
BARS	MDAQMD*BARSTOW-200 E BUENA VISTA	34	53	41	117	1	26	69
BEAR	BLM BEAR PEAK	35	53	3	118	3	6	250
BELL	BELL CANYON	33	32	30	117	35	30	21
BKGS	SJVUCD*BAKERSFIELD-1138 GOLDEN STATE	35	23	5	119	0	53	15
BKWC	CIMIS BLACKWELLS CORNER	35	38	59	119	57	30	21
BLFC	CARB *BAKERSFIELD-5558 CALIFORNIA ST	35	21	21	119	2	23	
BLHT	CIMIS BLYTHE NE	33	33	24	114	39	59	8
BLKM	Black MounSDCAPCD	32	58	54	117	6	56	47
BRBK	SCAQMD*BURBANK-228 W PALM AVE	34	10	33	118	18	57	16
BRMT	USFS BRANCH MOUNTAIN	35	11	20	120	5	0	114
BRST	CIMIS BARSTOW NE	34	53	3	116	59	0	62
BRWN	Brown FielNOAA	32	34	20	116	58	46	16
BSHP	CIMIS BISHOP	37	21	29	118	24	14	38
BURN	BLM BURNS CANYON	34	12	30	116	37	15	182

ID	Description	Lat-Deg	Lat-Min	Lat-Sec	Lon-Deg	Lon-Min	Lon-Sec	Elev (m)
BY23	Buoy 46023	34	42	50	120	58	0	0
BY45	Buoy 46045	34	50	12	118	27	0	0
BY54	Buoy 46054	34	16	8	120	26	54	0
CAJB	Cajon Pass (AV)	34	22	31	117	26	52	131
CALB	Calabasas (AV)	34	8	52	118	36	43	35
CALE	CARB *CALEXICO-CALEXICO HS ETHEL ST	32	40	33	115	28	58	
CAMB	CIMIS CALIPATRIA/MULBERRY	33	2	37	115	24	56	-3
CARL	Carlsbad NOAA	33	8	22	117	16	0	11
CARR	BLM CARRIZO	35	5	47	119	46	22	75
CASE	CASE SPRINGS	33	26	43	117	25	5	70
CATA	Catalina AP (AV)	33	26	30	118	29	50	3
CATH	CIMIS CATHEDRAL CITY	33	50	33	116	28	44	1
CATI	Catalina Isl (AV)	33	24	17	118	24	57	48
CATM	Santa CataNOAA	33	26	44	118	28	56	3
CBC	USN PORT HUENEME CBC	34	8	47	119	12	49	28
CHES	NPS CHEESEBORO	34	11	5	118	43	2	50
CHIL	USFS CHILAO	34	20	0	118	2	0	166
CHVT	SDAQMD*CHULA VISTA-80 E "J" ST	32	37	22	117	3	21	5
CLEM	San ClemenSDCAPCD	32	54	55	118	29	20	45
CLRM	CIMIS CLAREMONT	34	7	48	117	41	46	49
CLXC	ICAPCD*CALEXICO-900 GRANT ST	32	40	26	115	30	10	
CLXE	Calexico CARB	32	49	29	115	29	0	
CMFS	USFS CAMERON FIRE STATION	32	43	17	116	27	47	99
CMMV	SCAQMD*COSTA MESA-2850 MESA VERDE DR	33	40	29	117	55	47	
CMP9	CAMP 9	34	21	42	118	25	18	
CMPT	CMP TARGET RANGE	33	22	20	117	21	32	28
CONV	USFS CONVERSE	34	11	1	116	55	1	171
CPGB	CHVRON*CARPINTERIA-GOBERNADOR RD	34	24	10	119	27	28	13
CRZW		34	3	37	119	55	38	20
CUYA	CIMIS CUYAMA	34	55	54	119	36	17	69
DELO	BLM DELONAGHA	35	34	12	118	37	0	95
DEVO	DEVORE	34	13	16	117	24	11	63
DMMC	SDAQMD*DEL MAR-MIRACOSTA COLLEGE	32	57	10	117	15	46	3
ECAJ	SDAQMD*EL CAJON-1155 REDWOOD AVE	32	47	27	116	56	31	14

ID	Description	Lat-Deg	Lat-Min	Lat-Sec	Lon-Deg	Lon-Min	Lon-Sec	Elev (m)
ECSP	SBAPCD*EL CAPITAN STATE PARK	34	27	39	120	1	44	2
EDSN	CARB *EDISON-JOHNSON FARM	35	20	45	118	51	3	42
ELCR	USFS EL CARISO	33	39	6	117	24	24	92
ELDO	CIMIS EL DORADO	33	47	50	118	5	38	
ELRO	VCAPCD*EL RIO-RIO MESA SCHOOL	34	15	53	119	8	2	3
ELTR	SCAQMD*EL TORO-23022 EL TORO RD	33	37	37	117	41	23	13
EMAM	El Monte CARB	34	4	12	118	1	60	9
EMMA	VCAPCD*EMMA WOOD STATE BEACH	34	17	23	119	19	50	
ESCD	CIMIS ESCONDIDO	33	5	24	116	58	52	13
ESCO	SDAQMD*ESCONDIDO-600 E. VALLEY PKWY	33	7	40	117	4	26	20
FAMS	CIMIS FAMOSO	35	36	14	119	12	45	12
FAWN	USFS FAWNSKIN	34	15	58	116	53	56	210
FISH	BLM FISH CREEK MOUNTAI	32	59	0	116	3	28	23
FONT	SCAQMD*FONTANA-14360 ARROW BLVD	34	6	0	117	30	17	38
FRBH	CIMIS FIREBAUGH/TELLES	36	51	4	120	35	25	5
FSPR	FOUNTAIN SPRINGS	35	53	32	118	54	54	6
FSU	CIMIS FRESNO STATE	36	49	15	119	44	31	10
FVML	BLM FIVE MILE	35	52	18	117	55	6	126
FVPT	CIMIS FIVEPOINTS/WSFS USDA	36	20	11	120	6	47	8
GAFH	CIMIS GOLETA FOOTHILLS	34	28	18	119	52	4	19
GAIL		34	7	33	119	24	0	30
GAVE	CHVRON*GAVIOTA EAST-N OF CHEVRON PLAN	34	28	40	120	12	21	10
GAVW	CHVRON*GAVIOTA WEST-NW OF CHEVRON PLA	34	28	40	120	12	39	9
GCTY	SLOCO *GROVER CITY-9 LE SAGE DR	35	7	30	120	37	58	
GLDR	SCAQMD*GLENDORA-840 LAUREL	34	8	38	117	51	3	27
GLEL	CIMIS GLENDALE	34	12	0	118	13	55	33
GLWF	SBAPCD*GOLETA-380 W FAIRVIEW AVE	34	26	41	119	49	40	
GOLE	SBAPCD GOLETA-380 N FAIRVIEW	34	26	41	119	47	38	1
GRAN	BLM GRANITE MOUNTAIN	34	32	8	117	1	33	143
GTCB	TEXACO*NOJOQUI PASS-GTC B HWY 101	34	31	40	120	11	45	30
GTCC	TEXACO*GAVIOTA-GTC C 1 MI E OF PLANT	34	28	29	120	11	20	7
GUAD	CIMIS GUADALUPE	34	57	42	120	32	48	3
HAWH	SCAQMD*HAWTHORNE-5234 W. 120TH ST	33	55	51	118	22	8	2
HESP	MDAQMD*HESPERIA-17288 OLIVE ST	34	25	4	117	17	5	100

ID	Description	Lat-Deg	Lat-Min	Lat-Sec	Lon-Deg	Lon-Min	Lon-Sec	Elev (m)
HOND	Platform Hondo	34	24	0	120	6	2	44
HORS	BLM HORSE THIEF SPRING	35	46	14	115	54	33	152
HUEN	Oxnard NOAA	34	9	54	119	13	8	
INDO	SCAQMD*INDIO-46-990 JACKSON ST	33	42	32	116	12	50	
INWC	BLM INDIAN WELLS CANYON	35	41	6	117	53	22	122
IREN		34	36	40	120	43	58	30
IRVI	CIMIS IRVINE	33	41	19	117	43	14	12
JAWB	BLM JAWBONE	35	17	40	118	13	30	138
JOSH	NPS JOSHUA TREE NATIONAL MONUMENT	34	4	15	116	23	27	37
JPFT	JUNIPER FLAT	33	46	41	117	5	6	64
JULI	JULIAN	33	4	33	116	35	27	129
KEEN	USFS KEENWILD	33	42	47	116	42	48	150
KEST	CIMIS KESTERSON	37	13	57	120	52	48	2
KETT	CIMIS KETTLEMAN	35	52	8	119	53	39	10
LAGP	LAGUNA PEAK	34	6	31	119	3	55	
LANM	SCAQMD*LOS ANGELES-1630 N MAIN ST	34	4	1	118	14	31	8
LAPZ	LA PANZA	35	22	52	120	11	15	49
LELS	SCAQMD*LAKE ELSINORE-506 W FLINT ST	33	40	29	117	20	9	144
LFC1	EXXON *CAPITAN-LFC #1 LAS FLORES CNYN	34	29	23	120	2	45	18
LFC2	EXXON *CAPITAN-LFC #2 LAS FLORES CNYN	34	28	44	120	1	58	25
LFC3	EXXON *CAPITAN-LFC #3 LAS FLORES CNYN	34	28	8	120	2	20	14
LFC4	EXXON *CAPITAN-LFC #4 LAS FLORES CNYN	34	28	51	120	2	34	3
LGRE	SCAQMD*CRESTLINE-LAKE GREGORY-LAKE DR	34	14	38	117	16	26	138
LHAB	SCAQMD*LA HABRA-621 W. LAMBERT	33	55	33	117	57	3	8
LIND	CIMIS LINDCOVE	36	21	26	119	3	31	14
LODI	CIMIS LODI	38	6	34	121	20	46	
LOSB	CIMIS LOS BANOS	37	5	30	120	45	35	2
LOSP	UNOCAL*LOS PADRES NF-PARADISE RD	34	32	27	119	47	27	54
LOST	NPS LOST HORSE	34	1	4	116	11	16	128
LPHP	UNOCAL*LOMPOC-HS&P FACILITY 500 M SW	34	43	8	120	25	54	17
LPHS	UNOCAL*LOMPOC-HS&P FACILITY 500 M SW	34	43	33	120	25	40	24
LPSH	SBAPCD*LOMPOC-128 S 'H' ST	34	38	16	120	27	21	2
LRLM	BLM LAURAL MOUNTAIN	35	28	42	117	41	56	133
LSF	LSF LAS FLORES	33	17	20	117	26	20	3

ID	Description	Lat-Deg	Lat-Min	Lat-Sec	Lon-Deg	Lon-Min	Lon-Sec	Elev (m)
LTAB	LAS TABLAS	35	39	20	120	55	22	39
LYNW	SCAQMD*LYNWOOD-11220 LONG BEACH BLVD	33	55	44	118	12	35	2
MANT	CIMIS MANTECA	37	50	5	121	13	22	1
MBLD	Azusa CARB	34	14	21	117	37	15	133
MELO	CIMIS MELOLAND	32	48	24	115	26	46	-1
MEXA	Mexicali CARB	32	39	31	115	25	37	
MEXI	Mexicali CARB	32	37	10	115	23	53	
MEXT	Mexicali CARB	32	34	13	115	20	57	
MEXU	Mexicali CARB	32	37	45	115	26	47	
MID	BLM MID HILLS	35	9	58	115	24	55	165
MILL	USFS MILL CREEK	34	23	0	118	4	0	107
MOBY	SLOCO *MORRO BAY-MORRO BAY BL & KERNR	35	22	4	120	47	38	1
MODE	CIMIS MODESTO	37	38	10	121	11	10	1
MOJA	BLM MOJAVE RIVER SINK	35	3	30	116	5	0	29
MOJP	CARB *MOJAVE-923 POOLE ST	35	3	3	118	8	45	85
MONT	USFS MONTECITO	34	27	6	119	38	6	45
MRCP	SJVUCD*SCHOOL-755 STANISLAUS ST, MARI	35	3	14	119	24	14	28
MTLG	USFS MT LAGUNA	32	52	47	116	25	13	175
NAFB	Norton AFBCARB	34	9	12	117	15	0	32
NIPO	UNOCAL NIPOMO-1300 GUADALUPE RD	35	1	19	120	34	8	6
NLGB	SCAQMD*LONG BEACH-3648 N LONG BEACH	33	49	26	118	11	20	
NXP	NWS TWENTYNINE PALMS	34	7	48	115	56	36	54
OAKG	USFS OAK GROVE	33	23	36	116	47	42	83
OASS	CIMIS OASIS	33	31	32	116	9	15	
OCEA	SDAQMD*OCEANSIDE-1701 MISSION AVE	33	12	10	117	22	1	3
OCSD	CIMIS OCEANSIDE	33	15	21	117	19	11	1
ODOR	CHVRON*GAVIOTA-ODOR WEST-S OF PLANT	34	28	15	120	13	15	2
OJAI	VCAPCD OJAI-1768 MARICOPA HIWY	34	26	49	119	16	11	23
OLDL	CARB *OILDALE-3311 MANOR ST	35	26	20	119	0	57	18
OPAL	BLM OPAL MOUNTAIN	35	9	15	117	10	32	98
OTAY	SDAQMD*OTAY-1100 PASEO INTERNATIONAL	32	35	2	116	56	16	15
PALM	SCAQMD*PALM SPRINGS-FS 590 RACQUET CL	33	51	17	116	32	31	17
PANO	CIMIS PANOCHE	36	53	25	120	43	55	5
PDSW	SCAQMD*PASADENA-752 S. WILSON AVE	34	5	2	118	6	28	25

ID	Description	Lat-Deg	Lat-Min	Lat-Sec	Lon-Deg	Lon-Min	Lon-Sec	Elev (m)
PEND	Camp Del MSDCAPCD	33	13	2	117	23	46	
PERR	SCAQMD*PERRIS-237 .5 N "D" ST	33	47	27	117	14	31	43
PFLD	PARKFIELD	35	53	56	120	25	55	46
PHEL	MDAQMD*PHELAN-BEEKLEY & PHELAN RDS	34	25	33	117	33	46	410
PICO	SCAQMD*PICO RIVERA-3713 SAN GABRIEL	34	0	46	118	3	32	7
PIRU	CIMIS PIRU	34	22	30	118	47	20	19
PLVD	CIMIS PALO VERDE	33	23	15	114	43	21	7
POMA	SCAQMD*POMONA-924 N. GAREY AVE	34	4	1	117	45	3	27
POMO	CIMIS POMONA	34	3	30	117	48	42	22
POTR	POTRERO	32	36	22	116	36	29	73
PRLR	CIMIS PARLIER	36	35	52	119	30	11	10
PRTG	VCAPCD*PIRU-2SW, 2815 TELEGRAPH RD	34	23	56	118	49	26	18
PSRB	CARB *PASO ROBLES-235 SANTA FE AVE	35	37	55	120	41	23	10
PTCL	CHVRON*POINT CONCEPTION LIGHTHOUSE	34	27	7	120	27	28	4
PTHU	CIMIS PORT HUENEME	34	10	24	119	12	0	
PVSP	Palos Verdes (AV)	33	44	46	118	20	7	44
RAMO	CIMIS RAMONA	33	2	58	116	56	18	40
RANC	RANCHITA	33	12	44	116	30	19	127
RDLD	SCAQMD*REDLANDS-500 N. DEARBORN	34	3	35	117	9	35	
REDM	Fallbrook SDCAPCD	33	24	2	117	11	27	552
ROSE	USFS ROSE VALLEY	34	32	35	119	11	3	101
ROSW		34	0	31	120	14	15	16
RSDA	SCAQMD*RESEDA-18330 GAULT ST	34	11	56	118	31	58	22
SANB	SCAQMD*SAN BERNARDINO-24302 4TH ST	34	6	28	117	16	22	
SAND	CIMIS SAN DIEGO	32	43	59	117	8	5	11
SBAR	NPS SANTA BARBARA	33	29	0	119	2	0	5
SBWC	CARB *SANTA BARBARA-3 W. CARRILLO ST	34	25	15	119	42	3	7
SCIS	NPS SANTA CRUZ ISLAND	33	59	45	119	43	20	7
SCLA	Santa Clarita -- Sodar site	34	23	9	118	31	55	38
SCLH	San Clemente Island	32	52	33	118	25	57	592
SCLM	San ClemenNOAA	33	1	7	118	35	7	5
SCLR	Santa ClarSCAQMD	34	23	16	118	32	2	37
SD12	SDAQMD*SAN DIEGO-330A 12TH AVE	32	42	32	117	9	10	
SDOV	SDAQMD*SAN DIEGO-5555 OVERLAND AVE	32	49	40	117	7	58	13

ID	Description	Lat-Deg	Lat-Min	Lat-Sec	Lon-Deg	Lon-Min	Lon-Sec	Elev (m)
SELY	CIMIS SEELEY	32	45	34	115	43	54	1
SFDM	SANTA FE DAM	34	7	15	117	56	45	15
SGUS	SAUGUS	34	25	30	118	31	30	44
SHAF	CIMIS SHAFTER/USDA	35	31	59	119	16	52	11
SHFT	CARB *SHAFTER-548 WALKER ST	35	30	14	119	16	19	12
SLOM	CARB *SAN LUIS OBISPO-1160 MARSH ST	35	17	2	120	39	14	6
SLOP	CIMIS SAN LUIS OBISPO	35	18	22	120	39	37	10
SLTE	CIMIS SALTON SEA EAST	33	13	12	115	34	48	-2
SLTW	CIMIS SALTON SEA WEST	33	19	38	115	57	0	-2
SMI	San Miguel Island	34	1	59	119	21	51	254
SMPK	Deer SprinSDCAPCD	33	11	6	117	7	48	54
SMSB	CARB *SANTA MARIA-500 S BROADWAY B69	34	56	52	120	26	2	
SNBA	CIMIS SANTA BARBARA	34	26	16	119	44	10	7
SNBO	SCAQMD*SAN BERNARDINO-ARB	34	5	56	117	40	26	36
SNI	SAN NICOLOS ISLAND	33	14	0	119	27	0	9
SNTM	CIMIS SANTA MARIA	34	57	16	120	23	3	8
SNTY	CIMIS SANTA YNEZ	34	34	59	120	4	41	14
SOLM	La Jolla SDCAPCD	32	50	27	117	15	0	25
SQSP	BLM SQUAW SPRINGS	35	22	12	117	34	6	110
SRIS	NPS SANTA ROSA ISLAND	33	58	40	120	4	40	39
SRPL	SANTA ROSA PLATEAU	33	31	43	117	13	50	60
STAM	CIMIS SANTA MONICA	34	2	28	118	28	34	10
STRA	CIMIS STRATFORD	36	9	27	119	51	0	5
SVAL	VCAPCD*SIMI VALLEY-5400 COCHRAN ST	34	16	40	118	41	5	31
SVLM	Simi ValleVCAPCD	34	17	27	118	47	52	36
SYAP	SBAPCD*SANTA YNEZ-AIRPORT RD	34	36	10	120	4	15	21
TANB	USFS TANBARK	34	10	0	117	46	0	79
TEME	CIMIS TEMECULA	33	29	25	117	13	20	43
THER	CIMIS THERMAL	33	38	47	116	14	30	
THOS	CARB *OAK VIEW-5500 CASITAS PASS RD	34	23	13	119	24	57	32
TILM	Tijuana CARB	32	29	52	116	58	37	3
TIPL	Tijuana CARB	32	30	50	117	6	56	13
TIRP	Tijuana CARB	32	21	12	117	3	21	1
TITT	Tijuana CARB	32	31	30	116	59	6	13

ID	Description	Lat-Deg	Lat-Min	Lat-Sec	Lon-Deg	Lon-Min	Lon-Sec	Elev (m)
TME2	CIMIS TEMECULA-EAST II	33	33	24	117	1	49	46
TOMP	VCAPCD*THOUSAND OAKS-9 2323 MOORPARK	34	12	35	118	52	8	23
TRNA	MDAQMD*TRONA-83732 TRONA ROAD	35	46	29	117	22	1	49
TUST	Tustin NOAA	33	42	25	117	50	15	1
UCR	CIMIS U.C. RIVERSIDE	33	57	54	117	20	8	31
UCSB	EXXON *UCSB WEST CAMPUS-ARCO TANK, IS	34	24	53	119	52	44	
UHL	UHL	35	48	0	118	36	0	113
USCZ	Los AngeleNOAA	34	1	10	118	17	2	6
VALA	SCAQMD*W LOS ANGELES-VA HOSPITAL	34	3	3	118	27	17	9
VBPP	VBGAFB*VANDENBERG AFB-STS POWER PLANT	34	35	45	120	37	47	10
VCEN	SDAPCD VALLEY CENTER	33	13	57	117	1	28	366
VDMR	CHVRON*GAVIOTA-ODOR EAST	34	28	19	120	10	33	3
VICT	VICTORVILLE	34	30	15	117	19	47	876
VLYC	VALLEY CENTER	33	13	34	116	59	32	41
VNUY	Van Nuys	34	12	57	118	29	31	24
VSLA	CIMIS VISALIA/ICI AMERICAS	36	18	3	119	13	23	10
VTRV	CIMIS VICTORVILLE	34	28	42	117	15	40	26
WALK	BLM WALKER PASS	35	39	53	118	3	25	169
WARM	USFS WARM SPRINGS	34	35	0	118	33	0	122
WSPR	WARNER SPRINGS	33	19	20	116	41	4	945
WTLD	CIMIS WESTLANDS	36	38	0	120	22	55	5
YCAV	YUCCA VALLEY	34	7	24	116	24	28	99
APE	+Alpine Profiler	32	51	36	116	48	36	463
AZS	Azusa Profiler	34	9	36	117	54	0	232
BFD	+Brown Field Profiler	32	34	12	116	59	24	158
BTW	+Barstow Profiler	34	55	12	117	18	36	694
CBD	+Carlsbad Profiler	33	8	24	117	16	12	110
EAF	Edwards AFB Profiler	34	17	60	116	10	12	619
ECO	+El Centro Profiler	32	49	48	115	34	12	-18
EMT	+El Monte Profiler EMT	34	5	24	118	1	48	95
GLA	+Goleta Profiler	34	25	48	119	50	60	4
HPA	+Hesperia Profiler	34	23	24	117	24	0	975
LAS	+Las Alamitos,CA Profiler	33	47	24	118	3	0	7
LAX	+Los Angeles International Profiler	33	56	24	118	26	24	47

ID	Description	Lat-Deg	Lat-Min	Lat-Sec	Lon-Deg	Lon-Min	Lon-Sec	Elev (m)
NTN	+Norton Air Force Base Profiler	34	5	24	117	15	36	318
ONT	+Ontario Profiler	34	3	36	117	34	48	280
PDE	+Palmdale Profiler	34	36	36	118	5	24	777
PHE	+Port Hueneme Profiler	34	10	12	119	13	12	2
PLM	+Point Loma Profiler	32	42	0	117	15	0	23
RSD	+Riverside Profiler	33	55	12	117	18	36	488
SCA	Santa Clarita Profiler	34	25	12	118	31	48	354
SCE	+San Clemente Island Profiler	33	1	12	118	35	24	53
SCL	+Santa Catalina Island Profiler	33	27	0	118	28	48	37
SMIP	+Simi Valley Profiler	34	17	24	118	48	0	279
TCL	+Temecula Profiler	33	30	0	117	9	36	335
TML	+Thermal Profiler	33	38	24	116	9	36	-36
TTN	+Tustin Marine Base Profiler	33	42	36	117	50	24	16
29P	29 Palms Profiler	34	18	36	116	15	0	764
USC	+USC Profiler	34	1	12	118	16	48	67
VAF	+Vandenberg Air Force Base Profiler	34	46	12	120	31	48	149
VLC	+Valley Center Profiler	33	15	36	117	2	24	415
VNS	+Van Nuys Profiler	34	13	12	118	29	24	241