# FINAL QUALITY ASSURANCE AUDIT REPORT

# CENTRAL CALIFORNIA OZONE STUDY

**Prepared for**

**San Joaquin Valleywide Air Pollution Study Agency c/o**

California Environmental Protection Agency
California AIR RESOURCES BOARD

**California Air Resources Board**
**California EPA**
**Sacramento, CA**

**December 2001**

**Prepared by**


**PARSONS ENGINEERING SCIENCE, INC.**
**DESIGN • RESEARCH • PLANNING**
***100 WEST WALNUT STREET, PASADENA, CALIFORNIA 91124***

# DISCLAIMER

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# EXECUTIVE SUMMARY


The Central California Ozone Study (CCOS) field measurement program was conducted during a four-month period from 6/1/00 to 9/30/00. A network of air quality and upper-air meteorological monitoring stations supplement the existing routine measurements, the majority of them operating as part of the State and Local Air Monitoring Sites (SLAMS) and Photochemical Air Monitoring Sites (PAMS) networks. To meet the study goals, the CCOS field measurement program consisted of four categories of supplemental measurement sites with increasing levels of chemical speciation and time resolution; type 0, 1, and 2 “supplemental” (S) sites, and “research” (R) sites. Supplemental measurements included ozone and NO/NOy measurements at all sites, with the addition of carbonyl, non-methane hydrocarbons, nitric acid, and other measurements to the higher level sites. In addition, a network of upper-air meteorological monitoring stations supplemented the existing routine meteorological network in order to identify and characterize meteorological scenarios that are conducive to ozone formation during the ozone season. Radar profilers, Doppler sodars, and RASS were used at most of these supplemental sites because they acquire hourly average wind speed, wind direction, and temperature by remote sensing without constant operator intervention. Sodars were collocated with profilers at several locations because they provided greater vertical resolution in the first 200 m agl.

Five aircraft were used for the CCOS field study. Instrumented aircraft were used to measure the three-dimensional distribution of ozone, ozone precursors, and meteorological variables.

The purpose of quality assurance (QA) is to provide a quantitative estimate of the uncertainty of the measurements through estimates of the precision, accuracy (or bias), and validity. In addition, QA ensures that the procedures and sampling methods used in the study are well documented and are capable of producing data that meet the specifications of the study. With this in mind, a QA team was assembled for the Central California Ozone Study to assure the quality of the collected data.

The audits typically consisted of two components: systems audits and performance audits. Systems audits included a review of the operational and quality control (QC) procedures to assess whether they are adequate to assure valid data that meet the specified level of accuracy and precision. Performance audits involved challenging the measurement/analysis system with a known standard sample that is traceable to a primary standard.

This report presents the audit results for the supplemental CCOS measurements. QA for normal SLAMS and PAMS measurements are covered under the their respective QA programs, and audit results for these measurements can be found in the routine audit reports generated for these programs.

# TABLE OF CONTENTS

# TABLE OF CONTENTS (continued)

# LIST OF TABLES

# SECTION 1

# INTRODUCTION

## 1.1 CCOS Monitoring Overview

The primary purpose of the Central California Ozone Study (CCOS) was to provide another milestone in the understanding of relationships among emissions, transport, and ozone standard exceedances, as well as to facilitate planning for further emission reductions needed to attain state and federal ozone standards. The CCOS was proposed to gather aerometric and emissions databases for modeling and to apply air quality models for the attainment demonstration portion of the SIP for the federal 8-hour and state 1-hour ozone standards. CCOS was an integrated effort that includes air quality and meteorological field measurements, emissions characterization, data analysis and air quality modeling. The modeling domain for CCOS covered all of central California and most of northern California, extending from the Pacific Ocean to east of the Sierra Nevada and from Redding to the Mojave Desert. The selection of this study area reflects the regional nature of the state 1-hour and federal 8-hour ozone exceedances, increasing urbanization of traditionally rural areas, and a need to include all of the major flow features that affect air quality in central California in the modeling domain.

The CCOS field measurement program was conducted during a four-month period from 6/1/00 to 9/30/00. A network of air quality and upper-air meteorological monitoring stations supplement the existing routine measurements, the majority of them operating as part of the State and Local Air Monitoring Sites (SLAMS) and Photochemical Air Monitoring Sites (PAMS) networks. The California Air Resources Board and local air pollution control districts currently operate 185 air quality monitoring stations throughout northern and central California. Of the active sites, 130 measure ozone and 76 measure $NO_x$. Carbon monoxide and hydrocarbons are measured at 57 and 11 sites, respectively. Data from these sites are routinely acquired and archived by the ARB and Districts. This extensive surface air quality monitoring network provides a substantial database for setting initial conditions for the model, and for operational evaluation of model outputs.

To meet the study goals, the CCOS field measurement program consisted of four categories of supplemental measurement sites with increasing levels of chemical speciation and time resolution; type 0, 1, and 2 “supplemental” (S) sites, and “research” (R) sites. The site types are summarized below:

***Type 0 supplemental monitoring sites (S0)*** were used to fill in key areas of the modeling domain where ozone and nitrogen oxides are not currently measured. Ozone and $NO/NO_y$ were measured at theses sites.

***Type 1 supplemental monitoring sites (S1)*** were used to establish boundary and initial conditions for input into air quality models. These sites were needed at the upwind boundaries of the modeling domain, in the urban center (initial conditions) and at downwind locations (boundary conditions). With the exception of $NO_y$ measurements, S1 sites are equivalent to Photochemical Assessment Monitoring Stations (PAMS) sites. They included the S0 measurements (ozone and $NO/NO_y$), plus speciated volatile organic compounds (VOC), supplementing the 11 existing PAMS sites in the study area (four in Sacramento, four in Fresno, and three in Bakersfield).

***Type 2 supplemental monitoring sites (S2)*** were located at the interbasin transport and intrabasin gradient sites, and near the downwind edge of the urban center where ozone formation may either be VOC or $NO_x$ limited depending upon time of day and pattern of pollutant transport. S2 sites also provided data for initial conditions and operation evaluations and some diagnostic evaluation of model outputs. Measurements at S2 sites included those at S1 sites plus continuous nitrogen dioxide ($NO_2$) and peroxyacetylnitrate (PAN) using the CECERT continuous analyzer.

***Research sites (R)*** had the same site requirements as S2 sites. The sites were intended to measure a representative urban mix of pollutants, and were carefully selected to minimize the potential influence of local emission sources. As with S2 sites, research sites were located where ozone formation may either be VOC or $NO_x$ limited depending upon time of day and pattern of pollutant transport. Measurements at the R sites included those at S2 sites plus continuous measurements of nitric acid, carbon monoxide, carbon dioxide, photolytic rate parameters, light adsorption and scattering. In addition, hydrocarbons were measured using continuous gas chromatographs.

A network of upper-air meteorological monitoring stations supplemented the existing routine meteorological network in order to identify and characterize meteorological scenarios that are conducive to ozone formation during the ozone season. Radar profilers, Doppler sodars, and RASS were used at most of these supplemental sites because they acquire hourly average wind speed, wind direction, and temperature by remote sensing without constant operator intervention. Sodars were collocated with profilers at several locations because they provided greater vertical resolution in the first 200 m agl.

In addition to ozonesondes, aloft air quality measurements were available from fixed platforms that are part of the routine monitoring network (e.g., Walnut Grove radio tower and Sutter Buttes). CCOS added $NO_y$ measurements at Walnut Grove and Sutter Buttes to provide additional information on oxidants available as carry-over to mix-down on the following day.

Five aircraft were used for the CCOS field study. Instrumented aircraft were used to measure the three-dimensional distribution of ozone, ozone precursors, and meteorological variables.

Table 1-1 summarizes the supplemental measurements made for CCOS.

## 1.2 Auditing Program

The purpose of quality assurance (QA) is to provide a quantitative estimate of the uncertainty of the measurements through estimates of the precision, accuracy (or bias), and validity. In addition, QA ensures that the procedures and sampling methods used in the study are well documented and are capable of producing data that meet the specifications of the study. With this in mind, a QA team was assembled for the Central California Ozone Study to assure the quality of the collected data.

The CCOS QA effort was under the overall direction of the CCOS QA Manager, Mr. David Bush of Parsons Engineering Science, Inc. (Parsons). Due to the scope of the CCOS supplemental monitoring effort, Parsons assembled a QA team to specifically address the many aspects of the monitoring program. Mr. Robert Baxter (Parsons) was responsible for overseeing the audits of the surface and upper air meteorological measurements. He was responsible for coordinating the meteorological audits, interfacing with supporting subcontractors (Northwest Research Associates, Inc. and T&B Systems), and reviewing all data and reports associated with the meteorological audits. The QA Manager also coordinated with QA staffs from the California Air Resources Board (Mr. Michael Miguel) and the Bay Area AQMD (Mr. Avi Okin). ARB and BAAQMD conducted performance audits of the ozone, $NO/NO_x$, $NO/NO_y$ analyzers at exiting monitoring stations and at CCOS supplemental monitoring sites within their area of responsibility.

The audits typically consisted of two components: systems audits and performance audits. Systems audits included a review of the operational and quality control (QC) procedures to assess whether they are adequate to assure valid data that meet the specified level of accuracy and precision. Performance audits involved challenging the measurement/analysis system with a known standard sample that is traceable to a primary standard. Audit responsibilities were divided in the following manner:

**Audits performed by ARB and BAAQMD QA staff**

- Ozone, $NO/NO_x$, and meteorological measurements at existing District and ARB monitoring stations.
- Ozone, $NO/NO_x$ and $NO/NO_y$, $NOy/NO_y$*, $NO_2$ at CCOS supplemental monitoring sites.
- PAMS VOC measurements by ARB and supplemental hydrocarbon measurements by Desert Research Institute (DRI) and OGI, and supplemental carbonyl measurements by AtmAA. Audits consisted of a through-the-probe audit using a 25-component standard hydrocarbon mixture.
- Ozone and $NO/NO_y$ on up to six instrumented aircraft.

**Audits performed or arranged by Parsons Engineering Science**

- CCOS upper-air meteorological measurements.
- CO, $CO_2$, aethalometer, nephelometers, and particulate nitrate at CCOS research monitoring sites.
- Audits of sites not audited by the ARB due to scheduling limitations.

This report presents the audit results for the supplemental CCOS measurements. QA for normal SLAMS and PAMS measurements are covered under the their respective QA programs, and audit results for these measurements can be found in the routine audit reports generated for these programs.

# SECTION 2

# SURFACE METEOROLOGY

All surface meteorological measurements audited for CCOS by the Parsons team consisted of measurements associated with the upper air data collection. Some surface meteorology equipment was audited by the ARB during their audits of the supplemental air quality equipment at existing NAMS, SLAMS, and PAMS sites. The auditing of this equipment is mandated for these networks and is not summarized in this report. However, the ARB results have been retained in Appendix B as part of the reports provided for the CCOS supplemental measurements.

## 2.1 DESCRIPTION OF AUDIT EQUIPMENT

### R.M. Young Selectable Speed Anemometer Drive

To audit the wind speed sensor, various known rates of rotation were obtained using a R.M. Young Model 18801 anemometer drive. The rate of rotation was digitally controlled and the calibration verified using either a frequency counter or phototachometer.

### Garmin Global Positioning System (GPS)

A Garmin GPS 12 or Etrex-Summit 12-channel GPS receiver was used to walk the direction of the wind direction cross arm and determine the pointing angle.

### Brunton Pocket Transit

A Brunton Pocket Transit model F5007LM was used to verify the orientation of the wind direction crossarm in the event reliable readings could not be obtained from the GPS. The transit is tripod mounted and can be read to an accuracy of approximately ±0.5°.

### RM Young Wind Direction Calibration Fixture

Most audits performed were on the RM Young Wind Monitor type sensors. For these audits, the sensors were mounted on a RM Young calibration fixture and the relative accuracy and linearity of the wind direction sensor verified. The fixture can be read to an accuracy of approximately 0.5°.

### Precision Thermister Temperature Probe

A Radio Shack precision thermister temperature probe model RS 63-1009A was used to audit the temperature sensors. The probe was certified against a NIST traceable mercury in glass thermometer.

**Onset Computer Corporation Hobo Pro Relative Humidity/Temperature Data Logger**

An Onset Computer Corporation Hobo Pro Relative Humidity/Temperature data logging system with naturally aspirated radiation shield was used to collect temperature and relative humidity data to audit the site sensor.

**R.M. Young Torque Disc**

A RM Young model 18310 torque disc was mounted on the senor shaft and calibrated screws placed at known distances from the shaft center to determine the starting torque of the sensor.

## 2.2 SYSTEM AUDIT PROCEDURES

The system audit of the surface meteorological sensing systems consists of an inspection of the site to assess proper siting of the instrument sensors, a review of the station check logs and other site documentation, as well as an interview with the site operator concerning his or her knowledge of the QAPP and applicable SOP sections. Sensor siting criteria for meteorological sensors are specified in the EPA *Quality Assurance Handbook for Air Pollution Measurement Systems*, *Volume IV* (EPA, 1995) and *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA, 2000). On-site forms and site logs are reviewed to check that the documentation conforms to the specifications of the plan. The subjects that are addressed by the system audits include:

- Network design and siting
  - network size and design
  - sensor exposure
  - review of station
- Resources and facilities
  - instruments and methods
  - staff and facilities
  - standards and traceability
- Quality assurance and quality control
  - status of quality assurance program
  - audit participation
  - precision and accuracy checks

Additionally, once the system audits of all sites in a network are complete, the auditor checks for possible differences in operation among the various sites.

## 2.3 PERFORMANCE AUDIT PROCEDURES

**Wind Speed**

The wind speed audit begins with the inspection of the wind speed cups or propeller to ensure that they are intact. The cups are then removed to produce a zero point. Next, the

R.M. Young selectable speed anemometer drive is connected to the sensor shaft to simulate wind speeds of approximately 0, 3, 8, 16, and 26 m/s. Actual values depend on the sensor model and are determined by multiplying the motor speed by a cup or propeller transfer coefficient supplied by the manufacturer. The data logger responses are compared to the calculated actual values and the differences compared to the audit criteria.

The sensor bearings are then checked for excessive wear by manually turning the sensor shaft to determine whether there is any bearing drag. Next, the sensor is removed from the crossarm and the R.M. Young torque disc mounted on the sensor shaft. The starting torque is determined using the manufacturer-provided “k” value to determine the effective wind speed starting threshold.

**Wind Direction**

The wind sensor crossarm alignment relative to true north is determined using either the GPS or a tripod mounted Brunton pocket transit. Measurements obtained from the pocket transit are corrected for magnetic deviation using the measured and calculated azimuth angle to the sun. The calculated angle to the sun is obtained from the program COMPASS (version 1.2) with the required variables of time, latitude and longitude obtained from the GPS. The wind direction vane alignment relative to the crossarm is checked by pointing the vane down the crossarm and noting the reported wind direction on the data system. The sensor is then installed on the RM Young calibration protractor and the vane rotated in 30° to 90° increments around the full 360° circle. The data system response is noted at each of the audit points.

The sensor starting threshold is checked using a RM Young torque gauge to determine the starting torque required to begin rotation of the wind sensor shaft. This torque is used with the manufacturer supplied vane “k” value to determine the effective wind direction starting threshold.

**Temperature**

The temperature-sensing system is audited by immersing the system sensor and a NIST-traceable audit thermometer in the same water bath and comparing the readings of the thermometer with the data logger and chart recorder outputs at approximately 0°, 20° and 40° C. The difference calculated for each point is compared with the audit criteria.

**Relative Humidity and Dew Point Temperature**

The Hobo Pro RH/Temperature data logging system with radiation shield is placed adjacent to the site sensor and allowed to collect data over similar averaging periods as the site system. The data are then downloaded to a laptop computer and the reported relative humidity and dew point temperatures noted. The measured temperature on the Hobo Pro RH/Temperature system is used to convert the site relative humidity to equivalent dew point temperature and the calculated site values are compared to those obtained from the audit sensor.

### Solar Radiation

A certified LiCor pyranometer is collocated with the station solar radiation sensor and at least five simultaneous readings over the course of the audit are collected and the differences compared with the audit criteria.

## 2.4 PERFORMANCE AUDIT CRITERIA

Performance audit criteria are consistent with those recommended in the U.S. EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV (USEPA, 1995). The audit criteria are shown in Table 2-1.

Table 2-1. Surface Meteorology Performance Audit Criteria.

| Measurement Variable | Audit Criteria |
|---|---|
| Horizontal Wind Speed | Accuracy ±(0.2 m/s + 5% of observed)<br>Equivalent wind speed starting torque to meet the wind speed starting thresholds for the respective sensors. |
| Horizontal Wind Direction | Accuracy ±3 degrees for linearity, ±2 degrees for alignment to known direction.<br>Equivalent wind speed starting torque to meet the wind speed starting thresholds for the respective sensors. |
| Temperature | ±0.5°C (monitoring criteria)<br>±1.0°C (PSD criteria) |
| Temperature Difference (ΔT) | ±0.1°C tracking for all points |
| Solar Radiation | ± 5% of observed |
| Barometric Pressure | ±3 mb |
| Precipitation | ±10% |

## 2.5 AUDIT RESULTS

The individual, complete audit reports for each site can be found in the Appendices of this report. Appendix A contains audit reports for the surface meteorological measurements generated by Parsons, usually as part of the audits of the upper air monitoring sites. Table 2-2 summarizes the dates of the audits and the CCOS observables audited. Table 2-3 presents a summary of the performance audit results.

Table 2-2. Surface Meteorology Performance Audit Dates And CCOS Observables.

| Site | Operator | Audit Date(s) | Winds | Amb Temp. | Temp. Diff. | Relative Humidity | Solar Rad. | Ambient Pressure | Precip. | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Angels Camp (New Melones Lake) | NOAA/ETL | 06/27/00 | ● | ● | | ● | ● | ● | ● | |
| Angiola | NOAA/ETL | | ○ | ○ | ○ | | | | | Wind comparison performed in CRPAQS task. 100 m tower audit not performed as sensors were not removable from the tower. |
| Arbuckle | NOAA/ETL | 06/21/00 | ● | ● | ● | ● | ● | ● | ● | |
| Bodega Bay | STI | 06/08/00 | ● | ● | | ● | ● | ● | | |
| Carizo Plain | NOAA/ARL | 05/18/00 | ● | ● | | ● | | | | |
| Chico | NOAA/ETL | 06/20/00 | ● | ● | ● | ● | ● | ● | ● | |
| Fresno Air Terminal | NOAA/ETL | 06/23/00 | ● | ● | ● | ● | ● | ● | ● | |
| Grass Valley | NOAA/ETL | 06/22/00 | ● | ● | | ● | ● | ● | ● | |
| Lagrange (Waterford) | NOAA/ETL | 06/26/00 | ● | ● | ● | ● | ● | ● | ● | |
| Livermore | BAAQMD | 08/18/00 | ● | ● | | ● | ● | | | |
| Livermore (radar) | STI | 06/13/00 | ● | ● | | ● | ● | ● | | |
| Pleasant Grove | NOAA/ETL | 06/29/00 | ● | ● | ● | ● | ● | ● | ● | |
| Redding | NOAA/ETL | 06/19/00 | ● | ● | | ● | ● | ● | ● | |
| Richmond | NOAA/ETL | 06/28/00 | ● | ● | | ● | ● | ● | ● | |
| San Martin | STI | 06/12/00 | ● | ● | | ● | | ● | | |
| Sunol | BAAQMD | 08/18/00 | ● | ● | | ● | | ● | | |
| Tracy | STI | 06/14/00 | ● | ● | | ● | ● | ● | | |

Notes: ● Audit performed
○ Variable measured but no audit performed

The following sections discuss problems or issues noted at specific sites, including their resolution.

### Angels Camp (New Melones Lake)

Problem: The site is located near the Visitor's Center at New Melones Lake. The near surface meteorological variables measured by the sodar and surface meteorological station should be representative of general wind flow during the daytime hours but may be specific to drainage flows at night due to the complex terrain surrounding the site. The surface meteorological tower is located approximately 150 meters northeast of the sodar antennas.

Resolution: The above comment should be taken into consideration during analysis.

### Arbuckle

Problem: The aspirator for the 9-meter temperature/relative humidity sensor was not operating at the time of the audit. The aspirator was scheduled to be replaced within a week.

Resolution: The exact date of replacement is not known.

Problem: The ground underneath the meteorological tower was not really representative of the surrounding terrain. The site is surrounded by agricultural land, but the tower is located on a gravel maintenance yard. This difference in terrain will influence the measurement of temperature and relative humidity.

Resolution: The above comment should be taken into consideration during analysis.

Table 2-3. Surface Meteorology Performance Audits Summary.

| Site | Audit Date(s) | Winds Speed (m/s) | Winds Direction Orientation (°) | Winds Direction Linearity (°) | Winds Direction Max. Diff. (°) | Temperature Ambient (°C) | Temperature Delta-T (°C) | Rel. Hum. Eq. Dew Point (°C) | Solar Radiation (W/m2) | Amb. Press. (mb) | Precip. (%) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Angeles Camp (New Melones Lake) | 06/27/00 | 0.0 | 0.0 | -1.0 | -1.5 | 0.1 | | -1.5 | -35 | -0.5 | 1.0 | |
| Angiola | 06/25/00 | | | | | | | | | | | No direct audit perfomred as instruments on 100 meter tower were not removable from the tower. A wind comparison was performed as part of the CRPAQS program. |
| Arbuckle | 06/21/00 | 0.0 | 1.0 | 0.0 | 1.0 | 0.2 | 0.2 | -0.5 | -57 | 1.4 | -0.8 | One solar radiation point exceeds criteria, however the overall audit results look reasonable. |
| Bodega Bay | 06/08/00 | 0.0 | 1.0 | 0.0 | 0.0 | 0.4 | | 0.4 | 20 | 3.5 | | The audit of the pressure sensor exceeds criteria. An incorrect factor was found in the data logger program. The program was corrected following the audit. |
| Carrizo Plain | 05/18/00 | -0.1 | 0.0 | 1.8 | -3.0 | 0.4 | | -0.4 | | | | |
| Chico | 06/20/00 | 0.0 | 1.0 | 0.0 | 0.0 | 0.3 | -0.3 | 0.6 | -18 | 0.6 | -0.8 | Delta-T was measured with the site sensor lid on, which may have caused variation between the audit standard. |
| Fresno Air Terminal | 06/23/00 | 0.0 | 0.0 | 0.2 | -0.9 | -0.2 | 0.2 | 0.5 | 8 | 1.2 | -3.6 | Delta-T was measured with the site sensor lid on, which may have caused variation between the audit standard. |
| Grass Valley | 06/22/00 | 0.0 | 2.0 | -1.5 | 5.0 | 0.0 | | -0.5 | -40 | 0.2 | -1.7 | |
| Lagrange (Waterford) | 06/26/00 | 0.0 | 1.0 | -0.6 | 2.5 | 0.4 | 0.27 | 0.3 | -16 | 0.9 | 1.0 | Delta-T was measured with the site sensor lid on, which may have caused variation between the audit standard. |
| Livermore | 06/13/00 | 0.0 | 5.0 | 1.0 | 4.0 | 0.1 | | 1.0 | -38 | 1.2 | | The wind direction cross arm orientation exceeds the criteria. The crossarm was re-aligned following the audit. |
| Livermore | 08/17/00 | -0.2 | 0.5 | 0.8 | 1.0 | 3.1 | | -0.7 | -0.07 (ly/min) | | | One point on the ambient temperature audit did no pass criteria. The technician indicated the sensor would be replaced or repaired. |
| Pleasant Grove | 06/29/00 | 0.0 | 0.0 | 3.3 | -3.6 | 0.2 | 0.1 | -1.1 | -20 | -0.1 | -6.4 | The maximum linearity exceeds criteria, however the total difference does not exceed the ±5° criteria. |
| Redding | 06/19/00 | 0.0 | 1.0 | 0.8 | 3.0 | -0.2 | | 0.7 | 25 | -0.5 | -8.2 | |
| Richmond | 06/28/00 | 0.0 | 0.0 | 3.6 | -4.5 | -0.3 | | 0.5 | -53 | -0.4 | -2.7 | The maximum linearity exceeds criteria, however the total difference does not exceed the ±5° criteria. Two solar radiation points are just outside the criteria. The overall results look reasonable. |
| San Martin | 06/12/00 | -0.1 | -6.0 | -2.0 | -6.0 | 0.1 | | -0.8 | | 2.1 | | The wind sensor orientation was outside criteria causing the maximum difference to exceed criteria. The sensor was re-aligned following the audit. |
| Sunol | 08/18/00 | -0.2 | -2.0 | 0.0 | -2.0 | -0.2 | | -0.8 | | 2.1 | | |
| Tracy | 06/14/00 | 0.1 | 6.0 | 2.9 | 7.2 | -0.1 | | 0.5 | 81 | 0.3 | | The wind sensor orientation was outside criteria causing the maximum difference to exceed criteria. The sensor was re-aligned following the audit. The solar radiation audit exceeds criteria. It appears that an incorrect factor was used in the data logger program. |

## Bodega Bay

Problem: The data logger program was found to be incorrect during the audit. Variables affected included solar radiation and pressure.

Resolution: Correct factors were programmed into the logger during the audit and the accuracy of the affected sensors was verified to be within the audit criteria.

Problem: Approximately 20 meters to the east of the meteorological tower is a wall that is about 4 meters high. While the distance to the obstruction is closer than the recommended 10 times the height of the obstruction (40 meters), most of the data will not be affected as the prevailing wind direction is from the west to northwest. However, data when winds are from the east may have the indicated wind speeds and any calculated turbulence parameters affected.

Resolution: The above comment should be taken into consideration during analysis.

**Carrizo Plain**

Problem: There is a group of trees ~10 meters in height approximately 50 meters west of the meteorological tower. The height/distance is less than the recommended distance to maintain 10 times the height of an obstruction. As a result of this obstruction, the wind speeds under westerly winds may be somewhat reduced and average wind directions may also be influenced.

Resolution: The above comment should be taken into consideration during analysis.

**Chico**

Problem: Approximately 30 meters to the north-northwest of the meteorological tower is a large wastewater treatment tank that is approximately 5 meters tall. This height/distance is less than the recommended distance to maintain 10 times the height of an obstruction. As a result of this obstruction, the wind speeds under northerly winds may be somewhat reduced and turbulence calculations may be affected. The average wind direction may also be influenced during northerly winds.

Resolution: The above comment should be taken into consideration during analysis.

**Fresno Air Terminal**

Problem: The temperature difference (delta temperature) audit had results outside of the ±0.1°C audit criteria. The difference between the probes was verified by a side-by-side comparison performed by the site operator. It is recommended a more detailed calibration be performed to establish more accurate calibration curves for each temperature sensor. These curves will be needed to achieve the EPA recommended and CCOS data quality objective of a tracking within ±0.1°C.

Resolution: It was indicated by the site operator that temperature difference was not intended to be one of the provided variables and its inclusion was over and above the data provision scope. The accuracy of sensors may therefore not meet the stringent EPA recommended criteria. Furthermore, it is unclear if the solar aspirated shields meet the EPA specifications for flow rate. Analyses of the temperature difference data should take this fact into account.

**Grass Valley**

No problems noted.

**Lagrange (Waterford)**

No problems noted.

**Livermore (Radar profiler site)**

Problem: Upon arrival at the site it was noted that the solar radiation sensor was in the shadow of the tower.

Resolution: The technician indicated that the boom was not moved back to the 180° position following the last servicing of the tower when it was lowered to work on the wind instrumentation. The boom location was corrected following the audit.

Problem: The wind direction mounting boom was oriented to 5 degrees with respect to true north.

Resolution: The orientation of the boom was corrected following the audit.

Problem: The temperature aspirator, while oriented to the north, was mounted sideways allowing the sun to enter the shield during the late afternoon.

Resolution: The mounting was corrected during the audit.

**Livermore (Sodar site)**

Problem: The site temperature sensor responded approximately 3° high during the "cold" water bath audit. Additionally, it appears the slope of the sensor response curve has either changed or is incorrect, as indicated by the results of the audits at the two other temperatures. The response does not meet the USEPA recommended ±0.5° criteria. It is recommended the sensor be repaired, recalibrated, or replaced.

Resolution: The technician indicated the sensor would be replaced or repaired though the date of the repair is not known.

**Pleasant Grove**

No problems noted.

**Redding**

Problem: Approximately 30 meters to the north-northwest of the meteorological tower is a large tree that is approximately 15 meters tall. This height/distance is less than the recommended distance to maintain 10 times the height of an obstruction. As a result of this obstruction, the wind speeds under northerly winds may be somewhat reduced and turbulence calculations (standard deviation of the wind direction, sq) will be invalid. The average wind direction may also be influenced during northerly winds.

Resolution: The above comment should be taken into consideration during analysis.

**Richmond**

No problems noted.

**San Martin**

Problem: Approximately 30 meters to the north-northwest of the meteorological tower is a large tree that is approximately 15 meters tall. This height/distance is less than the recommended distance to maintain 10 times the height of an obstruction. As a result of this obstruction, the wind speeds under northerly winds may be somewhat reduced and turbulence calculations (standard deviation of the wind direction, sq) will be invalid. The average wind direction may also be influenced during northerly winds.

Resolution: The above comment should be taken into consideration during analysis.

Problem: The temperature aspirator was located on the south side of the tower with the aspirator aimed into the tower (north). The temperature sensor will be susceptible to artificial heating from reflections from the tower.

Resolution: The aspirator was moved to the north side of the tower following the audit.

Problem: The temperature and relative humidity sensors are located near unrepresentative terrain. About 2 meters to the north of the tower is very low cut grass and gravel. This may tend to bias temperatures slightly high under low wind speed daytime hours. It would be best to locate the tower further to the south to be more in the middle of the grass field.

Resolution: The location of the sensor was left as-is as it would have required movement of the tower. The above comment should be taken into consideration during analysis.

Problem: While the wind direction crossarm was oriented to true north, the sensor alignment to the cross arm was off by 6°. This caused a total alignment error outside of the audit criteria of ±5°.

Resolution: Following the audit, the sensor housing was realigned to true north.

Problem: A change was made to the data logger program that altered the relative humidity response. Prior to the change, the sensor did not meet criteria. After the change the response was well within criteria. The changes made were not suppose to change the calibration but, in fact, did bring the system within criteria. The temperature audit was performed prior to the program change and the system accuracy should be verified to assure the calibration did not change.

Resolution: The operator indicated that the temperature system was verified to be responding properly following the change in the data logger program.

**Sunol**

No problems noted.

**Tracy**

Problem: The orientation of the wind direction crossarm was 357°. When combined with the sensor alignment to the crossarm the orientation, the error was outside of the ±5° audit criteria.

Resolution: The orientation was corrected following the audit.

Problem: To the southwest are trees at a distance of about 20 to 30 m. The height of the trees is about 20 meters. These trees will form a block to the flow under southwest winds and the wind speed and any turbulence parameters will be affected by the blockage. There may also be some altering of the measured wind directions with south to west flows.

Resolution: The above comment should be taken into consideration during analysis.

Problem: The solar radiation sensor responded approximately 15% high, which at the observed readings during the audit, corresponded to about 150 W/m2 higher than the audit sensor. It appears that a potentially incorrect factor has been programmed into the data logger. The correct factor should be determined and entered into the data logger.

Resolution: It was indicated by the operator that solar radiation was not a required deliverable and was not submitted in the final database.

# SECTION 3

# UPPER-AIR METEOROLGY

As part of the CCOS QA effort, all remote upper air meteorological monitoring systems were subjected to an external audit of their operation. It was decided during planning that QA resources would best be utilized by concentrating on the system audit and not conducting more expensive performance audits using rawindsonde measurements, which have traditionally been conducted for upper air monitoring systems. This decision was based to a large degree on experience obtained during the CRPAQS upper air audits, where it was determined that problems noted using the rawinsonde measurements could be identified just as well through review of the data and comparisons with less expensive, more qualitative measurements, such as pibals and visual observations of meteorological conditions.

## 3.1 DESCRIPTION OF AUDIT EQUIPMENT

### Garmin 12-Channel Global Positioning System (GPS)

A Garmin GPS-12 or Etrex Summit 12-channel GPS was used to verify the sodar and radar wind profiler antenna alignment. The antenna orientation was measured by pacing off the pointing direction several times to achieve a repeatable bearing. A description of the method is provided in Baxter (2001).

### Brunton Pocket Transit

In instances where an inadequate distance was available to use the GPS method of alignment check, a Brunton Pocket Transit model F5007LM was used to verify the orientation of the antennas. The transit is tripod mounted and can be read to an accuracy of approximately ±0.5°. Magnetic readings were corrected for magnetic deviation from true north using solar sitings. Details on the solar method are provided in Baxter (2001)

### Brunton Inclinometer

A Brunton model CM360 Clinomaster was used to measure the inclination angles of obstructions around the radar and sodar antennas. This inclinometer was also used as one of the siting devices for tracking pilot balloons for wind measurement.

### Pro SmartLevel

A 24-inch Pro SmartLevel was used to check the level of the antennas and RASS sources. The SmartLevel is a digital level with a direct readout, in degrees, of the tilt angle of the surface it is placed on. The resolution of the level is 0.1° with an accuracy of about ±0.2°.

### Integrating Sound Level Meter

A Realistic model 33-2055 digital integrating sound level meter was used to measure the background noise levels at the time of the audit for the sodar sites, and relative RASS transmit levels. The sound level meter has automatic averaging and minimum and maximum level determination on both the A and C weighted scales. The noise level measurements are intended to give a general indication of the noise levels present and are made on the A weighting scale. This sound level meter meets ANSI S1.4 Type III specifications.

### Acoustic Pulse Transponder (APT)

The APT is a microcomputer based system for auditing sodars that is programmable for the number of pulses, pulse duration, pulse frequency, and timing delays. The system detects the transmit pulse from the sodar antenna and retransmits a preprogrammed pulse sequence. The pulse sequence consists of one or more sequential frequencies at specific timed intervals that represent known frequency offsets from the sodar system. The frequency offsets and timing of the pulses simulate wind speeds along each of the sodar component axes. The APT system is described in Baxter (1994).

### MiniSodar Antenna Array Test System

A Motorola transducer, similar to the ones used in the AeroVironment model 4000 MinSodar antenna system, was used to test the output level from each of the antenna transducer elements. Voltage measurements from the transducer were measured with a Fluke model 87 digital multimeter.

## 3.2 SYSTEM AUDIT PROCEDURES

The sodar, radar wind profiler or RASS system audit is divided into several tasks. A description of each task is provided below:

The antenna and controller interface cables are inspected for proper connections. Antennas and enclosures or clutter fences are inspected for structural integrity. The orientations of the antennas are checked using a GPS or a tripod mounted magnetic transit with the observed magnetic readings corrected to true directions using the local magnetic declination. The magnetic orientation measurements are also verified using solar azimuth measurements and latitude and longitude information obtained from a handheld GPS. The levels of the antennas are measured using a Pro SmartLevel. Measurements are made in at least two directions on the bottom of the antenna array’s support structure. For the multiple antenna systems the inclination angle is also measured and compared to the software setting. The results of the measurements are compared to the audit criteria of ±2° for orientation and ±0.5° for level.

A vista table is prepared that documents the surroundings of the site. The table identifies potential reflective sources for the radar or sodar signal, as well as potential active sources that could generate interference. The table also provides a description of the view in 30-degree increments around the antenna, including the elevation angle and estimated distance to potential sources. Pictures are taken in 45° increments looking from the antenna to further document the vista.

An evaluation of the site characteristics is performed. Passive and active noise sources are identified and noted to evaluate their impact on the sodar's or radar's ability to separate the return pulses from the background noise. Passive sources are objects that may reflect the pulse and contaminate the return spectra with what appears to be near-zero wind speeds. These sources include buildings, trees, nearby towers, road traffic, birds, etc. Active sources generate their own noise such as air conditioners, fans and industrial complexes for sodars and radio transmitters for radars. Low-level active white noise sources are not generally a problem except to reduce the maximum altitude. Active noise sources in the frequency spectrum of the sodar or radar operations may affect the operations. For the sodar, general sound levels are measured using an integrating sound level meter and measuring levels, in dBA, in at least the four cardinal directions. A spectral analysis of the background noise is also performed to determine if there are significant sources within the operating range of the sodar. A radio scanner is used to listen for signals in and around the operating spectrum of the radar.

In addition to the evaluation of the noise spectrum above, where possible, a system check is performed with the system "listening only," i.e., without transmitting a pulse. The results of this check should produce no measured winds, or winds with very low reliability. If winds are reported at any level, then there is probably an active noise source in the area that is generating frequencies in the operational region of the sodar or radar.

## 3.3 PERFORMANCE AUDIT PROCEDURES

As indicated above, the primary QA resources for the radar wind profiler and RASS focused on the system audit, with the performance audit providing a more qualitative assessment of the system performance. The performance audit procedures employed were a subset of those provided in Meteorological Monitoring Guidance for Regulatory Modeling Applications (EPA-454/R-99-005), February 2000 (EPA, 2000) and the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV (EPA, 1995). Because of the uniqueness and developmental stage of some of the sodars, a more detailed performance audit was performed on each of these sensors using procedures consistent with the most recent EPA guidance (EPA 2000). The more detailed analyses were needed to assure the systems were working properly.

### Sodars

The performance audit of the sodars typically consisted of two elements. The first was by comparison with simulated winds from an Acoustic Pulse Transponder (APT), and second, by comparison to independent wind measurements. The latter comparison to the independent wind measurements is needed if the sodars are of the phased array variety. This comparison verifies the beam steering is appropriate by assessing the reasonableness of the data.

Unlike conventional sensors where known wind speeds and directions can be input directly to the sensor through various rotational methods, the acoustic system relies on the measurement of time and frequency shift of the backscattered acoustic pulse. The only means of truly providing a known input is through the introduction of fixed audio frequencies at known times. The frequency shift will correspond to a Doppler shift introduced by winds to or from an antenna. The timing of the simulated return will represent a known altitude based on the speed of sound. These simulations of the Doppler shifted signal are performed using the APT.

As a final check of the sodar data, data collected during several days prior to the audit are reviewed to establish the internal consistency of the values. As this is a qualitative check, there are no fixed evaluation criteria. The goal is to evaluate the following:

Data reliability or quality codes for consistency

- Measured vertical intensity values for detection of potential fixed echoes
- Vertical profile of the individual wind components for detection of potential fixed echoes and consistency
- Vertical profile of the calculated vector winds for internal consistency
- Methods used to create hourly values from sub hourly intervals

**Radar Profilers**

Two general sets of performance audit procedures were used that were specific to given sites. If the site was equipped with a collocated sodar, the profiling system was audited by first establishing the on-site sodar as an audit device and then using the sodar data collected to compare to the radar profiler data. Sites with a radar profiler only were audited using another form of measurement, such as visual observations of cloud movement or an optically tracked pilot balloon (pibal). If a pibal was released then the collected data were compared to the radar data to determine if there was reasonable agreement between the two.

As a final part of the audit of the radar profilers, data from several days prior to the audit were reviewed for internal consistency. This type of review checked indicated flags for data reliability or quality codes for consistency, individual component intensity values to identify potential reflections, and the vertical profiles of the components and resultant values for internal consistency both in space and time.

**RASS**

Data collected by the RASS systems were audited through a review of collected data for internal consistency. Approximately five days of data prior to the audit were evaluated for reasonableness and consistency in both space and time.

## 3.4 PERFORMANCE AUDIT CRITERIA

The criteria used to evaluate the audit results for the upper air audits is shown in Table 3-1.

Table 3-1. Upper Air Performance Audit Critiera.

| Measurement Variable | Audit Criteria |
|---|---|
| Radar and Sodar Horizontal Wind Speed and Direction | Antenna alignment to true -- ±2°<br>Antenna level and/or zenith -- ±0.5°<br>Sodar APT response -- ±0.2 m/s for component, ± 1 gate for altitude<br>±0.5 m/s for vector speed, ±5° for vector direction |
| RASS Virtual Temperature | RASS element level -- ±1° |

## 3.5 AUDIT RESULTS

Appendix A presents the individual, complete audit reports for each site. Table 3-2 summarizes the dates of the audits and the CCOS observables audited. Table 3-3 presents a summary of the alignment and level audit results.

Table 3-2. Upper-Air Meteorology Audit Dates And CCOS Observables.

| Site | Operator | Audit Date(s) | Radar Winds | RASS Tv | Sodar Winds | Comments |
|---|---|---|---|---|---|---|
| Angels Camp (New Melones Lake) | NOAA/ETL | 06/27/00 | | | ● | |
| Angiola | NOAA/ETL | 06/25/00 | ○ | ○ | ● | Radar/RASS audited as part of CRPAQS in winter |
| Arbuckle | NOAA/ETL | 06/21/00 | ● | ● | | |
| Bodega Bay | STI | 06/08/00 | ● | ● | | |
| Carrizo Plain | NOAA/ARL | 05/18/00 | ○ | ○ | ● | Only the orientation and level of the radar could be audited, the system was not yet operational. |
| Chico | NOAA/ETL | 06/20/00 | ● | ● | | |
| Dublin | T&B | 08/19/00 | | | ● | |
| Fresno Air Terminal | NOAA/ETL | 06/23/00 | ● | ● | ● | |
| Grass Valley | NOAA/ETL | 06/22/00 | ● | ● | | |
| Lagrange (Waterford) | NOAA/ETL | 06/26/20<br>08/16/00<br>12/09/00 | ● | ● | ● | Multiple visits were made to the site to reaudit the sodar, because of changes made to the sodar software. |
| Livermore (radar) | STI | 06/13/00 | ● | ● | | |
| Livermore (sodar) | T&B | 08/17/00 | | | ● | |
| Pittsburg (Los Medonas) | PG&E | 08/21/00 | | | ● | |
| Pleasant Grove | NOAA/ETL | 06/29/00 | ● | ● | | |
| Redding | NOAA/ETL | 06/19/00 | ● | ● | | |
| Richmond | NOAA/ETL | 06/28/00 | ● | ● | ● | |
| San Martin | STI | 06/12/00 | ● | ● | | |
| Sunol | T&B | 08/18/00 | | | ● | |
| Tracy | STI | 06/14/00 | ● | ● | | |

Notes: ● Audit performed
○ Variable measured but no audit performed

Table 3-3. Upper-Air Meteorology Alignment And Level Audits Summary.

| Site | Auidt Date(s) | Maximum Error (°) | | | | | Comments |
|---|---|---|---|---|---|---|---|
| | | Radar | | RASS | Sodar | | |
| | | Align. | Level | Level | Align. | Level | |
| Angeles Camp (New Melones Lake) | 06/27/00 | | | | 0, -1 | 0.9, 0.1 | |
| Angiola | 06/25/00 | | | | 0 | 0.0, 0.0 | |
| Arbuckle | 06/21/00 | 0, 0 | 0.5 | 1.0 | | | |
| Bodega Bay | 06/08/00 | -1 | 0.1 | 1.5 | | | RASS source on NW side of array was out by 1.5 degrees |
| Carrizo Plain | 05/18/00 | | 0.1 | | 2 | 0.1 | The radar and RASS were not operational until May 31, 2000 and no performance review was performed. |
| Chico | 06/20/00 | 1, -1 | 1.1 | 2.4 | | | The SE radar antenna was out of level by 1.1 degrees. The RASS source north of the array was out of level by 2.4 degrees. |
| Dublin | 08/19/00 | | | | 0 | 0.2 | |
| Fresno Air Terminal | 06/23/00 | -1, -1 | | 1.0 | -1, 0 | -0.3, -0.5 | |
| Grass Valley | 06/22/00 | 2, 2 | 0.2 | 1.0 | | | |
| Lagrange (Waterford) | 6/26/00<br>8/16/00<br>12/9/00 | 1, 1 | 0.5 | 1.4 | 1, 0 | -4.0, 0.0 | 3 RASS sources were out of level, with the worst being out by 1.4 degrees. The east-facing sodar antenna was out of level by 4 degrees. |
| Livermore (Radar) | 06/13/00 | 3 | 0.1 | >1.0 | | | Three of the four RASS sources were out of level >1.0 degree. |
| Livermore (Sodar) | 08/17/00 | | | | 0 | 1.0 | The SW facing transducer zenith angle was 1 degree out from what the system indicated. |
| Pittsburg (Los Medonas) | 08/21/00 | | | | 0 | 0.2 | |
| Pleasant Grove | 06/29/00 | 1, 0 | 0.9 | 1.6 | | | All RASS sources were out of level, with the worst being out by 1.6 degrees. |
| Redding | 06/19/00 | 0, 0 | 0.9 | 1.2 | | | The RASS source on south side of array was out of level by 1.2 degrees. |
| Richmond | 06/28/00 | 0, 1 | 0.5 | NA | -1 | 1.6 | RASS source levels were not verified. The northwest facing sodar antenna was out 1.6 degrees from what the system indicated. |
| San Martin | 06/12/00 | 0 | 0.2 | 2.4 | | | The RASS source south of the array out of level by 2.4 degrees. |
| Sunol | 08/18/00 | | | | 3 | -0.6 | The sodar alignment was measured to be out by 3 degrees from what the system indicated. The north facing antenna was measured to be -0.6 degrees out from what the system indicated. |
| Tracy | 06/14/00 | 1 | 0.2 | 2.5 | | | All RASS sources were out of level, with the worst being out by 2.5 degrees. |

The following sections discuss problems or issues noted at specific sites, including their resolution.

**Angels Camp (New Melones Lake) Sodar**

Problem: One beam of the sodar appeared to have a faulty driver or another problem that was causing a ringing in the lowest several range gates. This ringing was at a frequency offset from zero. At the time of the audit the sodar was not collecting valid data.

Resolution: It was indicated from the operator that faulty driver was replaced and the system made operational. The date of repair is not known.

Problem: The zenith angle of the west beam of the sodar was measured at 21°. The software setting was 20°, which is outside the audit criteria of ±0.5°.

Resolution: The system settings were corrected following the audit.

Problem: At the time of the audit, the sodar was calculating the wind speeds incorrectly. This was also demonstrated several days prior with the audits at the Fresno and Waterford sites, with all systems using the same software. It was indicated that the radial velocities are being recorded and can be later reprocessed. New software was anticipated to be ready for the sodar within one week; however, delays pushed that date back further.

Resolution: New software was installed on the sodar subsequent to the audit. The exact date of installation is not known.

**Arbuckle Radar Profiler**

Problem: A review of the previously collected radar data at the site from June 16 through June 21 was performed and showed what may be internal inconsistencies in wind speed and direction below 1 km. There were a number of hours of what may be either a low level jet stream, or bird contamination. Northerly winds were observed with speeds in excess of 20 m/s. The distinction between these two is crucial since the identification of a low level jet stream is very important.

Resolution: The data should be carefully reviewed to assure values are either left in the database as valid or appropriately flagged.

Problem: A review of previously collected RASS data at the site was performed and showed periodic internal inconsistencies in the data. Data collected from June 16 shows numerous signals limited to ~300 meters. This is most likely related to the "high" wind speeds identified above. If the speeds are realistic then that may account for the loss of the RASS signal. The reason for this loss of data should be investigated and resolved.

Resolution: As in the wind data, the data should be carefully reviewed to determine the cause of the data loss. This will be for informational purposes only since there is most likely no way of recovering data to higher altitudes if it was lost due to high winds. It will be helpful to understand this to aid in the validation of the data.

### Bodega Bay Radar Profiler

Problem: The RASS source on the southeast side of the antenna array was not working. This will limit the altitude range of the instrument. The RASS source should be repaired as soon as possible.

Resolution: The RASS source was repaired subsequent to the audit. The exact repair date is unknown.

Problem: Ground clutter was noted on the screen spectral display in the lowest several range gates of the radar (up to about 300 meters). It is suspected the buildings to the southeast of the antenna and the meteorological tower at about 250 to 300 meters to the southeast may be causing the reflections. A quick review of the data showed the consensus data was affected in the lowest range gates.

Resolution: The above comment should be taken into consideration during the data validation.

Problem: For the most part, the radar profiler data shows good internal consistency with the exception of occasional missing or erroneous winds in the first couple of range gates. The suspected source of these problem data is most likely the potential clutter sources identified above.

Resolution: Validation of the data should include a look at the first several range gates with attention to inconsistencies in the vertical profile that may indicate clutter interference.

### Carrizo Plain Radar Profiler and Sodar

Problem: The radar profiler and RASS systems will not be operational until May 31, 2000. It was indicated that NOAA/ETL will set up all radar/RASS parameters consistent with their sites. It was recommended comparisons be made between the radar and sodar after the systems were fully operational.

Resolution: The radar was made operational following the audit and the NOAA/ARL compared data sets to verify consistency.

Problem: It had been two years since an array check had been performed on the sodar. Previous checks have shown that there are potential wiring problems causing some elements to not fire. It was recommended the array be checked again to confirm the problem and identify if more elements had been dropped.

Resolution: The operator later indicated that three more tests had been performed during the installation of the sodar and confirmed that 8 of the 120 elements were not functioning due to broken signal lines. In their evaluation they indicated that the sodar would still acquire reliable data even if 10% of the transducers did not function (assuming they are randomly distributed). A review of the transducer test data did show the faulty elements to be scattered randomly throughout the array.

Problem: It was noted that the sodar header information had incorrect latitude, longitude and time zone information, which may confuse the data processing steps.

Resolution: The above comment should be taken into consideration during the data processing and validation.

Problem: No performance check was conducted on the radar, since a comparison with the sodar profiler will demonstrate the operation of the radar. It was recommended that as soon as the radar profiler was operational the data from both the radar and sodar be compared for consistency.

Resolution: Subsequent comparisons were performed by NOAA/ARL.

**Chico Radar Profiler**

Problem: All RASS sources with the exception of the source on the north side were within criteria. The source on the north side was out of level by about 2.4°. This could potentially limit the altitude of the temperature measurements.

Resolution: The source was leveled during the audit.

Problem: The inclination of the southeast-facing antenna was measured at 16.1°, exceeding the criteria of 15° ± 0.5°.

Resolution: The inclination of the antenna was adjusted to 15° at the time of the audit.

Problem: It should be noted that erroneous winds are reported in the low mode above 800 to 1000 meters.

Resolution: Data above the 800-meter level should be used from the high mode only.

Problem: A review of the previously collected RASS data was performed and showed generally reasonable values. Occasional erroneous data appeared near the top of the sounding, but the frequency of occurrence was limited and the points should be easily recognized and appropriately flagged during the data validation.

Resolution: The above comment should be taken into consideration during data processing and validation.

**Dublin Sodar**

Problem: There are significant reflections from the cell towers and trees on the hillside. The reflections are present between about 70 and 95 meters, inclusive, and seem to affect primarily the U component. The result of the reflections is a biasing of winds toward zero in this component. This, in turn, affects the calculated resultant wind speeds and directions in that range. An independent wind comparison was made using an anemometer kite to look at the vertical profile and compare it to the sodar wind profile. The auditor was uncertain if the wind speeds actually decreased with height, as indicated by the sodar. The measured profile from the kite system did show an increasing profile during a similar time when the sodar showed decreasing wind speeds. This verified the effect of the reflections (described above) on the data. While alternate rotation angles were recommended, it was indicated by the operator that other angles were attempted and the current setup appeared to be the best compromise. Appropriate validation and flagging of the data from the affected region will therefore be required.

Resolution: The operator indicated data from the affected levels will be invalidated.

Problem: The indicated sodar zenith angles were 15 degrees. This is different from other model 4000 sodars that have been audited but may be related to the ~4800 Hz transmit frequency that is being used. The zenith angle should be verified with the manufacturer and, if found to be incorrect, corrections made during the post processing of the data.

Resolution: The zenith angle was found to be calculated from the system and was correct.

**Fresno Air Terminal Radar Profiler and Sodar**

Problem: The site, while it appears reasonably good for surface and radar/RASS measurements, is not very good for sodar operations. Daytime altitudes will be limited to a couple hundred meters, at best, and nighttime measurements will marginal due to reflective sources. It is the auditors understanding that the sodar does not incorporate any fixed echo rejection algorithms and will therefore be very susceptible to reflective interference, which will occur at night when the other active noise sources are diminished. Movement of the sodar to another location is recommended.

Resolution: No change in the sodar location was made during the summer CCOS program. Thus data will be limited from the sodar. The system was replaced with a minsodar for the winter program.

Problem: The radar at the site is a 449 MHz version that is designed for a greater altitude range in both winds and temperature. The maximum range setting for the winds is 10.4 km and for the RASS, 4.4 km. To accommodate the higher ranges the resolution of the measurements is less. The gate spacing for winds is 213 m with the first gate reported at 413 m. The gate spacing for the RASS is about 210 m with the first gate reported at 428 m. Given the problems found with the sodar operation at this site it is unclear if useable wind data will be obtained in the layer up to the first gate of the radar.

Resolution: As indicated above, no change in the sodar location was made, thus data in the lowest several hundred meters will be limited.

Problem: Upon arrival at the site the sodar was only firing on one beam. A blown fuse was found and replaced. A review of the sodar data collected during the previous several days showed very noisy data that did not make much sense. It is suspected much of the problem was due to the one antenna not firing. The data from that antenna would be very noisy since there was no transmit pulse being fired. The site check procedures should incorporate a routine check of the physical transmit properties of the system.

Resolution: More careful attention was paid to the sodar, but due to the surrounding active noise sources the data are limited.

Problem: A review of the collected RASS data showed generally reasonable results up to an altitude of about 4 km. However, there were several instances of clearly erroneous data where the temperature in the profile did go isothermal in the upper regions, which is indicative of radio interference.

Resolution: The operator is aware of the problems and is taking into account the interference problems in the data processing and validation.

Problem: The response of the sodar to the known inputs provided ambiguous results. In review of the code for the calculations an error was found in the incorporation of the antenna zenith angles. The specified zenith angle for antenna 1 was used for both of the antenna calculations. Additionally, the wind speed calculation did not appear to be correct. The code for the sodar system should be reviewed with particular attention to the handling of different zenith angles for each antenna and the actual calculation of wind speed. A change of the system configuration to simple 90 degree axes and similar zenith angles on the antennas still did not reproduce accurate wind speed calculations that were simulated by the Acoustic Pulse Transponder (APT). It is recommended the software coding for the wind speed calculations be carefully reviewed and corrections made to any problems that are found. When these corrections are made the systems using the software should be audited again using the APT.

Resolution: Multiple revisions to the software were made subsequent to the audit with the final versions not installed until later in the fall. The exact date of installation is not known.

Problem: The site is located at the Fresno airport adjacent to the Air National Guard facility and airport runways. There are some significant audio sources that do interfere with the sodar operations. The noise problems for the sodar are particularly bad during the daytime due to noise from aircraft at the airport. A quick scan of the audio spectrum showed significant background noise below 1000 Hz. General noise levels were found to be 53 to 55 dBA when no aircraft were nearby, i.e. at the quietest times. The noise was generally from other operations and air conditioners. Given the large magnitude of low frequency noise, the sodar may benefit by operations at a higher frequency.

Resolution: No changes in the operational frequency of the sodar were made.

Problem: The site is surrounded by buildings and structures that can act as passive (reflective) noise sources for both the radar and sodar. Audible reflections could be heard from the sodar transmit pulse that could bias the data toward lower wind speeds. At night the reflective sources will make the collection of useable data questionable unless the sodar has the ability to remove the effects of the reflective sources. The processing of the sodar data should review the data on a component basis to invalidate the levels affected by reflections. The components reviewed must be along the antenna axes in order to perform this type of validation. Some of the reflections could be seen in the sodar backscatter data.

Resolution: The above comment should be taken into consideration during the data processing and validation.

Problem: Of the five days reviewed, the radar profiler data for most part look reasonable. However, there were periods when there were obvious erroneous winds. It is suspected that these data may be due to radio or other interference. Some RF noise sources that can be seen on the spectral display from the radar. The radar frequency is shared with amateur radio communications and there are numerous transient signals that could contaminate the data. Care should be exercised in the data validation to assure erroneous data are appropriately flagged in the database.

Resolution: The above comment should be taken into consideration during the data processing and validation.

Problem: RASS Data collected in the past five days looked reasonable. However, there were several instances where a jump to significantly higher and unrealistic temperatures was observed in the upper portions of the sounding. It is suspected that some radio interference from other voice transmitters in the region caused this problem. Validation of the RASS data should look for, and recognize this type of problem to keep the erroneous data from entering the final database.

Resolution: The above comment should be taken into consideration during the data processing and validation.

**Grass Valley Radar Profiler**

Problem: With the exception of periodic spurious signals, the RASS data look reasonable. In review of five days of RASS data the spurious data occurred in the afternoons and showed up at levels above about 500 meters. It appears there may be radio interference that affects the data. The data should be carefully validated to assure the erroneous data are flagged appropriately.

Resolution: The above comment should be taken into consideration during the data processing and validation.

**Lagrange (Waterford) Radar Profiler and Sodar**

Problem: During the audit on June 26, three of the four RASS sources were found out of level with each exceeding the level criteria of ±1°. This can potentially limit the altitude of the temperature measurements.

Resolution: The site operator re-leveled the RASS sources after the audit.

Problem: During the audit on June 26, the sodar antennas were located adjacent to the RASS sources and could receive "idle" noise from the RASS drivers. It was suggested that the antennas be moved away from the sources to minimize this type of interference. The antennas were moved subsequent to the August 16 reaudit and prior to the December 9 audit for the CRPAQS program. During the brief site review audit on December 9, it was noted that the antennas were moved away from the RASS sources but were now closer to trailer air conditioner and in direct line with buildings within 150 meters of the antennas. A temporary shield was placed around the air conditioner to help reduce the audible noise. However, the nearby buildings were producing significant reflections in the sodar data below 150 meters obscuring most atmospheric echoes. Also noted during the review was that the east facing sodar antenna (indicated at the site as 62°) was found to be pointed at 66°, which was outside of the audit criteria of ±2°. Because it was understood by the auditor that the sodar did not have fixed echo rejection or fixed frequency rejection, it was recommended that either the antennas be moved again, or appropriate noise shields be constructed.

Resolution: The exact date of antenna movement is not known, however, following the move, the data below 150 meters is questionable and the processing and validation should reflect this. It is not known if the antenna was moved again following the December audit.

Problem: At the time of the initial audit on June 26 the sodar was calculating the wind speeds incorrectly. This was also demonstrated several days prior with the audit at the Fresno site, and both systems were using the same software. However, it was indicated that the radial velocities are being recorded and can be later reprocessed. New software was anticipated to be ready for the sodar within one week; however, delays pushed that date back further. On August 16 a reaudit of the sodar was performed and improved responses to known input values were obtained. However, wind speed responses were still lower than expected. The reasons for the differences were not clear but it appeared to be due to the peak detection algorithm and the ability to recognize and calculate the peak at the signal levels being input by the audit Acoustic Pulse Transponder into the sodar. Several simulations were attempted but with no change in the results. Discussions were held with NOAA and while the auditor does not completely understand the signal processing being performed by the sodar, the data being calculated appear much more reasonable than the original software. It is recommended that comparisons be made between the radar and sodar in the range of overlap (lowest radar range gates). In this range there should be reasonable agreement in the sodar directions and speeds. If not, then further exploration into the sodar processing should be performed.

Resolution: It was indicated by NOAA/ETL that comparisons of the data following the final version of the software installation showed reasonable agreement. Additionally, it was indicated that the moments data collected prior to the software installation would be reprocessed using the correct algorithms to calculate the winds.

**Livermore Radar Profiler**

Problem: Three of the four RASS sources were out of level by more than the criteria of ±1°. The only source within level was the one on the northwest side of the antenna (along the indicated 331° beam). This may limit the altitude of the temperature measurements.

Resolution: The level of the sources was corrected following the audit.

Problem: The audit orientation of the array was found to be 334°. The indicated orientation was 331°, which was outside the criteria of ±2°.

Resolution: The orientation was verified by the site technician and the software settings in the radar corrected to the appropriate value.

Problem: A release of a pilot balloon was performed to review the reasonableness of the radar data. On the basis of the balloon release it appeared there was a problem with the wind direction calculations. The balloon was physically seen to travel to the south indicating north winds yet the radar profile showed winds from the south.

Resolution: The wiring of the radar electronics to the antenna was found to be incorrect and was replaced. It was indicated by the operator that the data would be reprocessed to compensate for the wiring problem that altered the expected component directions.

**Livermore Sodar**

Problem: The southwest facing transducer zenith angle was measured at 15°. The software setting was 16 degrees. Rather than adjusting either the software or hardware settings it is recommended data collection continue as-is and when the program is over the data be post-processed to account for the difference in the zenith angle settings.

Resolution: It was indicated the data would be reprocessed to compensate for the zenith angle difference.

Problem: Given the high zenith angle (16°), consideration should be given to vertical velocity correcting the data. A review of the collected data did show daytime vertical velocities reaching a magnitude of 0.4 m/s or greater, which will have a significant effect on the derived horizontal wind speeds and directions. Nighttime vertical speeds were generally less than 0.1 m/s in magnitude and thus would not have much effect on the data.

Resolution: The operator reviewed the data and made the determination that the correction would not be made. The above comment should be taken into consideration during the analysis if periods chosen show significant vertical velocities.

Problem: Noise from airport traffic will affect the altitude performance of the sodar during periods of high activity. It was also indicated that the adjacent paved area will soon have buses and potentially other vehicles parked which may provide a source of reflections. When the vehicles arrive it is recommended the data be reviewed carefully to identify any added reflective sources, and the data appropriately flagged.

Resolution: The above comment should be taken into consideration during the data processing and validation.

**Pittsburg - Los Medonas Sodar**

No problems noted.

**Pleasant Grove Radar Profile**

Problem: The level of all RASS driver sources were within criteria. However, all of the RASS dishes were out of level by approximately 1° to 2.3°. This can potentially limit the altitude of the temperature measurements.

Resolution: All dishes were leveled during the audit.

Problem: A review of data several days prior to the audit revealed a number of erroneous data points in the RASS profiles. Whether this is due to radio interference or reflective sources is not known. The RASS data should be reviewed carefully and erroneous values appropriately flagged.

Resolution: The above comment should be taken into consideration during the data processing and validation.

**Redding Radar Profiler**

No problems noted.

**Richmond Radar Profiler and Sodar**

Problem: One RASS source was not firing. The technician identified a bad solder connection and repaired the RASS during the audit.

Resolution: The above comment should be taken into consideration during analysis.

Problem: The northwest facing sodar antenna had a measured zenith angle of 21.6° with a system specification of 20°. The tilt angle was corrected by the technician during the audit.

Resolution: The above comment should be taken into consideration during analysis.

Problem: The RASS source levels were not verified because there was no ladder onsite.

Resolution: The above comment should be taken into consideration during analysis.

Problem: The site is located on a ridge with several storage tanks. Audible echoes from the sodar transmit pulse could be heard returning from the storage tanks.

Resolution: The above comment should be taken into consideration during analysis.

Problem: Radar data were limited to less than 2000 meters, and at times 1000 meters, most likely due to the relatively low subsidence inversion and very dry air aloft.

Resolution: The above comment should be taken into consideration during analysis.

Problem: Radar data collected several days prior to the audit show a number of instances of significantly higher or unrealistic temperatures in the upper portions of the soundings, above 600 meters. Nearby radio interference is the likely cause of the unrealistic values.

Resolution: The above comment should be taken into consideration during analysis.

**San Martin Radar Profiler**

Problem: Upon arrival at the site there were problems with the radar wind profiler electronics, and the technician had the system down to troubleshoot it. Whether the problem was related to the air conditioner being turned off and potentially getting the system too hot is unknown. The technician indicated the personnel responsible for the trailer operations had been notified to keep the A/C on at all times. Additionally, the radar has been reporting various internal errors and it is uncertain if that is why it is shutting down.

Resolution: It was determined by the end of the audit that the radar computer may have some faulty components and the computer was removed for servicing.

Problem: All RASS sources with the exception of the source on the south side were within criteria. The source on the south side was out of level by about 2.4°.

Resolution: The level was corrected during the audit.

Problem: Significant ground clutter was noted on the screen spectral display in the lowest 600 to 800 meters. The low mode appears to be most affected and the west beam seems to receive the most clutter interference. The clutter sources are probably the adjacent highway and numerous buildings and trees that surround the site.

Resolution: The above comment should be taken into consideration during the data processing and validation.

**Sunol Sodar**

Problem: The time on the sodar computer was set for PDT. It is recommended to change to PST to comply with the Project's time standard of PST.

Resolution: The clock was reset to comply with the project standard.

Problem: The north and east facing antennas were measured at zenith angles of 16.6 and 16.5 degrees, respectively, which differed from the software setting of 16 degrees. The vertical antenna was found to be out of level by 0.6 degrees. All of the angles were at or out of the specified audit criteria of +/- 0.5 degrees. Additionally, the sodar trailer was not level, which probably accounted for each of the sodar angles being out of specification.

Resolution: The sodar trailer was leveled during the audit and the antennas were leveled.

Problem: The sodar antenna rotation angle orientation was measured at 004°. The software setting was 001°, the difference of which is outside the ±2° criteria. It was recommended to change the software settings to the correct angles or let the system continue data collection as-is and when the program is over the data be post-processed to account for the difference in the angle settings.

Resolution: The orientation setting was not changed and the auditor felt no further action was needed since the total error was less than the project criteria of ±5°.

Problem: The data is not vertical velocity corrected. It is recommend the measured vertical velocities be reviewed and determine if post processing to account for the vertical motion is warranted.

Resolution: The operator reviewed the data and made the determination that the correction would not be made. The above comment should be taken into consideration during the analysis if periods chosen show significant vertical velocities.

Problem: The sodar transmit pulse is turned off each night to prevent noise problems with the neighbors. This provides a good opportunity to evaluate the background noise. A review of the previously collected data did show some serious noise contamination where the sodar interpreted valid winds without a transmit pulse. This noise is shown by equal components (N/S and E/W) and consistent speeds at about 10 m/s at 225 degrees. Unfortunately this may be in a quadrant from the prevailing wind direction. This source could contaminate the daytime data when the sodar pulse is turned on. A scan of the adjacent air conditioners showed that both produce spectral lines in the range of the sodar. In order to see the resultant 10 m/s 225 degree wind a frequency of about 1480 Hz would be required. The air conditioner to the west did show a spectral line at about that frequency. Shielding of the air conditioners is needed to prevent the noise contamination.

Resolution: The site operator built an enclosure around the air conditioner to minimize the noise. The exact date of the shield installation is not known but data prior to the installation should take the above comment into consideration during the data processing and validation and appropriately flag the data.

**Tracy Radar Profiler**

Problem: All RASS sources were out of level with each exceeding the level criteria of ±1°. This could limit the altitude of the temperature measurements.

Resolution: The source levels were corrected during the audit.

Problem: The northwest beam of the radar has clutter in gates up to about 300 meters. This seems relatively consistent in both the low and high modes.

Resolution: The above comment should be taken into consideration during the data processing and validation.

# SECTION 4

# CONTINUOUS GASEOUS AIR QUALITY

## 4.1 DESCRIPTION OF AUDIT EQUIPMENT

**Parsons**

Environics Dilution Calibrator

An Environics series 100 mass flow controlled dilution calibrator was used to dilute known concentrations of audit gas with zero air and create known audit concentrations. Zero grade air from Scott-Marrin was used.

Dasibi Transfer Standard

A Dasibi model 1003 PC ozone analyzer was converted to a transfer standard and certified against a primary photometer. The standard is used to assess concentrations of ozone generated by the Environics calibrator.

Super Blend Cylinders

Nitric oxide (NO), sulfur dioxide ($SO_2$) and carbon monoxide (CO) concentrations were generated using National Institute of Standards and Testing (NIST) traceable EPA Protocol cylinders and gas dilution. Zero is used to dilute the concentrations of cylinder gas. Cylinders were provided by Scott Marrin Inc., Riverside, California.

**California Air Resources Board**

The CARB audit system involves mixing high concentration pollutants in compressed gas cylinders with zero air using a gas calibrator. The audit gas is distributed to the air monitoring station's probe inlet through a presentation line. Each component is described below.

Zero Air Supply

The system's zero air supply is composed of an air compressor, pure air generator, methane reactor, and cooling coil. The air compressor provides ambient air to the pure air generator and methane reactor which remove pollutants from the air. A cooling coil is needed because the methane reactor heats the air to over 300 degrees Celsius. The output is a constant supply of zero air at up to 30 liters per minute (LPM). The zero air system is compared to an independent certified ultra pure air source to ensure that the system is operating properly before each audit.

Super Blend Cylinders

Three compressed gas cylinders called super blends, contain high concentration pollutants at specific ratios. When diluted with zero air, the pollutant ratios allow for simultaneous audits of several analyzers. Table 4-1 shows the pollutants in each super blend and their concentrations.

The super blends are purchased certified to +/- 2 percent by the manufacturer, and the CARB's Standards Laboratory recertifies the cylinders each calendar quarter. All certifications are traceable to the National Institute of Standards and Technology (NIST). The super blends allow for audits of the following pollutants:

- Carbon monoxide (CO)
- Sulfur dioxide ($SO_2$)
- Nitrogen dioxide ($NO_2$) through gas phase titration of nitric oxide (NO) with ozone ($O_3$)
- Total hydrocarbons using methane ($CH_4$)
- Non-methane hydrocarbons (NMHC) using hexane ($C_6H_{14}$)
- Hydrogen sulfide ($H_2S$)

Gas Calibrator

A gas calibrator is used to dilute the high concentration pollutants from a super blend cylinder with zero air to target the desired audit concentration levels. The calibrator is capable of generating $O_3$ for audits and gas phase titration of NO to generate $NO_2$.

Audit Analyzers

The audit system uses $O_3$ and CO analyzers to accurately measure the system's audit gas concentrations. The $O_3$ analyzer is a transfer standard that is certified quarterly by the CARB's Standards Laboratory using a NIST standard reference photometer. The CO analyzer cannot be certified as a transfer standard, so it must be calibrated before each audit. Both the $O_3$ and CO analyzers have an accuracy of +/-3 percent.

Calibration Gases

To calibrate the CO analyzer, three compressed gas cylinders are used. A 40 parts per million (ppm) CO cylinder is used to span the analyzer, a 7 ppm CO cylinder is used for the low point, and an ultra pure gas is used for the zero point. The CO concentrations are critical for accurately calibrating the analyzer, so the cylinders are purchased certified to +/- 2 percent by the manufacturer. The CARB's Standards Laboratory recertifies the CO cylinders each calendar quarter. All certifications are traceable to the NIST.

Manifolds and Presentation Line

The system uses two manifolds to distribute gases. The output manifold receives the audit gas from the gas calibrator and distributes it to the van manifold and presentation line. The van manifold receives either audit gases or CO calibration gases and distributes them to the CO and $O_3$ analyzer. The type of gas the van manifold receives depends on a selector valve.

The system output is distributed by a 150 foot presentation line which connects the audit system to the air monitoring station. The presentation line is made of 1/2 inch Teflon enclosed in braided stainless steel. The line is mounted on a reel in the audit van for storage.

Audit Van

All the equipment is mounted and operated in a self-sufficient audit van. The latest audit van purchased by the CARB is a 30-foot long utility van. It contains a 17.5 kilowatt (kW) generator, heater and air conditioner for environmental control, computer with printer, rest room, microwave, refrigerator, and sink with running hot and cold water. Its large size accommodates the audit system and all the equipment necessary for conducting performance audits of various particulate samplers and meteorological sensors.

The audit van enables the auditors to drive to most air monitoring stations throughout California. Additionally, the equipment may be warmed-up en route to the station, so the audit may begin upon arrival.

**Bay Area Air Quality Management District**

Environics Dilution Calibrator

An Environics series 100 mass flow controlled dilution calibrator was used to dilute known concentrations of audit gas with zero air and create known audit concentrations. Zero grade air from Scott-Marrin is used.

Dasibi Transfer Standard

A Dasibi model 1003 PC ozone analyzer was converted to a transfer standard and certified by against a primary photometer. The standard is used to assay concentrations of ozone generated by the Environics calibrator.

Super Blend Cylinders

Nitric oxide (NO), sulfur dioxide ($SO_2$) and carbon monoxide (CO) concentrations are generated using National Institute of Standards and Testing (NIST) traceable EPA Protocol cylinders and gas dilution. Zero is used to dilute the concentrations of cylinder gas. Cylinders are provided by Scott Marrin Inc., Riverside, California.

## 4.2 SYSTEM AUDIT PROCEDURES

The system audit of air quality monitoring systems consist of an inspection to determine if the sampling and DAS equipment are operational, sample lines are clean and secure, and a review of the station check logs and onsite forms to determine if the documentation conforms to the specifications of the plan. The system audit of particulate samplers consist of an inspection to determine if the samplers are operational and clean, the spatial distribution of the samplers at each site conforms to the siting criteria. Specifically designed system audit forms are used to document the system audit results and are included in the final audit report. The subjects that are addressed by the system audits include:

- Network design and siting
  - network size and design
  - sensor exposure
  - review of station
- Resources and facilities

- instruments and methods
- staff and facilities
- standards and traceability

- Quality assurance and quality control
  - status of quality assurance program
  - audit participation
  - precision and accuracy checks

An evaluation of the quality assurance/quality control plan procedures including preventive maintenance is performed. Reviews of calibration records and maintenance logs are checked for consistency, frequency and accuracy. Equipment settings including flow rates and zero/span settings are evaluated to determine if ranges are acceptable.

Additionally, once the system audits of all sites in a network are complete, the auditor checks for possible differences in operation among the various sites.

## 4.3 PERFORMANCE AUDIT PROCEDURES

**Parsons Engineering Science**

$NO/NO_x/NO_2$, $SO_2$, CO

The entire sample train of the analyzer is connected to the Environics Series 100 dilution system output port via a glass manifold. Care is taken to introduce the audit span gas through as much of the normal sampling train (i.e., filters, and scrubbers) as possible. The analyzers are challenged with specific concentrations of span gas as follows:

| Audit Points | Concentration Range (ppm) |
|---|---|
| | **$O_3$ $H_2S$, $NO/NO_x/NO_2$, $SO_2$** |
| 1 | 0.000 |
| 2 | .03 to .08 |
| 3 | .15 to .20 |
| 4 | .35 to .45 |
| | **CO** |
| 1 | 0.0 |
| 2 | 3 to 8 |
| 3 | 15 to 20 |
| 4 | 35 to 45 |

$NO_2$ Audit Source Value Determination

Nitrogen dioxide concentrations are introduced into a $NO/NO_2/NO_x$ analyzer by gas-phase titration (GPT) of NO with $O_3$. Nitric oxide reacts completely with ozone to produce nitrogen dioxide and oxygen.

The $NO_2$ input concentration is determined by:

$$[NO_2 \text{ input}] = \frac{[NO \text{ initial}] - [NO \text{ final}]}{NO \text{ slope}}$$

[NO initial] = analyzer's NO channel response to the NO span prior to the addition of $O_3$
[NO final] = analyzer's NO response after the addition of $O_3$
NO slope = slope of the curve generated by linear regression of the NO concentrations versus the analyzer's response during the audit of the NO channel, where the NO input is the abscissa and the response is the ordinate

The final stage of the $NO/NO_2/NO_x$ analyzer audit is to determine the converter efficiency from the following relationships:

$$[NO_2 \text{ converted}] = [NO_2 \text{ input}] - \frac{[NO_x \text{ initial}] - [NO_x \text{ final}]}{NO_x \text{ slope}}$$

[$NO_x$ initial] = analyzer's $NO_x$ channel response before the addition of $O_3$
[$NO_x$ final] = analyzer's $NO_x$ response after the input sample of NO is titrated with $O_3$
$NO_x$ slope = slope obtained from the audit of the $NO_x$ channel

The converter efficiency for each audit point is:

$$\frac{[NO_2 \text{ converted}]}{[NO_2 \text{ input}]} \times 100$$

The converter efficiency is defined as the slope of the linear regression using the $NO_2$ source versus the $NO_2$ converted x 100. The converter efficiency must be greater than or equal to 96 percent to pass the audit.

Ozone

Ozone concentrations are generated by a stable ozone generator and verified by a certified transfer standard. Zero air is provided from a cylinder of ultrapure air. Otherwise, audit procedures are similar to those presented above.

**California Air Resources Board**

The typical air monitoring station in California is composed of a probe, which directs ambient air into the station, a distribution manifold, and analyzers, which draw the ambient air from the manifold. When conducting an audit, the analyzers are operated in their normal sampling mode and the audit gas is passed through as much of the ambient air inlet system as practical. The United States Environmental Protection Agency's (U.S. EPA) Quality Assurance Handbook for Ambient Air Measurement Systems: Volume II recommends that each analyzer be audited separately by disconnecting an analyzer from the station manifold and connecting it to an audit manifold. This configuration works well for testing an analyzer's response to a pollutant concentration, but the ambient air sampling system from the probe inlet through the distribution manifold is bypassed. Contaminants that scavenge pollutants or leaks in the air sampling system will not be identified. The data quality from the air monitoring station may still be suspect using this audit method.

The through the probe (TTP) audit method is conducted by introducing the audit gas through the station's probe inlet. This method allows the audit gas to travel through the complete air sampling system with no modifications to the system. Problems such as contaminates or leaks will be identified by poor analyzer response. This method tests the station's response to a pollutant instead of just an analyzer's response.

The TTP audit method can also be used to assist with troubleshooting when a problem is identified during an audit. Any analyzer that failed an audit can be isolated from the air sampling system, and the audit gas can be introduced at the back of the analyzer. If the analyzer's response improves, the problem is in the air sampling system. If the analyzer's response does not improve, the analyzer's the source of the problem. Quality Assurance Section (QAS) auditors use this technique to assist station operators to locate problems identified during an audit.

Ozone

The Ozone ($O_3$) audit concentrations are controlled by the gas calibrator and measured by the audit $O_3$ analyzer. The calibrator generates $O_3$ and mixes it with zero air to target the desired audit concentration levels. The audit gas is directed to the output where the majority of the gas is distributed to the air monitoring station through the presentation line. A portion of the audit gas is distributed to the van manifold, which directs it to the audit $O_3$ analyzer. The audit $O_3$ analyzer measures the audit concentrations. The air monitoring station's $O_3$ analyzer is allowed to stabilize and its responses are compared to the audit concentrations.

$NO/NO_y$

The pollutant audit concentrations are controlled by the gas calibrator. The calibrator dilutes pollutants from the selected super blend cylinder with zero air to target the desired audit concentration levels. The audit gas is directed to the output manifold where the majority of the gas is distributed to the air monitoring station through the presentation line. A portion of the audit gas is distributed to the van manifold, which directs it to the audit CO analyzer. The audit CO analyzer measures the audit gas CO concentration. The audit concentrations of the other pollutants are not directly measured, but are calculated based on the amount of CO dilution. The dilution is expressed as a ratio (dilution ratio) by comparing the CO concentration after dilution (audit concentration) to the CO concentration before dilution (super blend concentration) using Equation 1:

$$\text{Dilution Ratio} = \text{Audit Concentration} \div \text{Super Blend Concentration} \quad (1)$$

The dilution ratio is then applied to each pollutant in the super blend cylinder to calculate it's audit concentration using Equation 2:

$$\text{Super Blend Concentration X Dilution Ratio} = \text{Audit Concentration} \quad (2)$$

For example:

If the CO audit concentration = 40.0ppm then,

Dilution Ratio = Audit Concentration ÷ Super Blend Concentration

Dilution Ratio = 40.0 ppm CO ÷15,000 ppm CO

Dilution Ratio = 0.002667

Apply the Dilution Ratio to the other pollutants,

Super Blend Concentration X Dilution Ratio = Audit Concentration

325 ppm NO X 0.002667 = 0.867 ppm NO

140 ppm $SO_2$ X 0.002667 = 0.373 ppm $SO_2$

6,600 ppm CH4 X 0.002667 = 17.60 ppm CH4

$NO_2$ performance audits are conducted by gas phase titration of the NO. Equation 3 below shows how NO reacts with $O_3$:

$$NO + O_3 = NO_2 + O_2 \quad (3)$$

Excess NO is utilized to force the complete reaction of $O_3$. The resulting $NO_2$ concentration is nearly equal to the $O_3$ concentration. The audit $NO_2$ concentrations are calculated based on the method described in the U.S. EPA's Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, Section 2.0.12.7.

The station analyzers are allowed to stabilize at each audit level and their responses are compared to the audit concentrations.

**Bay Area AQMD**

Audit procedures of the BAAQMD are similar to those of the ARB, with two notable differences. First, dilution concentrations are not monitored, and consequently corrected, through the use of a CO analyzer. All concentrations are calculated directly from the certified dilution ratios from the audit calibrator. Second, during GPT, $NO_2$ concentrations are calculated based on a one-to-one conversion of NO and ozone to $NO_2$, based on ozone concentrations determined using the audit ozone transfer standard, usually during the ozone audit conducted prior to the NO/$NO_y$ audit.

## 4.4 PERFORMANCE AUDIT CRITERIA

Performance audit criteria are consistent with those recommended in the U.S. EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II (USEPA, 1998). The audit criteria are shown below.

Table 4-1. Gaseous Air Quality Audit Criteria.

| Relationship between the Audit and Site | Audit Criteria |
|---|---|
| Slope<br>Intercept<br>Correlation Coeff. | ±0.15 or ±15% for any point<br>±3% of analyzer range<br>>.9950 |
| Station Temperature | ±1°C response<br>20 – 30°C operation |

## 4.5 AUDIT RESULTS

Appendix B presents the individual, complete audit reports for each site. The majority of these were generated by the ARB. ARB's original summary of the audits conducted during CCOS is also included in Appendix B. Table 4-2 summarizes the dates of the audits and the CCOS observables audited. Table 4-3 presents a summary of the performance audit results. Table 4-4 presents summary statistics for key instrument groupings. Results of the audits are presented both as raw values obtained during the audit and as values corrected using the appropriate post-monitoring data processing adjustment values. It should also be noted that, for the NO/$NO_y$ analyzers, ARB's reports only summarize results relative to audit criteria for $NO_2$, as this is the criteria pollutant typically reported to the EPA. However, since the analyzer is actually measuring NO and $NO_y$, and simply calculating $NO_2$ as the difference between the two, NO and $NO_y$ results have been emphasized in the included tables.

Audit results for instruments with known problems or for audits where the results have been questioned were removed prior to calculating the statistics presented in Table 4-4.

The following sections discuss problems or issues noted at specific sites, including their resolution. The original ARB Action Requests and resolution recommendations are included in Appendix B. Please note that the following discussions of problem resolutions supercede those presented in Appendix B, as additional information was gathered after the ARB reports were produced.

**S0 Sites**

### Bella Vista

Problem: The NO/$NO_y$ analyzer failed the audit. At the low point, the analyzer NO/$NO_y$ difference was found to be 19.0% greater than the audit $NO_2$ value.

Resolution: Given the magnitude of the effort required to set up and maintain the supplemental air monitoring network, DRI frequently chose to not adjust an analyzer's response if the response was stable, with the intent of adjusting the collected data during post-processing. Adjusting the audit results using DRI-supplied factors obtained from routine calibrations of the analyzers brought the audit results to within 13.5%.

### Kettleman City #2

Problem: Audit found the NO/$NO_y$ analyzer operating –22.3%, -23.2%, and –22.5% from true at the low, middle and high levels, respectively.

Table 4-2. CCOS Air Quality Sites And Observables.

| Site | Type | O3 | NO/NOy | NO/NOx | NMOC | Carbonyl | Met | NOy*/NOy (Nitric Acid) | CO | NO2/PAN | CO2 | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Camp Parks | misc | ● | | | | | | | | | | |
| Kregor Peak | misc | ● | | | | | | | | | | |
| Granite Bay | R | ● | | ● | ● | ● | ○ | ● | | ● | ● | |
| Parlier | R | ● | | ● | ● | ● | ● | ● | ● | ● | ● | |
| Sunol | R | ● | | ● | ● | ● | ● | ● | ● | ● | ● | |
| Bella Vista | S0 | ● | ● | | | | ○ | | | | | |
| Kettleman City | S0 | ● | ● | | | | ○ | | | | | |
| Lake Cabot | S0 | ● | ● | | | | | | | | | |
| Lambie Road | S0 | ● | ● | | | | | | | | | |
| Livermore-Rincon | S0 | ● | ● | | | | | | | | | |
| McKittrick | S0 | ● | ● | | | | ○ | | | | | |
| Red Hills | S0 | ● | ● | | | | | | | | | |
| San Martin | S0 | ● | ● | | | | | | | | | |
| Sloughhouse | S0 | ● | ● | | | | ○ | | | | | |
| Angiola | S1 | ● | ● | | ● | ● | ● | | | | | Met audit as part of CRPAQS QA |
| Bodega Bay | S1 | ● | ● | | ○ | ● | | | | | | |
| Elk Grove | S1 | ● | ● | ● | ● | ○ | | | | | | |
| Piedras Blancas | S1 | ● | ● | | ● | ● | ○ | | | | | |
| San Andreas | S1 | ● | ● | | ○ | ● | | | ● | | | |
| Sutter Buttes | S1 | ● | ○ | | ○ | ○ | | | | | | Parameters not audited due to accessability limitations. |
| Turlock | S1 | ● | ● | ● | ○ | ● | | | ● | | | |
| White Cloud | S1 | ● | ● | | ● | ● | | | | | | |
| Arvin | S2 | ● | ● | ● | ● | ○ | | | | ● | | |
| Bethyl Island | S2 | ● | ● | | ○ | ● | | | | ● | | NO2/PAN audit as part of CRPAQS QA |
| Pacheco Pass | S2 | ● | ● | | ● | ● | | | | ○ | | |
| Patterson Pass | S2 | ● | ● | | ● | ● | | | | ○ | | |
| Trimmer | S2 | ● | ● | | ● | ● | | | | ● | | |

Notes: ● Audit performed
○ Variable measured but no audit performed

Table 4-3. Continuous Air Quality Analyzer Audit Results.

| Site | Type | Operator | Date | Auditor | Parameter[2] | Input | Response[1] | % diff | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Angiola | S1 | STI | 8/16/00 | ARB | NO | 0.178 | 0.177 | -0.3% | |
| Angiola | S1 | STI | 8/16/00 | ARB | NO | 0.277 | 0.275 | -0.6% | |
| Angiola | S1 | STI | 8/16/00 | ARB | NO | 0.491 | 0.490 | -0.3% | |
| Angiola | S1 | STI | 8/16/00 | ARB | NO2 | 0.065 | 0.061 | -6.5% | |
| Angiola | S1 | STI | 8/16/00 | ARB | NO2 | 0.161 | 0.154 | -4.5% | |
| Angiola | S1 | STI | 8/16/00 | ARB | NO2 | 0.385 | 0.369 | -4.2% | |
| Angiola | S1 | STI | 8/16/00 | ARB | NOy | 0.178 | 0.181 | 1.7% | |
| Angiola | S1 | STI | 8/16/00 | ARB | NOy | 0.277 | 0.281 | 1.4% | |
| Angiola | S1 | STI | 8/16/00 | ARB | NOy | 0.491 | 0.499 | 1.6% | |
| Angiola | S1 | STI | 8/10/00 | ARB | Ozone | 0.067 | 0.068 | 1.5% | |
| Angiola | S1 | STI | 8/10/00 | ARB | Ozone | 0.174 | 0.179 | 2.9% | |
| Angiola | S1 | STI | 8/10/00 | ARB | Ozone | 0.394 | 0.409 | 3.8% | |
| Arvin | S2 | ARB | 9/12/00 | ARB | (NO2) | 0.060 | 0.063 | 5.0% | |
| Arvin | S2 | ARB | 9/12/00 | ARB | (NO2) | 0.167 | 0.172 | 3.0% | |
| Arvin | S2 | ARB | 9/12/00 | ARB | (NO2) | 0.350 | 0.366 | 4.6% | |
| Arvin | S2 | DRI | 8/1/00 | ARB | NO | 0.175 | 0.192 | 9.8% | |
| Arvin | S2 | DRI | 8/1/00 | ARB | NO | 0.280 | 0.302 | 7.8% | |
| Arvin | S2 | DRI | 8/1/00 | ARB | NO | 0.453 | 0.492 | 8.6% | |
| Arvin | S2 | DRI | 8/1/00 | ARB | NO2 | 0.066 | 0.071 | 7.4% | |
| Arvin | S2 | DRI | 8/1/00 | ARB | NO2 | 0.166 | 0.178 | 7.5% | |
| Arvin | S2 | DRI | 8/1/00 | ARB | NO2 | 0.379 | 0.407 | 7.4% | |
| Arvin | S2 | CECERT | 8/9/00 | PES | NO2/PAN | 0.031 | 0.029 | **-7.4%** | AC just fixed, analzyer still stabilizing |
| Arvin | S2 | CECERT | 8/9/00 | PES | NO2/PAN | 0.079 | 0.068 | **-13.8%** | AC just fixed, analzyer still stabilizing |
| Arvin | S2 | CECERT | 8/9/00 | PES | NO2/PAN | 0.141 | 0.121 | **-14.5%** | AC just fixed, analzyer still stabilizing |
| Arvin | S2 | DRI | 8/1/00 | ARB | NOy | 0.175 | 0.193 | 10.3% | |
| Arvin | S2 | DRI | 8/1/00 | ARB | NOy | 0.280 | 0.303 | 8.1% | |
| Arvin | S2 | DRI | 8/1/00 | ARB | NOy | 0.453 | 0.493 | 8.8% | |
| Arvin | S2 | ARB | 9/12/00 | ARB | Ozone | 0.075 | 0.076 | 1.6% | |
| Arvin | S2 | ARB | 9/12/00 | ARB | Ozone | 0.175 | 0.171 | -2.3% | |
| Arvin | S2 | ARB | 9/12/00 | ARB | Ozone | 0.403 | 0.396 | -1.7% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | CO | 3.700 | 3.800 | 2.7% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | CO | 6.200 | 6.300 | 1.6% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | CO | 7.300 | 7.400 | 1.4% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | NO | 0.090 | 0.091 | 1.1% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | NO | 0.124 | 0.124 | 0.0% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | NO | 0.150 | 0.152 | 1.3% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | NO2 | 0.027 | 0.029 | 7.4% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | NO2 | 0.053 | 0.056 | 5.7% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | NO2 | 0.076 | 0.082 | 7.9% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | NOy | 0.090 | 0.091 | 1.1% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | NOy | 0.124 | 0.124 | 0.0% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | NOy | 0.150 | 0.152 | 1.3% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | Ozone | 0.068 | 0.069 | 1.5% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | Ozone | 0.168 | 0.175 | 4.2% | |
| Aztec (STI) | Aircraft | STI | 7/3/00 | ARB | Ozone | 0.381 | 0.397 | 4.2% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | NO | 0.167 | 0.172 | 2.9% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | NO | 0.264 | 0.280 | 5.9% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | NO | 0.425 | 0.462 | 8.7% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | NO2 | 0.058 | 0.066 | 13.5% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | NO2 | 0.143 | 0.154 | 8.0% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | NO2 | 0.342 | 0.364 | 6.4% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | NOy | 0.167 | 0.173 | 3.3% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | NOy | 0.264 | 0.280 | 6.1% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | NOy | 0.425 | 0.462 | 8.7% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | Ozone | 0.071 | 0.069 | -2.8% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | Ozone | 0.176 | 0.172 | -2.3% | |
| Bella Vista | S0 | DRI | 8/22/00 | ARB | Ozone | 0.393 | 0.385 | -2.0% | |
| Bethyl Island | S2 | DRI | 8/22/00 | BAAQMD | NO | 0.077 | 0.079 | 3.0% | |
| Bethyl Island | S2 | DRI | 8/22/00 | BAAQMD | NO | 0.188 | 0.195 | 3.8% | |
| Bethyl Island | S2 | DRI | 8/22/00 | BAAQMD | NO | 0.393 | 0.422 | 7.3% | |
| Bethyl Island | S2 | DRI | 8/22/00 | BAAQMD | NO2 | 0.069 | 0.062 | -10.2% | |
| Bethyl Island | S2 | DRI | 8/22/00 | BAAQMD | NO2 | 0.172 | 0.172 | 0.2% | |
| Bethyl Island | S2 | DRI | 8/22/00 | BAAQMD | NO2 | 0.378 | 0.383 | 1.4% | |

Table 4-3. Continuous Air Quality Analyzer Audit Results (continued).

| Site | Type | Operator | Date | Auditor | Parameter[2] | Input | Response[1] | % diff | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Bethyl Island | S2 | DRI | 8/22/00 | BAAQMD | NOy | 0.077 | 0.079 | 2.6% | |
| Bethyl Island | S2 | DRI | 8/22/00 | BAAQMD | NOy | 0.188 | 0.189 | 0.5% | |
| Bethyl Island | S2 | DRI | 8/22/00 | BAAQMD | NOy | 0.393 | 0.405 | 3.1% | |
| Bethyl Island | S2 | BAAQMD | 8/22/00 | BAAQMD | Ozone | 0.069 | 0.065 | -5.8% | |
| Bethyl Island | S2 | BAAQMD | 8/22/00 | BAAQMD | Ozone | 0.172 | 0.158 | -8.1% | |
| Bethyl Island | S2 | BAAQMD | 8/22/00 | BAAQMD | Ozone | 0.378 | 0.365 | -3.4% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | NO | 0.173 | 0.182 | 5.0% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | NO | 0.292 | 0.299 | 2.5% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | NO | 0.474 | 0.487 | 2.7% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | NO2 | 0.067 | 0.068 | 1.3% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | NO2 | 0.178 | 0.179 | 0.6% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | NO2 | 0.383 | 0.390 | 1.9% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | NOy | 0.173 | 0.182 | 5.1% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | NOy | 0.292 | 0.299 | 2.6% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | NOy | 0.474 | 0.488 | 2.9% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | Ozone | 0.066 | 0.059 | -10.6% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | Ozone | 0.171 | 0.160 | -6.4% | |
| Bodega Bay | S1 | DRI | 8/30/00 | ARB | Ozone | 0.389 | 0.372 | -4.4% | |
| Camp Parks | Misc | T&B | 8/16/00 | PES | Ozone | 0.057 | 0.063 | 9.8% | |
| Camp Parks | Misc | T&B | 8/16/00 | PES | Ozone | 0.158 | 0.165 | 4.3% | |
| Camp Parks | Misc | T&B | 8/16/00 | PES | Ozone | 0.348 | 0.359 | 3.3% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | NO | 0.094 | 0.088 | -6.4% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | NO | 0.124 | 0.118 | -4.8% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | NO | 0.153 | 0.148 | -3.3% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | NO2 | 0.030 | 0.029 | -3.3% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | NO2 | 0.055 | 0.056 | 1.8% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | NO2 | 0.082 | 0.084 | 2.4% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | NOy | 0.094 | 0.088 | -6.4% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | NOy | 0.124 | 0.118 | -4.8% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | NOy | 0.153 | 0.148 | -3.3% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | Ozone | 0.068 | 0.069 | 1.5% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | Ozone | 0.173 | 0.174 | 0.6% | |
| Cessna 172 (UCD) | Aircraft | UCD | 6/13/00 | ARB | Ozone | 0.369 | 0.389 | 5.4% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | NO | 0.095 | 0.087 | -8.4% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | NO | 0.125 | 0.115 | -8.0% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | NO | 0.156 | 0.143 | -8.3% | |
| Cessna 182 (STI) | Aircraft | STI | 7/3/00 | ARB | NO | 0.090 | 0.095 | 5.6% | |
| Cessna 182 (STI) | Aircraft | STI | 7/3/00 | ARB | NO | 0.124 | 0.128 | 3.2% | |
| Cessna 182 (STI) | Aircraft | STI | 7/3/00 | ARB | NO | 0.150 | 0.158 | 5.3% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | NO2 | 0.029 | 0.025 | -13.8% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | NO2 | 0.060 | 0.051 | -15.0% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | NO2 | 0.086 | 0.074 | -14.0% | |
| Cessna 182 (STI) | Aircraft | STI | 7/3/00 | ARB | NO2 | 0.027 | 0.029 | 7.4% | |
| Cessna 182 (STI) | Aircraft | STI | 7/3/00 | ARB | NO2 | 0.054 | 0.058 | 7.4% | |
| Cessna 182 (STI) | Aircraft | STI | 7/3/00 | ARB | NO2 | 0.077 | 0.083 | 7.8% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | NOy | 0.095 | 0.086 | -9.5% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | NOy | 0.125 | 0.113 | -9.6% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | NOy | 0.156 | 0.140 | -10.3% | |
| Cessna 182 (STI) | Aircraft | STI | 7/3/00 | ARB | NOy | 0.090 | 0.094 | 4.4% | |
| Cessna 182 (STI) | Aircraft | STI | 7/3/00 | ARB | NOy | 0.124 | 0.128 | 3.2% | |
| Cessna 182 (STI) | Aircraft | STI | 7/3/00 | ARB | NOy | 0.150 | 0.158 | 5.3% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | Ozone | 0.068 | 0.068 | 0.0% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | Ozone | 0.163 | 0.169 | 3.7% | |
| Cessna 182 (STI) | Aircraft | STI | 6/19/00 | ARB | Ozone | 0.368 | 0.383 | 4.1% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | NO | 0.092 | 0.093 | 1.1% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | NO | 0.124 | 0.125 | 0.8% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | NO | 0.153 | 0.156 | 2.0% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | NO2 | 0.031 | 0.033 | 6.5% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | NO2 | 0.058 | 0.061 | 5.2% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | NO2 | 0.088 | 0.092 | 4.5% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | NOy | 0.092 | 0.095 | 3.3% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | NOy | 0.124 | 0.127 | 2.4% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | NOy | 0.153 | 0.158 | 3.3% | |

Table 4-3. Continuous Air Quality Analyzer Audit Results (continued).

| Site | Type | Operator | Date | Auditor | Parameter[2] | Input | Response[1] | % diff | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | Ozone | 0.067 | 0.066 | -1.5% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | Ozone | 0.173 | 0.171 | -1.2% | |
| Cessna 182 (UCD) | Aircraft | UCD | 6/12/00 | ARB | Ozone | 0.393 | 0.391 | -0.5% | |
| Elk Grove | S1 | SMAQMD | 11/7/00 | ARB | (NO2) | 0.075 | 0.078 | 4.0% | |
| Elk Grove | S1 | SMAQMD | 11/7/00 | ARB | (NO2) | 0.189 | 0.192 | 1.6% | |
| Elk Grove | S1 | SMAQMD | 11/7/00 | ARB | (NO2) | 0.368 | 0.377 | 2.4% | |
| Elk Grove | S1 | DRI | 9/8/00 | ARB | NO | 0.175 | 0.180 | 2.6% | |
| Elk Grove | S1 | DRI | 9/8/00 | ARB | NO | 0.277 | 0.281 | 1.3% | |
| Elk Grove | S1 | DRI | 9/8/00 | ARB | NO | 0.418 | 0.419 | 0.3% | |
| Elk Grove | S1 | DRI | 9/8/00 | ARB | NO2 | 0.067 | 0.069 | 3.3% | |
| Elk Grove | S1 | DRI | 9/8/00 | ARB | NO2 | 0.170 | 0.171 | 0.6% | |
| Elk Grove | S1 | DRI | 9/8/00 | ARB | NO2 | 0.349 | 0.352 | 0.8% | |
| Elk Grove | S1 | DRI | 9/8/00 | ARB | NOy | 0.175 | 0.180 | 3.1% | |
| Elk Grove | S1 | DRI | 9/8/00 | ARB | NOy | 0.277 | 0.281 | 1.5% | |
| Elk Grove | S1 | DRI | 9/8/00 | ARB | NOy | 0.418 | 0.421 | 0.8% | |
| Elk Grove | S1 | SMAQMD | 11/7/00 | ARB | Ozone | 0.069 | 0.070 | 1.4% | |
| Elk Grove | S1 | SMAQMD | 11/7/00 | ARB | Ozone | 0.175 | 0.179 | 2.3% | |
| Elk Grove | S1 | SMAQMD | 11/7/00 | ARB | Ozone | 0.399 | 0.406 | 1.8% | |
| Granite Bay | Research | DRI | 8/17/00 | ARB | CO | 4.200 | 4.168 | -0.8% | |
| Granite Bay | Research | DRI | 8/17/00 | ARB | CO | 7.800 | 7.723 | -1.0% | |
| Granite Bay | Research | DRI | 8/15/00 | PES | CO2 | 260 | 262 | 0.7% | |
| Granite Bay | Research | DRI | 8/15/00 | PES | CO2 | 522 | 525 | 0.5% | |
| Granite Bay | Research | DRI | 8/15/00 | PES | CO2 | 782 | 760 | -2.8% | |
| Granite Bay | Research | DRI | 8/17/00 | ARB | (NO) | 0.177 | 0.196 | **10.6%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | (NO) | 0.284 | 0.302 | **6.4%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | (NO) | 0.425 | 0.473 | **11.3%** | Audit results in question |
| Granite Bay | Research | DRI | 8/31/00 | PES | (NO) | 0.185 | 0.179 | -3.5% | |
| Granite Bay | Research | DRI | 8/31/00 | PES | (NO) | 0.431 | 0.414 | -4.1% | |
| Granite Bay | Research | DRI | 8/17/00 | ARB | (NO2) | 0.051 | 0.061 | **19.5%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | (NO2) | 0.159 | 0.171 | **7.8%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | (NO2) | 0.345 | 0.382 | **10.8%** | Audit results in question |
| Granite Bay | Research | DRI | 8/31/00 | PES | (NO2) | 0.088 | 0.083 | -5.2% | |
| Granite Bay | Research | DRI | 8/31/00 | PES | (NO2) | 0.152 | 0.146 | -3.9% | |
| Granite Bay | Research | CECERT | 8/31/00 | PES | NO2/PAN | 0.033 | 0.034 | 1.8% | |
| Granite Bay | Research | CECERT | 8/31/00 | PES | NO2/PAN | 0.088 | 0.090 | 2.2% | |
| Granite Bay | Research | CECERT | 8/31/00 | PES | NO2/PAN | 0.152 | 0.155 | 2.0% | |
| Granite Bay | Research | DRI | 8/31/00 | PES | NOY | 0.185 | 0.181 | -2.2% | |
| Granite Bay | Research | DRI | 8/31/00 | PES | NOY | 0.431 | 0.423 | -1.9% | |
| Granite Bay | Research | DRI | 8/17/00 | ARB | NOY | 0.177 | 0.201 | **13.5%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | NOY | 0.284 | 0.311 | **9.3%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | NOY | 0.425 | 0.485 | **14.1%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | (NOx) | 0.177 | 0.196 | **10.9%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | (NOx) | 0.284 | 0.302 | **6.4%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | (NOx) | 0.425 | 0.471 | **10.9%** | Audit results in question |
| Granite Bay | Research | DRI | 8/31/00 | PES | (NOx) | 0.185 | 0.179 | -3.2% | |
| Granite Bay | Research | DRI | 8/31/00 | PES | (NOx) | 0.431 | 0.416 | -3.5% | |
| Granite Bay | Research | DRI | 8/31/00 | PES | NOY* | 0.185 | 0.179 | -3.2% | |
| Granite Bay | Research | DRI | 8/31/00 | PES | NOY* | 0.431 | 0.421 | -2.3% | |
| Granite Bay | Research | DRI | 8/17/00 | ARB | NOY* | 0.177 | 0.200 | **12.7%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | NOY* | 0.284 | 0.309 | **8.7%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | NOY* | 0.425 | 0.483 | **13.7%** | Audit results in question |
| Granite Bay | Research | DRI | 8/17/00 | ARB | Ozone | 0.071 | 0.070 | -1.4% | |
| Granite Bay | Research | DRI | 8/17/00 | ARB | Ozone | 0.171 | 0.168 | -1.8% | |
| Granite Bay | Research | DRI | 8/17/00 | ARB | Ozone | 0.388 | 0.381 | -1.8% | |
| Gulfstream | Aircraft | PNNL | 7/6/00 | ARB | Ozone | 0.069 | 0.069 | 0.0% | |
| Gulfstream | Aircraft | PNNL | 7/6/00 | ARB | Ozone | 0.168 | 0.168 | 0.0% | |
| Gulfstream | Aircraft | PNNL | 7/6/00 | ARB | Ozone | 0.379 | 0.374 | -1.3% | |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | NO | 0.216 | 0.214 | -1.1% | |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | NO | 0.371 | 0.373 | 0.7% | |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | NO | 0.543 | 0.559 | 2.9% | |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | NO2 | 0.069 | 0.068 | -1.7% | |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | NO2 | 0.207 | 0.203 | -1.8% | |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | NO2 | 0.488 | 0.483 | -1.0% | |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | NOy | 0.216 | 0.212 | -1.8% | |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | NOy | 0.371 | 0.370 | -0.1% | |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | NOy | 0.543 | 0.556 | 2.3% | |

Table 4-3. Continuous Air Quality Analyzer Audit Results (continued).

| Site | Type | Operator | Date | Auditor | Parameter[2] | Input | Response[1] | % diff | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Kettleman City | S0 | DRI | 8/2/00 | ARB | Ozone | 0.068 | 0.062 | **-8.8%** | Audit results in question |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | Ozone | 0.167 | 0.154 | **-7.8%** | Audit results in question |
| Kettleman City | S0 | DRI | 8/2/00 | ARB | Ozone | 0.378 | 0.347 | **-8.2%** | Audit results in question |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | NO | 0.057 | 0.064 | 12.5% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | NO | 0.160 | 0.180 | 12.2% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | NO | 0.348 | 0.386 | 11.0% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | NO2 | 0.057 | 0.063 | 11.1% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | NO2 | 0.177 | 0.194 | 9.8% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | NO2 | 0.332 | 0.365 | 10.1% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | NOy | 0.057 | 0.063 | 11.0% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | NOy | 0.160 | 0.180 | 12.3% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | NOy | 0.348 | 0.385 | 10.7% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | Ozone | 0.055 | 0.050 | -8.8% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | Ozone | 0.164 | 0.150 | -8.2% | |
| Lake Chabot | S0 | T&B | 8/16/00 | PES | Ozone | 0.355 | 0.330 | -7.0% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | NO | 0.079 | 0.075 | -5.4% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | NO | 0.198 | 0.191 | -3.6% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | NO | 0.415 | 0.417 | 0.5% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | NO2 | 0.068 | 0.064 | -5.2% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | NO2 | 0.179 | 0.172 | -3.8% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | NO2 | 0.389 | 0.383 | -1.5% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | NOy | 0.079 | 0.076 | -3.3% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | NOy | 0.198 | 0.192 | -2.9% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | NOy | 0.415 | 0.420 | 1.1% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | Ozone | 0.068 | 0.066 | -2.8% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | Ozone | 0.179 | 0.172 | -4.0% | |
| Lambie Road | S0 | DRI | 8/18/00 | BAAQMD | Ozone | 0.389 | 0.381 | -2.0% | |
| Livermore | S0 | T&B | 8/23/00 | BAAQMD | NO | 0.076 | 0.074 | -2.6% | |
| Livermore | S0 | T&B | 8/23/00 | BAAQMD | NO | 0.184 | 0.182 | -1.1% | |
| Livermore | S0 | T&B | 8/23/00 | BAAQMD | NO | 0.389 | 0.386 | -0.8% | |
| Livermore | S0 | T&B | 8/23/00 | BAAQMD | NO2 | 0.074 | 0.076 | 2.7% | |
| Livermore | S0 | T&B | 8/23/00 | BAAQMD | NO2 | 0.183 | 0.186 | 1.6% | |
| Livermore | S0 | T&B | 8/23/00 | BAAQMD | NO2 | 0.387 | 0.394 | 1.8% | |
| Livermore | S0 | T&B | 8/23/00 | BAAQMD | NOy | 0.076 | 0.076 | 0.0% | |
| Livermore | S0 | T&B | 8/23/00 | BAAQMD | NOy | 0.184 | 0.186 | 1.1% | |
| Livermore | S0 | T&B | 8/23/00 | BAAQMD | NOy | 0.389 | 0.394 | 1.3% | |
| Livermore | S0 | BAAQMD | 8/23/00 | BAAQMD | Ozone | 0.066 | 0.067 | 1.5% | |
| Livermore | S0 | BAAQMD | 8/23/00 | BAAQMD | Ozone | 0.168 | 0.168 | 0.0% | |
| Livermore | S0 | BAAQMD | 8/23/00 | BAAQMD | Ozone | 0.367 | 0.366 | -0.3% | |
| McKitterick | S0 | DRI | 8/1/00 | ARB | NO | 0.180 | 0.206 | **14.3%** | Audit results in question |
| McKitterick | S0 | DRI | 8/1/00 | ARB | NO | 0.274 | 0.320 | **16.7%** | Audit results in question |
| McKitterick | S0 | DRI | 8/1/00 | ARB | NO | 0.444 | 0.472 | **6.3%** | Audit results in question |
| McKitterick | S0 | DRI | 8/1/00 | ARB | NO2 | 0.071 | 0.071 | -0.5% | |
| McKitterick | S0 | DRI | 8/1/00 | ARB | NO2 | 0.174 | 0.177 | 1.9% | |
| McKitterick | S0 | DRI | 8/1/00 | ARB | NO2 | 0.355 | 0.369 | 3.9% | |
| McKitterick | S0 | DRI | 8/1/00 | ARB | NOy | 0.180 | 0.205 | **14.1%** | Audit results in question |
| McKitterick | S0 | DRI | 8/1/00 | ARB | NOy | 0.274 | 0.317 | **15.8%** | Audit results in question |
| McKitterick | S0 | DRI | 8/1/00 | ARB | NOy | 0.444 | 0.469 | **5.6%** | Audit results in question |
| McKitterick | S0 | DRI | 8/1/00 | ARB | Ozone | 0.068 | 0.061 | **-10.3%** | Audit results in question |
| McKitterick | S0 | DRI | 8/1/00 | ARB | Ozone | 0.167 | 0.147 | **-12.0%** | Audit results in question |
| McKitterick | S0 | DRI | 8/1/00 | ARB | Ozone | 0.381 | 0.335 | **-12.1%** | Audit results in question |
| Monterey Plane | Aircraft | TVA | 7/27/00 | ARB | Ozone | 0.051 | 0.044 | -13.7% | |
| Monterey Plane | Aircraft | TVA | 7/27/00 | ARB | Ozone | 0.095 | 0.082 | -13.7% | |
| Monterey Plane | Aircraft | TVA | 7/27/00 | ARB | Ozone | 0.190 | 0.165 | -13.2% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | NO | 0.168 | 0.173 | 3.0% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | NO | 0.285 | 0.291 | 2.3% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | NO | 0.470 | 0.486 | 3.4% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | NO2 | 0.063 | 0.064 | 2.1% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | NO2 | 0.175 | 0.178 | 1.9% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | NO2 | 0.374 | 0.385 | 3.0% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | NOy | 0.168 | 0.173 | 2.9% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | NOy | 0.285 | 0.291 | 2.3% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | NOy | 0.470 | 0.487 | 3.6% | |

Table 4-3. Continuous Air Quality Analyzer Audit Results (continued).

| Site | Type | Operator | Date | Auditor | Parameter[2] | Input | Response[1] | % diff | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | Ozone | 0.067 | 0.066 | -1.5% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | Ozone | 0.173 | 0.170 | -1.7% | |
| Pacheco Pass | S2 | DRI | 8/29/00 | ARB | Ozone | 0.392 | 0.385 | -1.8% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | (NO) | 0.155 | 0.169 | 9.0% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | (NO) | 0.274 | 0.295 | 7.7% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | (NO) | 0.466 | 0.497 | 6.7% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | (NO2) | 0.065 | 0.068 | 4.6% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | (NO2) | 0.180 | 0.184 | 2.2% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | (NO2) | 0.392 | 0.395 | 0.8% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | (NOx) | 0.155 | 0.170 | 9.7% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | (NOx) | 0.274 | 0.298 | 8.8% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | (NOx) | 0.466 | 0.501 | 7.5% | |
| Parlier | Research | DRI | 8/31/00 | ARB | CO | 3.900 | 3.398 | -12.9% | |
| Parlier | Research | DRI | 8/31/00 | ARB | CO | 7.290 | 6.827 | -6.4% | |
| Parlier | Research | DRI | 8/31/00 | ARB | CO | 16.200 | 15.763 | -2.7% | |
| Parlier | Research | DRI | 8/8/00 | PES | CO2 | 255 | 257 | 0.8% | |
| Parlier | Research | DRI | 8/8/00 | PES | CO2 | 491 | 499 | 1.5% | |
| Parlier | Research | DRI | 8/8/00 | PES | CO2 | 715 | 708 | -1.0% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | NMHC | 6.000 | 8.1 | **35.0%** | Instument removed for repair |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | NMHC | 12.200 | 16.1 | **32.0%** | Instument removed for repair |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | NMHC | 17.900 | 23.7 | **32.4%** | Instument removed for repair |
| Parlier | Research | CECERT | 8/31/00 | ARB | NO2/PAN | 0.065 | 0.067 | 3.5% | |
| Parlier | Research | CECERT | 8/31/00 | ARB | NO2/PAN | 0.171 | 0.161 | -5.8% | |
| Parlier | Research | DRI | 8/31/00 | ARB | NOY | 0.177 | 0.189 | 6.6% | |
| Parlier | Research | DRI | 8/31/00 | ARB | NOY | 0.392 | 0.415 | 6.0% | |
| Parlier | Research | DRI | 8/31/00 | ARB | NOY* | 0.177 | 0.188 | 6.4% | |
| Parlier | Research | DRI | 8/31/00 | ARB | NOY* | 0.392 | 0.415 | 5.9% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | Ozone | 0.069 | 0.069 | 0.0% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | Ozone | 0.168 | 0.169 | 0.6% | |
| Parlier | Research | SJVUAPCD | 8/30/00 | ARB | Ozone | 0.380 | 0.386 | 1.6% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | NO | 0.158 | 0.170 | 7.6% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | NO | 0.250 | 0.273 | 9.3% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | NO | 0.408 | 0.438 | 7.5% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | NO2 | 0.064 | 0.070 | 9.2% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | NO2 | 0.148 | 0.159 | 7.6% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | NO2 | 0.373 | 0.400 | 7.3% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | NOy | 0.158 | 0.170 | 7.8% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | NOy | 0.250 | 0.273 | 9.2% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | NOy | 0.408 | 0.437 | 7.0% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | Ozone | 0.067 | 0.063 | -6.0% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | Ozone | 0.165 | 0.158 | -4.2% | |
| Patterson Pass | S2 | DRI | 8/16/00 | ARB | Ozone | 0.373 | 0.360 | -3.5% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | NO | 0.173 | 0.175 | 1.1% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | NO | 0.277 | 0.279 | 0.6% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | NO | 0.462 | 0.463 | 0.2% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | NO2 | 0.068 | 0.067 | -1.5% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | NO2 | 0.173 | 0.171 | -1.2% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | NO2 | 0.395 | 0.392 | -0.9% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | NOy | 0.173 | 0.176 | 1.5% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | NOy | 0.277 | 0.279 | 0.6% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | NOy | 0.462 | 0.465 | 0.6% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | Ozone | 0.066 | 0.065 | -1.5% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | Ozone | 0.171 | 0.168 | -1.8% | |
| Piedras Blancas | S1 | DRI | 7/11/00 | ARB | Ozone | 0.388 | 0.384 | -1.0% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | NO | 0.175 | 0.183 | 4.6% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | NO | 0.289 | 0.299 | 3.5% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | NO | 0.466 | 0.483 | 3.6% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | NO2 | 0.062 | 0.063 | 1.6% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | NO2 | 0.166 | 0.170 | 2.4% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | NO2 | 0.359 | 0.368 | 2.5% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | NOy | 0.175 | 0.181 | 3.4% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | NOy | 0.289 | 0.296 | 2.4% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | NOy | 0.466 | 0.478 | 2.6% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | Ozone | 0.067 | 0.069 | 3.0% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | Ozone | 0.166 | 0.174 | 4.8% | |
| Red Hills | S0 | SLOCAPCD | 7/20/00 | ARB | Ozone | 0.379 | 0.399 | 5.3% | |

Table 4-3. Continuous Air Quality Analyzer Audit Results (continued).

| Site | Type | Operator | Date | Auditor | Parameter[2] | Input | Response[1] | % diff | Comments |
|---|---|---|---|---|---|---|---|---|---|
| San Andreas | S1 | ARB | 5/8/00 | ARB | CO | 6.200 | 6.400 | 3.2% | |
| San Andreas | S1 | ARB | 5/8/00 | ARB | CO | 17.600 | 18.000 | 2.3% | |
| San Andreas | S1 | ARB | 5/8/00 | ARB | CO | 40.200 | 39.900 | -0.7% | |
| San Andreas | S1 | DRI | 8/24/00 | ARB | NO | 0.173 | 0.181 | 4.9% | |
| San Andreas | S1 | DRI | 8/24/00 | ARB | NO | 0.282 | 0.297 | 5.4% | |
| San Andreas | S1 | DRI | 8/24/00 | ARB | NO | 0.448 | 0.474 | 5.7% | |
| San Andreas | S1 | DRI | 8/24/00 | ARB | NO2 | 0.066 | 0.069 | 5.1% | |
| San Andreas | S1 | DRI | 8/24/00 | ARB | NO2 | 0.171 | 0.183 | 7.0% | |
| San Andreas | S1 | DRI | 8/24/00 | ARB | NO2 | 0.376 | 0.400 | 6.4% | |
| San Andreas | S1 | DRI | 8/24/00 | ARB | NOy | 0.173 | 0.182 | 5.3% | |
| San Andreas | S1 | DRI | 8/24/00 | ARB | NOy | 0.282 | 0.299 | 6.0% | |
| San Andreas | S1 | DRI | 8/24/00 | ARB | NOy | 0.448 | 0.475 | 6.0% | |
| San Andreas | S1 | ARB | 5/8/00 | ARB | Ozone | 0.068 | 0.062 | -8.8% | |
| San Andreas | S1 | ARB | 5/8/00 | ARB | Ozone | 0.176 | 0.164 | -6.8% | |
| San Andreas | S1 | ARB | 5/8/00 | ARB | Ozone | 0.401 | 0.377 | -6.0% | |
| San Martin | S0 | DRI | 8/16/00 | BAAQMD | NO | | | | Pump failure - instrument not operating |
| San Martin | S0 | DRI | 8/16/00 | BAAQMD | NO | | | | Pump failure - instrument not operating |
| San Martin | S0 | DRI | 8/16/00 | BAAQMD | NO | | | | Pump failure - instrument not operating |
| San Martin | S0 | DRI | 8/16/00 | BAAQMD | NO2 | 0.063 | 0.016 | **-74.6%** | Pump failure - instrument not operating |
| San Martin | S0 | DRI | 8/16/00 | BAAQMD | NO2 | 0.159 | 0.039 | **-75.5%** | Pump failure - instrument not operating |
| San Martin | S0 | DRI | 8/16/00 | BAAQMD | NO2 | 0.356 | 0.088 | **-75.3%** | Pump failure - instrument not operating |
| San Martin | S0 | DRI | 8/16/00 | BAAQMD | NOy | | | | Pump failure - instrument not operating |
| San Martin | S0 | DRI | 8/16/00 | BAAQMD | NOy | | | | Pump failure - instrument not operating |
| San Martin | S0 | DRI | 8/16/00 | BAAQMD | NOy | | | | Pump failure - instrument not operating |
| San Martin | S0 | BAAQMD | 8/16/00 | BAAQMD | Ozone | 0.063 | 0.064 | 1.6% | |
| San Martin | S0 | BAAQMD | 8/16/00 | BAAQMD | Ozone | 0.159 | 0.158 | -0.6% | |
| San Martin | S0 | BAAQMD | 8/16/00 | BAAQMD | Ozone | 0.356 | 0.353 | -0.8% | |
| Sloughhouse | S0 | DRI | 10/11/00 | ARB | NO | 0.177 | 0.207 | **16.9%** | Instrument off line |
| Sloughhouse | S0 | DRI | 10/11/00 | ARB | NO | 0.280 | 0.325 | **15.9%** | Instrument off line |
| Sloughhouse | S0 | DRI | 10/11/00 | ARB | NO | 0.354 | 0.405 | **14.4%** | Instrument off line |
| Sloughhouse | S0 | DRI | 10/11/00 | ARB | NO2 | 0.064 | 0.072 | **12.6%** | Instrument off line |
| Sloughhouse | S0 | DRI | 10/11/00 | ARB | NO2 | 0.167 | 0.189 | **13.4%** | Instrument off line |
| Sloughhouse | S0 | DRI | 10/11/00 | ARB | NO2 | 0.333 | 0.377 | **13.3%** | Instrument off line |
| Sloughhouse | S0 | DRI | 10/11/00 | ARB | NOy | 0.177 | 0.208 | **17.4%** | Instrument off line |
| Sloughhouse | S0 | DRI | 10/11/00 | ARB | NOy | 0.280 | 0.327 | **16.7%** | Instrument off line |
| Sloughhouse | S0 | DRI | 10/11/00 | ARB | NOy | 0.354 | 0.407 | **15.1%** | Instrument off line |
| Sloughhouse | S0 | SMAQMD | 10/11/00 | ARB | Ozone | 0.069 | 0.070 | 1.4% | |
| Sloughhouse | S0 | SMAQMD | 10/11/00 | ARB | Ozone | 0.177 | 0.177 | 0.0% | |
| Sloughhouse | S0 | SMAQMD | 10/11/00 | ARB | Ozone | 0.399 | 0.398 | -0.3% | |
| Sunol | Research | DRI | 7/26/00 | ARB | (NO) | 0.175 | 0.186 | 6.5% | |
| Sunol | Research | DRI | 7/26/00 | ARB | (NO) | 0.279 | 0.295 | 5.6% | |
| Sunol | Research | DRI | 7/26/00 | ARB | (NO) | 0.451 | 0.481 | 6.6% | |
| Sunol | Research | DRI | 7/26/00 | ARB | (NO2) | 0.066 | 0.071 | 6.9% | |
| Sunol | Research | DRI | 7/26/00 | ARB | (NO2) | 0.168 | 0.177 | 5.6% | |
| Sunol | Research | DRI | 7/26/00 | ARB | (NO2) | 0.379 | 0.398 | 5.1% | |
| Sunol | Research | DRI | 7/26/00 | ARB | (NOx) | 0.175 | 0.186 | 6.2% | |
| Sunol | Research | DRI | 7/26/00 | ARB | (NOx) | 0.279 | 0.295 | 5.6% | |
| Sunol | Research | DRI | 7/26/00 | ARB | (NOx) | 0.451 | 0.481 | 6.6% | |
| Sunol | Research | DRI | 7/26/00 | ARB | CO | 3.300 | 3.341 | 1.2% | |
| Sunol | Research | DRI | 7/26/00 | ARB | CO | 7.200 | 7.306 | 1.5% | |
| Sunol | Research | DRI | 7/26/00 | ARB | CO | 9.200 | 9.289 | 1.0% | |
| Sunol | Research | DRI | 8/15/00 | PES | CO2 | 234 | 218 | -6.9% | |
| Sunol | Research | DRI | 8/15/00 | PES | CO2 | 448 | 429 | -4.2% | |
| Sunol | Research | DRI | 8/15/00 | PES | CO2 | 635 | 618 | -2.8% | |
| Sunol | Research | CECERT | 8/15/00 | PES | NO2/PAN | 0.028 | 0.029 | 4.3% | |
| Sunol | Research | CECERT | 8/15/00 | PES | NO2/PAN | 0.076 | 0.077 | 1.9% | |
| Sunol | Research | CECERT | 8/15/00 | PES | NO2/PAN | 0.138 | 0.150 | 8.6% | |
| Sunol | Research | DRI | 8/15/00 | PES | NOY | 0.063 | 0.059 | -6.8% | |
| Sunol | Research | DRI | 8/15/00 | PES | NOY | 0.160 | 0.145 | -9.2% | |
| Sunol | Research | DRI | 8/15/00 | PES | NOY | 0.397 | 0.365 | -8.0% | |
| Sunol | Research | DRI | 8/15/00 | PES | NOY* | 0.063 | 0.059 | -5.8% | |
| Sunol | Research | DRI | 8/15/00 | PES | NOY* | 0.160 | 0.148 | -7.5% | |
| Sunol | Research | DRI | 8/15/00 | PES | NOY* | 0.397 | 0.370 | -6.7% | |

Table 4-3. Continuous Air Quality Analyzer Audit Results (continued).

| Site | Type | Operator | Date | Auditor | Parameter[2] | Input | Response[1] | % diff | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Sunol | Research | DRI | 7/26/00 | ARB | Ozone | 0.068 | 0.067 | -1.2% | |
| Sunol | Research | DRI | 7/26/00 | ARB | Ozone | 0.168 | 0.165 | -1.7% | |
| Sunol | Research | DRI | 7/26/00 | ARB | Ozone | 0.379 | 0.376 | -0.7% | |
| Sutter Buttes | S1 | ARB | 8/25/00 | ARB | Ozone | 0.068 | 0.068 | 0.0% | |
| Sutter Buttes | S1 | ARB | 8/25/00 | ARB | Ozone | 0.170 | 0.170 | 0.0% | |
| Sutter Buttes | S1 | ARB | 8/25/00 | ARB | Ozone | 0.389 | 0.390 | 0.3% | |
| Trimmer | S2 | DRI | 8/3/00 | ARB | NO | 0.167 | 0.175 | 4.7% | |
| Trimmer | S2 | DRI | 8/3/00 | ARB | NO | 0.274 | 0.284 | 3.7% | |
| Trimmer | S2 | DRI | 8/3/00 | ARB | NO | 0.454 | 0.475 | 4.5% | |
| Trimmer | S2 | DRI | 8/3/00 | ARB | NO2 | 0.066 | 0.069 | 4.0% | |
| Trimmer | S2 | DRI | 8/3/00 | ARB | NO2 | 0.178 | 0.183 | 3.0% | |
| Trimmer | S2 | DRI | 8/3/00 | ARB | NO2 | 0.388 | 0.398 | 2.5% | |
| Trimmer | S2 | CECERT | 8/3/00 | ARB | NO2/PAN | 0.071 | 0.062 | **-13.0%** | Audit results in question |
| Trimmer | S2 | CECERT | 8/3/00 | ARB | NO2/PAN | 0.189 | 0.206 | **8.8%** | Audit results in question |
| Trimmer | S2 | DRI | 8/3/00 | ARB | NOy | 0.167 | 0.175 | 4.8% | |
| Trimmer | S2 | DRI | 8/3/00 | ARB | NOy | 0.274 | 0.284 | 3.7% | |
| Trimmer | S2 | DRI | 8/3/00 | ARB | NOy | 0.454 | 0.473 | 4.1% | |
| Trimmer | S2 | DRI | 8/3/00 | ARB | Ozone | 0.067 | 0.060 | **-9.9%** | Audit results in question |
| Trimmer | S2 | DRI | 8/3/00 | ARB | Ozone | 0.166 | 0.152 | **-8.7%** | Audit results in question |
| Trimmer | S2 | DRI | 8/3/00 | ARB | Ozone | 0.379 | 0.346 | **-8.7%** | Audit results in question |
| Turlock | S1 | SJVUAPCD | 9/11/00 | ARB | (NO2) | 0.064 | 0.061 | -4.7% | |
| Turlock | S1 | SJVUAPCD | 9/11/00 | ARB | (NO2) | 0.178 | 0.163 | -8.4% | |
| Turlock | S1 | SJVUAPCD | 9/11/00 | ARB | (NO2) | 0.363 | 0.333 | -8.3% | |
| Turlock | S1 | SJVUAPCD | 9/11/00 | ARB | CO | 7.2 | 7.200 | 0.0% | |
| Turlock | S1 | SJVUAPCD | 9/11/00 | ARB | CO | 18.8 | 18.400 | -2.1% | |
| Turlock | S1 | SJVUAPCD | 9/11/00 | ARB | CO | 38 | 37.300 | -1.8% | |
| Turlock | S1 | DRI | 9/11/00 | ARB | NO | 0.173 | 0.188 | 9.0% | |
| Turlock | S1 | DRI | 9/11/00 | ARB | NO | 0.28 | 0.309 | 10.4% | |
| Turlock | S1 | DRI | 9/11/00 | ARB | NO | 0.438 | 0.485 | 10.7% | |
| Turlock | S1 | DRI | 9/11/00 | ARB | NO2 | 0.064 | 0.068 | 7.0% | |
| Turlock | S1 | DRI | 9/11/00 | ARB | NO2 | 0.174 | 0.192 | 10.4% | |
| Turlock | S1 | DRI | 9/11/00 | ARB | NO2 | 0.371 | 0.411 | 10.7% | |
| Turlock | S1 | DRI | 9/11/00 | ARB | NOy | 0.173 | 0.189 | 9.3% | |
| Turlock | S1 | DRI | 9/11/00 | ARB | NOy | 0.28 | 0.309 | 10.5% | |
| Turlock | S1 | DRI | 9/11/00 | ARB | NOy | 0.438 | 0.484 | 10.4% | |
| Turlock | S1 | SJVUAPCD | 9/11/00 | ARB | Ozone | 0.066 | 0.064 | -3.0% | |
| Turlock | S1 | SJVUAPCD | 9/11/00 | ARB | Ozone | 0.171 | 0.165 | -3.5% | |
| Turlock | S1 | SJVUAPCD | 9/11/00 | ARB | Ozone | 0.387 | 0.374 | -3.4% | |
| White Cloud | S1 | DRI | 9/6/00 | ARB | NO | 0.168 | 0.181 | 7.7% | |
| White Cloud | S1 | DRI | 9/6/00 | ARB | NO | 0.265 | 0.288 | 8.7% | |
| White Cloud | S1 | DRI | 9/6/00 | ARB | NO | 0.416 | 0.445 | 6.9% | |
| White Cloud | S1 | DRI | 9/6/00 | ARB | NO2 | 0.059 | 0.061 | 3.5% | |
| White Cloud | S1 | DRI | 9/6/00 | ARB | NO2 | 0.158 | 0.169 | 6.7% | |
| White Cloud | S1 | DRI | 9/6/00 | ARB | NO2 | 0.343 | 0.374 | 8.9% | |
| White Cloud | S1 | DRI | 9/6/00 | ARB | NOy | 0.168 | 0.181 | 7.6% | |
| White Cloud | S1 | DRI | 9/6/00 | ARB | NOy | 0.265 | 0.288 | 8.8% | |
| White Cloud | S1 | DRI | 9/6/00 | ARB | NOy | 0.416 | 0.445 | 6.9% | |
| White Cloud | S1 | ARB | 9/6/00 | ARB | Ozone | 0.066 | 0.066 | 0.0% | |
| White Cloud | S1 | ARB | 9/6/00 | ARB | Ozone | 0.173 | 0.172 | -0.6% | |
| White Cloud | S1 | ARB | 9/6/00 | ARB | Ozone | 0.395 | 0.396 | 0.3% | |

[1]Response values corrected using operator supplied factors.

[2]NOy = NOy channel of NOy analyzer
NOY = NOy channel of Nitric Acid analyzer
NOY* = NOy - Nitric Acid channel of Nitric Acid analyzer
(NO), (NOx), and (NO2) refer to traditional NO/NOx analyzer

Table 4-4. Summary of Continuous Air Quality Audit Results (percent differences).

| | | Surface | | | | | | Aircraft | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DRI | T&B | CECERT | STI | Districts | All | STI | UCD | TVA | PNNL | All |
| Ozone | Average difference | -2.9% | -1.1% | | 2.7% | -0.8% | -1.4% | 2.9% | 0.7% | -13.5% | -0.4% | -1.1% |
| | Standard deviation | 2.2% | 7.9% | | 1.2% | 3.3% | 3.7% | 1.8% | 2.6% | 0.3% | 0.8% | 6.1% |
| | Number of analyzers | 8 | 2 | | 1 | 12 | 23 | 2 | 2 | 1 | 1 | 6 |
| NO | Average difference | 4.4% | 5.2% | | -0.4% | 3.9% | 4.2% | -0.9% | -1.8% | | | -1.3% |
| | Standard deviation | 3.8% | 7.4% | | 0.2% | 0.6% | 4.2% | 5.8% | 3.5% | | | 4.9% |
| | Number of analyzers | 14 | 2 | | 1 | 1 | 18 | 3 | 2 | | | 5 |
| NOy | Average difference | 4.3% | 6.1% | | 1.6% | 2.8% | 3.1% | -1.5% | -0.9% | | | -1.3% |
| | Standard deviation | 3.7% | 5.8% | | 0.1% | 0.5% | 4.4% | 6.4% | 4.4% | | | 5.5% |
| | Number of analyzers | 14 | 2 | | 1 | 1 | 18 | 3 | 2 | | | 5 |
| NO2 | Average difference | 3.2% | 6.2% | | -5.0% | 2.2% | 3.0% | 0.1% | 2.8% | | | 1.2% |
| | Standard deviation | 4.7% | 4.6% | | 1.2% | 0.5% | 4.9% | 10.8% | 3.5% | | | 8.5% |
| | Number of analyzers | 14 | 2 | | 1 | 1 | 18 | 3 | 2 | | | 5 |
| (NO) | Average difference | 2.2% | | | | | 2.2% | | | | | |
| | Standard deviation | 5.5% | | | | | 5.5% | | | | | |
| | Number of analyzers | 2 | | | | | 2 | | | | | |
| (NOx) | Average difference | 2.4% | | | | | 2.4% | | | | | |
| | Standard deviation | 5.2% | | | | | 5.2% | | | | | |
| | Number of analyzers | 2 | | | | | 2 | | | | | |
| (NO2) | Average difference | 1.7% | | | | 0.6% | 0.9% | | | | | |
| | Standard deviation | 5.7% | | | | 4.9% | 5.0% | | | | | |
| | Number of analyzers | 2 | | | | 4 | 6 | | | | | |
| NO2/PAN | Average difference | | | 2.3% | | | 2.3% | | | | | |
| | Standard deviation | | | 4.0% | | | 4.0% | | | | | |
| | Number of analyzers | | | 3 | | | 3 | | | | | |
| NOY* | Average difference | -1.9% | | | | | -1.9% | | | | | |
| | Standard deviation | 5.8% | | | | | 5.8% | | | | | |
| | Number of analyzers | 3 | | | | | 3 | | | | | |
| NOY | Average difference | -2.2% | | | | | -2.2% | | | | | |
| | Standard deviation | 6.4% | | | | | 6.4% | | | | | |
| | Number of analyzers | 3 | | | | | 3 | | | | | |
| CO | Average difference | -2.5% | | | | | -1.4% | 1.9% | | | | 1.9% |
| | Standard deviation | 4.9% | | | | | 4.1% | 0.7% | | | | 0.7% |
| | Number of analyzers | 3 | | | | | 4 | 1 | | | | 1 |
| CO2 | Average difference | -1.6% | | | | | -1.6% | | | | | |
| | Standard deviation | 2.8% | | | | | 2.8% | | | | | |
| | Number of analyzers | 3 | | | | | 3 | | | | | |

NO, NOy, and NO2 refer to channels of NOy analyzer
NOY = NOy channel of Nitric Acid analyzer
NOY* = NOy - Nitric Acid channel of Nitric Acid analyzer
(NO), (NOx), and (NO2) refer to channels of traditional NO/NOx analyzer

Resolution: Given the magnitude of the effort required to set up and maintain the supplemental air monitoring network, DRI frequently chose to not adjust an analyzer's response if the response was stable, with the intent of adjusting the collected data during post-processing. Adjusting the audit results using DRI-supplied factors obtained from routine calibrations of the analyzers brought the audit results to –1.7%, -1.8%, and –1.0% from true at the low, middle and high levels, respectively.

Problem: While meeting all audit criteria, the audit results for the ozone analyzer showed the analyzer responding between 8% and 10% low. This is notably lower than most other ozone audit results for this project.

Resolution: Ozone audits for this week (three audits performed in three days using the same equipment) all showed the same 8% to 10% difference. Calibrations and zero/span checks for all three of the affected ozone analyzers showed no problems and an essential one-to-one comparison with a transfer standard. Given this information, the representativeness of these three ozone audits is in question.

**Lake Chabot**

Problem: The response of the ozone analyzer was extremely low – responding by less than half to the audit concentrations. The site technician had noted this low response and had calculated a correction factor of 2.1 for the collected ozone data, which was consistent with the audit results.

Resolution: To investigate the problem, audit concentrations were also input to the analyzer bypassing the analyzer's inlet filter. Without the inlet filter, the analyzer's sample flow rates increased from 0.7 to 1.1 lpm, and the span response immediately increased by 80%. Upon investigation, the high pressure drop across the filter holder was discovered to be due to an incorrect configuration of the filter holder parts. This high pressure drop, coupled with the known failure of the analyzers pressure/temperature compensation feature, caused the low response. The filter holder was fixed and the response increased as expected, though response was still about 19% low. Data collected prior to the audit may be difficult to validate.

Problem: The response of the $NO/NO_y$ analyzer was approximately 22% low.

Resolution: A check of station calibrator revealed that the calibrator dilution flow rate was about 33% lower than indicated, resulting in mis-calibration of the analyzer. The analyzer was recalibrated, and data prior to the calibration was corrected accordingly.

**Lambie Road**

No problems noted.

**Livermore**

Problem: The original Bay Area AQMD audit results for the $NO/NO_y$ analyzer showed the analyzer to be operating 15.2%, 10.7% and 7.4% for the high, middle, and low audit $NO_2$ concentrations, respectively.

Resolution: A review of the audit data showed that the concentrations of the ozone used to created the $NO_2$ concentrations likely changed between measurement using the ozone transfer standard and use during GPT. Calculating $NO_2$ concentrations using the ARB equations produced audit results of 1.8%, 1.6%, and 2.7% for the high, middle and low concentrations, respectively. These are consistent with QC checks and calibrations for this analyzer, and are consequently used in the summary tables.

**McKitterick**

Problem: While meeting all audit criteria, the audit results for the ozone analyzer showed the analyzer responding between 8% and 10% low. This is notably lower than most other ozone audit results for this project.

Resolution: Ozone audits for this week (three audits performed in three days using the same equipment) all showed the same 8% to 10% difference. Calibrations and zero/span checks for all three of the affected ozone analyzers showed no problems and an essential one-to-one comparison with a transfer standard. Given this information, the representativeness of these three ozone audits is in question.

Problem: $NO_2$ audit results for the $NO/NO_y$ analyzer showed good agreement with ARB inputs. However, the results for the NO and $NO_y$ channels fail the ±15% audit criteria. Since the ARB is primarily concerned with the $NO_2$ response (the criteria pollutant) the poorer NO and $NO_y$ results were not presented in any ARB reports.

Action: The NO and $NO_y$ audit results show a non-linear response that is not seen in any other $NO/NO_y$ audits conducted for this study, except at the Granite Bay site, where the audit results are also in question. In addition, all calibrations and checks performed on this analyzer show no problems with linearity. In fact, this analyzer was viewed by the operator as one of the most trouble-free analyzers in the CCOS network. In the absence of any collaborating data, the representativeness of the audit results for the site are in question.

**Red Hills**

No problems noted.

**San Martin**

Problem: The response of the $NO/NO_y$ analyzer was approximately 75% low at the time of the audit.

Resolution: The low response was confirmed by the station technician. The problem was later traced to a failing sample pump. The pump was replaced, restoring the analyzer to normal operation.

**Shasta Lake**

No problems noted.

**Sloughhouse**

Problem: The audit found the $NO/NO_y$ analyzer to be operating 39.0%, 38.9% and 37.5% for the high, middle, and low audit $NO_2$ concentrations, respectively. The audit criteria is 15%.

Resolution: The audit of this analyzer was conducted after the end of the study, and QC checks of the analyzer had been suspended for two weeks. Adjusting the audit results using DRI-supplied factors obtained from the final calibration of the analyzer conducted two weeks prior to the audit brought the $NO_2$ audit results to 12.6%, 14.4%, and 13.3% for the high, middle, and low audit $NO_2$ concentrations, respectively. Response for the NO and $NO_y$ channels remained slightly above the 15% criteria. However, since there were no QC data to tie the audit results to the final calibration, these figures are inconclusive. Given the good results of the QC checks and calibration conducted at this site and the fact that these checks and calibrations adequately prevented any other failures of the audit criteria within the network, the NO/$NO_y$ data collected from the Sloughhouse site is considered valid.

## S1 Sites

### Angiola

Problem: The NO/$NO_y$ analyzer was found to be inoperable when initially audited on August 10, 2000. The performance audit of the NO/$NO_y$ analyzer on August 16, 2000 found the $NO_2$ converter efficiency to be at 92.7%. This is below the 96% control limit.

Resolution: This analyzer experience repeated problems with lower than expected converter efficiency, and the converters were replaced several times over the course of its operation. STI has decided to accept data as reported unless the converter efficiency fell below 85%.

### Bodega Bay

No problems noted.

### Elk Grove (Bruceville)

No problems noted.

### Piedras Blancas

No problems noted.

### San Andreas

No problems noted.

### San Leandro

No problems noted.

### Sutter Buttes

No problems noted.

### Turlock

No problems noted.

### White Cloud

No problems noted.

### S2 Sites

### Arvin

No problems noted.

### Bethyl Island

No problems noted.

### Pacheco Pass

Problem: The audit found the NO/$NO_y$ analyzer operating 15.9% and 15.8% from true at the low and high $NO_2$ levels, respectively.

Resolution: Given the magnitude of the effort required to set up and maintain the supplemental air monitoring network, DRI frequently chose to not adjust an analyzer's response if the response was stable, with the intent of adjusting the collected data during post-processing. Adjusting the audit results using DRI-supplied factors obtained from routine calibrations of the analyzers brought the $NO_2$ audit results to 2.1%, 1.9%, and 3.0% from true at the low, middle and high levels, respectively.

### Patterson Pass

Problem: The NO/$NO_y$ analyzer read 15.6% high at the low $NO_2$ audit point, which exceeds site criteria for this method.

Resolution: Given the magnitude of the effort required to set up and maintain the supplemental air monitoring network, DRI frequently chose to not adjust an analyzer's response if the response was stable, with the intent of adjusting the collected data during post-processing. Adjusting the audit results using DRI-supplied factors obtained from routine calibrations of the analyzers brought the $NO_2$ audit results to within 9.2%.

### Trimmer

Problem: The audit found the ozone analyzer operating -17.9%, -16.9%, and -16.9% from true at the low, middle, and high audit levels, respectively, failing the audit criteria of ±15%.

Resolution: Given the magnitude of the effort required to set up and maintain the supplemental air monitoring network, DRI frequently chose to not adjust an analyzer's response if the response was stable, with the intent of adjusting the collected data during post-processing. Adjusting the audit results using DRI-supplied factors obtained from routine calibrations of the analyzers brought the audit results to –9.9%, -8.7%, and –8.7% from true at the low, middle, and high audit levels, respectively.

Problem: While meeting all audit criteria, the audit results for the ozone analyzer showed the analyzer responding between 8% and 10% low. This is notably lower than most other ozone audit results for this project.

Resolution: Ozone audits for this week (three audits performed in three days at McKitterick, Kettleman City, and Trimmer using the same equipment) all showed the same 8% to 10% difference. Calibrations and zero/span checks for all three of the affected ozone analyzers showed no problems and an essential one-to-one comparison with a transfer standard. Given this information, the representativeness of these three ozone audits is in question.

Problem: This was the ARB's initial chance to audit the $NO_2$/PAN analyzers operated by CECERT. The audit results were atypical of the results obtained for this analyzer, and did compare well with data with QC data obtained immediately before and after the audit. In addition, CECERT notes indicated that the response of the analyzer started to drop after the audit, and notes regarding the number of audit points conflict with those reported by ARB.

Resolution: Given the above, the representativeness of the audit is in question.

## Research Sites

### Granite Bay

Problem: While the initial ARB report showed the NO/$NO_y$ analyzer results to be within the audit criteria, adjustment of the results using the supplied DRI factors put the results outside of the ±15% criteria.

Resolution: The results for this audit are unusual in that they appear to show a non-linear response for the NO and $NO_y$ channels. It appears that there may have been a problem with the input of the audit concentrations. This is supported by the fact that the response of the nitric acid analyzer, which was audited concurrently, exhibits exactly the same non-linear response. Both analyzers were audited two weeks later by Parsons, with good results and linear responses. The representativeness of the original ARB audits for both the NO/$NO_y$ and nitric acid analyzers is in question.

Problem: The temperature sensor for the R&P 8400N continuous nitrate analyzer was located inside the site. The sensor should have been, in fact, measuring the temperature of the ambient air. However, the sensor was not weatherproof, and it was determined that it should be located indoors rather than risk a total loss of processed nitrate data in the event that the sensor failed because exposure to moisture. If ambient temperature is a critical parameter in the calculation of nitrate values, the data should be adjusted using available ambient temperature data.

Resolution: Data were corrected based on ambient temperature data obtained from other sources at the site.

### Parlier

Problem: The NMHC analyzer at the Parlier site failed the ARB's audit on August 31, 2000. The analyzer was found to be operating outside of the control limits at 32.4%, 32.0%, and 35.0% from true at the high, middle, and low points, respectively.

Resolution: The District indicated that the instrument had been experiencing continuous problems. The instrument was sent to the manufacturer for repairs. Data prior to its return are considered invalid.

Problem: The date on the $NO_2$/PAN computer was incorrect. It was set to August 19 instead of August 8. If the data files from the computer are used, this needs to be taken into account.

Resolution: $NO_2$/PAN data were recorded on a separate data logger. Thus, the date was not critical.

Problem: The CO analyzer at the Parlier site failed the ARB's audit on August 31, 2000. The analyzer was found to be operating outside the ±15% control limit at 15.4% from true at the low audit point.

Resolution: Given the magnitude of the effort required to set up and maintain the supplemental air monitoring network, DRI frequently chose to not adjust an analyzer's response if the response was stable, with the intent of adjusting the collected data during post-processing. Adjusting the audit results using DRI-supplied factors obtained from routine calibrations of the analyzers brought the audit results to -12.9%, -6.4%, and -2.7% from true at the low, middle and high levels, respectively.

**Sunol**

Problem: The residence time for the ozone sample inlet time was estimated to be 21.4 seconds. US EPA 40 CFR, Part 58, Appendix E, Section 9 requires residence time not to exceed 20 seconds.

Resolution: The through-the-probe audit showed that the sampling system was reporting concentrations to within 2.1% of true, indicating that the longer than normal sample inlet time had an insignificant affect on the data. No further action was required.

Problem: The temperature sensor for the R&P 8400N continuous nitrate analyzer was located inside the site. The sensor should have been, in fact, measuring the temperature of the ambient air. However, the sensor was not weatherproof, and it was determined that it should be located indoors rather than risk a total loss of processed nitrate data in the event that the sensor failed because exposure to moisture. If ambient temperature is a critical parameter in the calculation of nitrate values, the data should be adjusted using available ambient temperature data.

Resolution: Data were corrected based on ambient temperature data obtained from other sources at the site.

## Aircraft

It was originally anticipated that a summary of the side-by-side comparison flights conducted as part of the aircraft QA would be included in this report. However, data from the comparison flights were still not available from the majority of the aircraft contractors at the writing of this report. A brief summary of the comparisons will be presented at a later date, and the responsibility of performing a comprehensive review of the comparison data will fall on the Level II data reviewers.

### Gulfstream (Fresno)

Problem: The ozone sampler failed the audit. The analyzer was found to be operating outside the control limits at –20.3%, -20.8%, and –21.4% from true at low, mid, and high audit points, respectively.

Resolution: Mr. Richard Barchet from Pacific Northwest National Laboratory indicated the staff used the analyzer's display instead of the data acquisition system's converted readings during the audit. The converted values from the DAS for the audit points should be: 0.374 ppm, 0.168 ppm, and 0.069 ppm at the high, middle, and low point, respectively. The analyzer therefore passed the audit.

Problem: At the time of the audit (July 6, 2000), the NO/NOy analyzer was found inoperable.

Resolution: Mr. Richard Barchet from Pacific Northwest National Laboratory indicated that the analyzer was repaired and returned to service on July 7, 2000. Zero and span checks were conducted from July 7 to July 12, 2000. However, an NIST traceable standard was unavailable for field calibrations.

### Cessna 172 (UC Davis)

No problems noted.

### Cessna 182 (UC Davis)

No problems noted.

### Cessna 182 (STI)

No problems noted.

### Piper Aztec (STI)

No problems noted.

### TVA Twin Otter (Monterey)

Problem: At the time of the audit (July 27, 2000), the $SO_2$ analyzer and all four $NO/NO_y$ analyzers were found to be inoperable.

Resolution: The scheduled audit of this aircraft occurred prior to TVA's completed checkout of its operation, and prior to any study flights. All analyzers were made operational prior to the study flights. A review of the QA/QC procedures implemented for this aircraft showed them to be NIST-traceable and sufficient for the collection of accurate data. All data collected by this aircraft are considered valid.

**Miscellaneous Sites**

**Camp Parks**

Problem: The analyzer at this site displayed an unusual response characteristic. Any time the analyzer inlet filter was changed, the analyzer responded with a 100 - 200 ppb spike, which would then very slowly return to lower concentrations (ambient levels or zero check), taking up to half an hour to stabilize at the lower/zero concentration. This long response time could be eliminated by subjecting the analyzer to a high concentration span, after which the response time was basically normal. This characteristic had been noted consistently by the site operator, and was demonstrated during the audit.

Resolution: This unusually slow response time appeared to occur only when the filter was changed, and therefore it did not appear that ambient data were being affected. However, the data should be reviewed with this unusual response characteristic in mind.

# SECTION 5

# PARTICULATE MATTER, DISCRETE SAMPLES, AND VISIBILITY

## 5.1 DESCRIPTION OF AUDIT EQUIPMENT

For flow rates between 0.02 lpm and 30 lpm, a Gilian Gilibrator 2 primary flowmeter was used to audit the sampler flow rates. This flowmeter is a portable, low resistance, primary flowmeter that reports flow rates at ambient conditions. The Gilibrator flowmeter is a NIST-certified primary standard; consequently, it does not require any further certification. However, the flowmeter is returned to the manufacturer annually for recertification. An electronic thermometer calibrated against a NIST-traceable thermometer and an Ultimeter 3 electronic barometer were used for the temperature sensor and barometric pressure sensor audits.

## 5.2 SYSTEM AUDIT PROCEDURES

The system audit of particulate samplers consisted of an inspection to determine if the samplers were operational and clean, and the spatial distribution of the samplers at each site conformed to the siting criteria. Specifically designed system audit forms were used to document the system audit results and deviations from any criteria are noted in the audit reports. The subjects that were addressed during the system audits included:

- Network design and siting
  - network size and design
  - sensor exposure
  - review of station
- Resources and facilities
  - instruments and methods
  - staff and facilities
  - standards and traceability
- Quality assurance and quality control
  - status of quality assurance program
  - audit participation
  - precision and accuracy checks

An evaluation of the quality assurance/quality control plan procedures including preventive maintenance was performed. Reviews of calibration records and maintenance logs were checked for consistency, frequency and accuracy. Equipment settings including flow rates and zero/span settings were evaluated to determine if ranges were acceptable.

Additionally, once the system audits of all sites in a network were complete, the auditor checked for possible differences in operation among the various sites.

## 5.3 PERFORMANCE AUDIT PROCEDURES

### Parsons Engineering Science

General Performance Audit Procedures for Air Samplers

Sampler flow rates were audited using the appropriate field standard. Measured audit flow rates were compared against the measured or nominal flow rates supplied by the site technicians. Site comparison flow rates should correspond to the flow rates used to calculate sample concentrations. The ambient temperature and atmospheric pressure were recorded for each flow rate audited, allowing audit flow rates to be reported in either volumetric or standard units, using the following equations:

$$Q_{std} = Q_{vol} \text{ x } (P_a / 29.92) \text{ x } (298 / T_a)$$

$$Q_{vol} = Q_{std} \text{ x } (29.92 / P_a) \text{ x } (T_a / 298)$$

where $Q_{std}$ is the flow rate at standard conditions (P = 29.92” Hg, T = 298°C)

$Q_{vol}$ is the volumetric flow rate

$P_a$ is the ambient pressure in inches of Hg

$T_a$ is the ambient temperature in °C

An audit thermometer calibrated against an NIST-traceable thermometer and a transfer standard barometer were used to take readings of ambient temperature and barometric pressure, which are required for the flow calculations. The flow appropriate units are used when comparing audit and site flow rates.

Whenever possible, additional flow measurements were made to check the sample system for leaks. In general, this involved measuring the flow at the sampler inlet or immediately above the leak-prone area, in addition to the flow at the collection media. Any noted difference between these upstream and downstream measurements indicates a leak within the system. Taking into account the accuracy and precision of the flow measuring devices, any difference between upstream and downstream flows of greater than 2% of the upstream flow was considered indicative of a leak.

In addition to the above measurements, flow rates of any other component vital for the operation of the sampler was checked. This included by-pass and inlet flow rates for samplers equipped with size selective inlets.

Radiance Research Nephelometers

The nephelometers were challenged using zero air and SUVA gas. The sample fan and inlet were disconnected from the nephelometer chamber, and the chamber openings were capped. The cap for the uppermost opening contained a small hole to allow venting of the audit gases. The chamber was then flooded with zero air generated using a 0.4 micron HEPA filter and a 7 lpm pump. After obtaining a stable zero reading, the chamber was flooded with SUVA gas at 4 lpm to provide an upscale reading. The instrument's response to the SUVA gas was then compared against the theoretical value for the gas at the current ambient conditions (against both the instrument's calculated value and the value independently calculated by the auditor).

After the zero/span check, the instrument was returned to its original sampling configuration. With the sample shelter open, the instrument's internal temperature and relative humidity sensors were audited by comparing them with the current ambient readings obtained from a certified motor aspirated psychrometer. The instrument's pressure setting was compared against a digital barometer. During the initial round of audits in June 2000, checks of the temperature and relative humidity sensors were not conducted. It was later realized that this was an important part of the audit. Thus, for the June 2000 audits, an alternate audit method was used to verify the performance of the sensors. A Hobo Pro portable temperature / RH measurement system was taken by the site technicians and collocated next to the nephelometer for a period during their regular site visits. The Hobo Pro is equipped with its own data logger, and was certified in field tests prior to deployment for the audit. Temperature and RH readings collected from the nephelometers were then compared with those collected by the Hobo Pro.

### California Air Resources Board

Non-Methane Hydrocarbon Canisters

Through-the-probe performance audits were conducted at each hydrocarbon monitoring site to assess the integrity of the sampling equipment and transport system, and the accuracy of the analytical methods used by the laboratory to measure the ambient concentrations. In a TTP audit, a gaseous mixture of standards prepared by NIST is mixed with purified air under controlled conditions and introduced into the sampling probe inlet of a hydrocarbon sampler. The audit sample is humidified between 55% and 75% using an in-line humidification system. The sample is collected into a stainless steel canister over a 3-hour period and shipped to the laboratory along with regular ambient samples where it is analyzed following standard operating procedures. The laboratory reports the results to the QAS, who in turn calculates the percent difference and reports the final results to the laboratory.

Carbonyl Samplers

Carbonyl sampler through-the-probe (TTP) audits are conducted annually at each Photochemical Assessment Monitoring Site (PAMS) by the QAS staff. A sample of audit gas with known (assigned) concentrations is collected on a carbonyl cartridge for a three-hour period and then analyzed by the laboratory. The sample is run, wherever possible, in conditions duplicating a routine ambient run. The analytical laboratory results are compared with the known concentrations, and a percent bias calculated.

## 5.4 PERFORMANCE AUDIT CRITERIA

Performance audit criteria are consistent with those recommended in the U.S. EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II (USEPA, 1997, 1998). The audit criteria are shown Table 5-1.

Table 5-1. Audit Criteria.

| Variable | Audit Criteria |
|---|---|
| General Sampler Flow Rate Criteria | ±10% |
| NMOC Analysis | ±10% (see discussion below) |
| Carbonyl Analysis | ±10% |
| Nephelometer (Suva gas) | ±10% |

## 5.5 AUDIT RESULTS

Appendix B presents the individual, complete audit reports for each site. The majority of these were generated by the ARB. ARB's original summary of the audits conducted during CCOS is also included in Appendix B.

The following sections discuss problems or issues noted at specific sites, including their resolution.

### Non-methane Organic Carbon Sampling (NMOC)

Results of the through-the-probe audits of NMOC are presented in Table 5-2. Results of the audits were mixed. The original ARB report of the audit results (see Appendix B) stated that all 23 of the NMOC sampling systems (CCOS and PAMS) audited during the summer of 2000 failed the audits. However, ARB's criteria for failing the audit required that only one compound out of the up to 21 compounds analyze differ from the audit concentration by more than 10%. For most of the audits, at least 75% of the analyzed compounds agreed to within 10% of the audit concentrations. It should be noted that the original ARB report showed poor agreement for the automated MSGC analyzer at Granite Bay, and did not report results for the audits of the automated MSGC samplers at Parlier and Sunol. The poor results at Granite Bay were the result of confusion over the reported units from the analyzer, and results for Parlier and Sunol were eventually found. These revised results for the three research sites generated by the ARB and are included in Appendix B. However, the ARB did not provide a revised summary report.

As an alternative to evaluating audit results strictly using the ±10% criteria, upper and lower 95% probability limits for each compound were calculated using results from 10 PAMS NMOC that all had at least 75% of the compounds fall within ARB's ±10% criteria. As can be seen in Table 5-2, this expanded the acceptance range for some compounds.

The results show that both Biospheric Research Corp. (BRC) and Desert Research Institute (DRI), the analytical laboratories for the supplemental sites, had some samples that did not meet audit criteria, and some samples that did. In general, a sample either failed for all compounds, or passed for all compounds. One possible explanation of the inconsistent results involves a basic limitation with the performance of the audits. Due to scheduling problems associated with the very hectic pace of all organizations associated with CCOS effort, it was rarely possible for an operator to be available at the site during the audit. Consequently, auditors were responsible for operating the canister sampling

Table 5-2. Non-Methane Organic Carbon Audit Results.

| Compound | ARB True | ARB Criteria -10% | +10% | Lower 95% limit | Upper 95% limit | Angiola BRC | Piedras Blancas BRC | Pacheco Pass BRC | Granite Bay DRI GC | Parlier DRI GC | Sunol DRI GC | Patterson Pass DRI | Trimmer DRI | White Cloud DRI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ethane | 11.2 | 10.1 | 12.3 | 9.4 | 14.6 | 6.7 | 8.5 | 11.4 | 7.5 | 8.6 | 8.1 | 12.2 | 14.6 | 9.7 |
| Ethene | 9.8 | 8.8 | 10.8 | 8.9 | 10.7 | 5.3 | 5.7 | 9.7 | 5.1 | 6.3 | 6.7 | 9.9 | 9.6 | 8.2 |
| 1-Butene | 6.5 | 5.9 | 7.2 | 6.0 | 6.6 | | 5.7 | | 5.3 | 5.6 | 5.7 | 6.6 | 6.4 | 5.4 |
| Pentane | 7.8 | 7.0 | 8.6 | 6.7 | 9.4 | | 8.4 | | 7.0 | 8.4 | 5.5 | 7.4 | 6.3 | 5.6 |
| 2-Methyl-2-butene | 5.9 | 5.3 | 6.5 | 4.1 | 5.8 | | 1.7 | | 6.0 | 5.3 | 5.3 | 4.5 | 4.3 | 3.8 |
| 2-Methylpentane | 11.1 | 10.0 | 12.2 | 10.9 | 12.3 | 5.7 | 7.8 | 11.5 | 12.0 | 12.4 | 12.5 | 10.1 | 9.4 | 7.9 |
| Hexane | 5.2 | 4.7 | 5.7 | 5.1 | 5.9 | 2.8 | 4.0 | 5.5 | 5.4 | 5.4 | 5.2 | 4.7 | 4.5 | 3.9 |
| 2,2,3-Trimethylbutane | 11.2 | 10.1 | 12.3 | 11.2 | 13.4 | | | | 6.0 | 5.5 | 9.2 | 10.6 | 10.1 | 9.0 |
| Benzene | 9.3 | 8.4 | 10.2 | 8.9 | 10.6 | 4.8 | 7.2 | 10.5 | 10.2 | 9.8 | 9.8 | 8.6 | 8.2 | 7.2 |
| 3-Methylhexane | 3.3 | 3.0 | 3.6 | 3.2 | 5.1 | 2.3 | 0.0 | 5.0 | 3.5 | 3.5 | 3.2 | 3.1 | 3.0 | 2.9 |
| 2,2,4-Trimethylpentane | 7.9 | 7.1 | 8.7 | 7.3 | 9.4 | 4.0 | 5.7 | 8.4 | 7.2 | 7.7 | 6.4 | 7.2 | 6.8 | 6.3 |
| Methylcyclohexane | 3.1 | 2.8 | 3.4 | 2.9 | 3.6 | 1.7 | 2.3 | | 2.8 | 2.9 | 2.7 | 3.0 | 2.8 | 2.6 |
| Toluene | 15 | 13.5 | 16.5 | 13.8 | 17.5 | 7.8 | 13.0 | 16.1 | 15.4 | 13.9 | 14.9 | 14.3 | 13.3 | 11.5 |
| 3-Methylheptane | 7.4 | 6.7 | 8.1 | 7.2 | 8.1 | | | | 7.2 | 7.5 | 7.4 | 6.8 | 6.4 | 5.8 |
| Octane | 3.1 | 2.8 | 3.4 | 2.4 | 4.7 | 1.7 | 1.0 | 3.3 | 3.2 | 3.1 | 3.0 | 3.1 | 2.3 | 2.4 |
| Ethylbenzene | 6 | 5.4 | 6.6 | 5.5 | 6.3 | 2.8 | 4.3 | 6.2 | 5.6 | 5.7 | 5.7 | 5.8 | 2.8 | 4.6 |
| m/p-Xylene | 13.3 | 12.0 | 14.6 | 12.2 | 13.6 | 6.2 | 9.0 | 12.9 | 12.8 | 11.7 | 12.2 | 12.6 | 11.7 | 10.0 |
| o-Xylene | 5.4 | 4.9 | 5.9 | 5.1 | 5.8 | 2.5 | 3.8 | 5.3 | 5.0 | 5.1 | 4.9 | 5.1 | 4.7 | 4.2 |
| n-Propylbenzene | 5.4 | 4.9 | 5.9 | 4.8 | 5.7 | 2.5 | 3.3 | 5.0 | 5.4 | 5.6 | 5.2 | 5.3 | 4.7 | 4.2 |
| 1,2,3-Trimethylbenzene | 4.8 | 4.3 | 5.3 | 3.8 | 4.7 | | | | 4.0 | 3.8 | 4.1 | 4.2 | 3.7 | 3.4 |
| Decane | 4.8 | 4.3 | 5.3 | 3.8 | 6.1 | 2.2 | 3.2 | 4.0 | 3.8 | 4.5 | 4.5 | 4.8 | 4.2 | 3.9 |

All units in ppb

Failed primary audit criteria of +/-10%.

Failed primary audit criteria, but within 95% probability limits (see text).

equipment. The CCOS sample durations were different from those at the PAMS sites. Auditors therefore had to attempt to reprogram the sampling equipment. It may be that ambient air was somehow drawn into the canister, causing the discrepancies in the results. The fact that both CCOS contractors had at least one canister that agreed with the audit input concentrations implies that the analysis is accurate, and that the variability in the audit results is more likely due to problems with obtaining the audit sample. In addition, a review of the samples that did not meet the audit criteria showed that the ratio of the measured compound concentrations relative to each other was essentially the same as the ratios of the input concentrations. For example, if the concentrations for the sample is normalized against m/p-Xylene, the overwhelming majority (60 out of 70) of the failed parameters for the Angiola, Piedras Blancas, Trimmer, and White Cloud samples would pass the audit criteria. This implies some sort of dilution of the sample, which a variety of sampling problems could have caused.

In contrast, the continuous GC analyzers operated by DRI, which inherently were not as susceptible to sampling errors, showed relatively good agreement with the audit input concentrations. The exception is in the reporting of ethane, ethene and 1-Butene, which were apparently underreported at all three sites. This discrepancy should be investigated further.

**Carbonyl Sampling**

Table 5-3 presents the results of the ARB through-the-probe carbonyl audits. In general, the results are good. Operational problems were experienced at several of the sites, invalidating the audit sample. Once these samples are removed, the audit results are very good, with all audit samples agreeing to within 3.1% of the ARB audit acetaldehyde concentration.

**Aethalometers**

The aethalometer sample flow rate was checked at each of the three research sites. A similar problem was noted at each of the sites. When the sample flow rate for the aethelometer was first audited at each site, a flow rate well below the expected approximately 9 lpm was measured going through the sample inlet. Measured flow rates of 4.7 lpm, 6.5 lpm, and 0.0 lpm were noted at the Granite Bay, Parlier, and Sunol sites, respectively. A major leak was identified where the sample tube connects with the instrument. The tubing was tightened during the audit the flow was rechecked, with satisfactory results. Since a large portion of the sample air was being drawn from inside the site shelter, the aethelometer should be considered non-operational prior to the audit. The problem was likely caused by the large number of additional sample tubes that were hung on the metal aethelometer sampler tube with the assumption that the tube would serve as a suitable support. However, the weight of the additional tubes appeared to cause the tube to pull away from its connector at the back of the aethelometer, causing the leak.

Table 5-3. Carbonyl Audit Results.

| Site | Sampler Flow ml/min | Reported Sampling min. | Actual Sampling min. | ppb Acetal. | ARB actual ppb | % diff. | ppb Acetone | Remarks: |
|---|---|---|---|---|---|---|---|---|
| Bodega Bay | 782 | 180 | | 0.21 | | | 0.25 | No exposure, blank-like; pump not on, or cartridge installed in the wrong channel. |
| Granite Bay | 847 | 180 | | 0.60 | | | 2.67 | Major peak is acetone. Standard tank on? |
| Trimmer | 797 | ? | | | | | | Ambient air sampled, contains all C1-C6 carbonyls. |
| Patterson Pass | 806 | 153 | **?** | 7.7 | | | 0.23 | Site technician was uncertain of actual time sampled. |
| Pacheco Pass | | | | | | | | Audit sample missing. |
| Turlock | | | | | | | | Audit sample missing. |
| | | | | | | | | |
| Angiola | 806 | 180 | 180 | 9.5 | 9.8 | -3.1% | 0.49 | |
| Parlier | 691 | 180 | **165** | 9.9 | 9.8 | 1.5% | 0.75 | Sampling time overlapped with 15 min. purge cycle from 12:45-1:00 p.m. in Ch. 5. |
| Sunol | 855 | 180 | 180 | 10.0 | 9.8 | 1.9% | 0.61 | |
| White Cloud | 760 | 180 | **99.4**** | 9.8 | 9.5 | 3.2% | 0.81 | Ch. 2 used between 11:55 am to 2:55 pm. ** |
| San Andreas | 804 | 180 | **165** | 9.6 | 9.8 | -2.0% | 0.37 | Sampling time overlapped with 15 min. purge cycle from 12:45-1:00 p.m. at Ch. 5 |
| Piedras Blancas | 831 | 180 | 180 | 9.4 | 9.8 | -0.1 | 0.84 | |

** From 11:55 to 12:45 (50 min.), all flow went to Ch.2.
From 12:45 pm to 1:00 pm (15 min.), flow went through purge channel (5) turned on by the 3rd timer.
From 1:00 pm to 2:55 pm (115 min.), sample flow was split between Ch 2 and Ch 3, that was turned on automatically by the second timer in the unit.
Result: Approximately only ~38% of the flow (by measurement) went to Ch 2 when the other channels are on, or equivalent to sampling ~ 49.4 min.
Thus estimated total equivalent sampling time was (50 + 49.4)= 99.4 minutes.

### Nephelometers

Granite Bay was the only CCOS supplemental site containing a nephelometer. The performance audit of the nephelometer showed agreement to within 2.7 %.

### Additional Comments

Patterson Pass

Problem: The flow meter used at the site to set and record the flow rates for the NMOC sampler appeared to be reading low. This resulted in the NMOC sampler flow rates being set higher than normal, causing the canisters to fill too quickly, possibly affecting the sample integration.

Resolution: Sample flow rates were adjusted during the audit from about 81 cc/min to 68 cc/min.

# SECTION 6

# DATA PROCESSING AND MANAGEMENT

## 6.1 AUDIT PROCEDURES

The audit began with a review of existing documentation describing the study. On-site audits at the Desert Research Institute were conducted using questionnaires developed for performing data processing / data management system audits. Completed forms have been included in Appendix A and Appendix B of this report. The questionnaires were based on current EPA guidelines as presented in the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II (August 1998). The use of the questionnaires ensured that all aspects of the audits were covered completely and consistently.

The data management questionnaire covers data monitoring and processing/management tasks common to all data collection efforts. Principle efforts audited included:

- Data Handling
- Documentation
- Data Validation and Correction
- Data Processing
- Reporting

For each group monitored, the audit consisted of two basic parts. First, key personnel were interviewed and the audit questionnaire was filled out. This provided the auditor with a current description of the data processing and reporting procedures. Second, several data points were traced through the entire data processing sequence to verify that the described procedures were being followed and to verify the integrity of the database.

## 6.2 AUDIT RESULTS

**Supplemental NO/$NO_y$ and Ozone Measurements (DRI)**

- In validating the data, DRI has followed a policy of favoring flagging data "suspicious" as opposed to "invalid" when unusual instrument responses were noted but no documented problems could be identified. This policy is consistent with CCAQS data guidelines, and allows data users to determine the usefulness of suspicious data. However, there are cases where highly suspicious data is almost certainly invalid. Three such cases are discussed below:

1) At the Bodega Bay site, there was one day when the response of the ozone analyzer rose to around 400 ppb. Even though data immediately before this

period were flagged as invalid due to station activity affecting the ozone analyzer, the data were not flagged as "invalid", since the response had a nice, diurnal shape, and the analyzer seemed to function normally after this day. With reported concentrations 4X higher than even the urban areas and following so closely a known "problem" with the analyzer, it is almost certain that these data are invalid.

2) At the Lambie Road site, the ozone analyzer was prone to periods where the analyzer response became erratic, with frequent, large positive and negative spikes. The instrument is clearly not functioning properly, though the problem is not apparent in the hourly average data, where the positive and negative spikes approximately cancel each other out. Such data have been flagged as "suspect", it is difficult to classify the analyzer as "functional" when reviewing the time series plots of the one-minute data.

3) At the San Martin site, there was a 10-day period during which the sample pump for the $NO/NO_y$ analyzer was failing. The problem was documented by the audit performed at the site, which showed the response to be 75% low. The automatic zero/span system was not working at this site, so it was not possible to view the change in the analyzer response over the period, and it was therefore impossible to correct the data. The data are flagged as "suspicious", though it is difficult to imagine how data that could be as much as 75% or more off could be considered useful.

All of these problems will likely be addressed further during Level 1B and Level 2 validation, during which the above data will very likely be invalidated. However, the above information should be included in Final Quality Assessment Report (FQAR) to accompany the data set. To date, the FQAR has not been assembled for this data set. The FQAR should include summaries of automatic zero/span checks, precision checks, and calibration data, it should also include a discussion of the data correction procedures and a summary of the data that underwent correction. In addition, it should briefly discuss known issues such as the above. The field and validation personnel have a wealth of information regarding the quality of the collected data. Much of this information will be valuable to Level 1B and 2 validation personnel, but is not really documented in a convenient and accessible format. The FQAR provides such an opportunity.

- Comparison of the $NO/NO_y$ calibration factors used to adjust the CCOS data with the results of audits conducted during CCOS revealed a problem at White Cloud, where calibration factors had a negative influence on the audit results. John Bowen reviewed the calibration information and found problems with the original factors. New factors were computed, which corrected the problem. The White Cloud $NO/NO_y$ data should be reprocessed and resubmitted.

- Further review of CCOS audit data revealed that, in general, audit results are improved using the correction factors supplied for the CCOS data. However, audit results at some sites were made worse using the correction factors, though in no cases were the results outside of the specified audit criteria of ±15%. The affected sites were:

Sunol – NO/NOx
Turlock – $NO/NO_y$
Arvin – $NO/NO_y$
Bethyl Island – NO

It is recommended that the factors for these sites be verified.

- Data chosen from three sites were checked, following several data points through the entire validation sequence. The following inconsistencies were noted:
  - Data calibration factors were established for the $NO/NO_y$ data at the Arvin site. However, the $NO/NO_y$ data for August and September 2000 had not been adjusted. These data should be reprocessed using the appropriate calibration factors.
  - The ozone data for Lambie Road had been adjusted using calibration factors, as needed. However, the data had not been flagged as having undergone such an adjustment, as similarly adjusted data had.
  - The spreadsheet data file for the Granite Bay site had some inconsistencies in the naming of the spreadsheet columns. These were internally used names, and the misnaming of the columns did not appear to have had any affect on the final output of the data in the CCAQS format, though this should be confirmed.

  Based on the above, it is recommended that personnel independent of the processing effort conduct a quick check to verify that all data requiring adjustment using calibration factors have been so adjusted and flagged.

**Upper Air Radar Wind Profiler, RASS and Sodar (NOAA/ETL)**

While no formal audit of the NOAA/ETL processing of radar, RASS and sodar data was peformed, an informal interview was conducted of Dan Gottas regarding the general processing procedures used. Dan indicated that the radar and RASS data under went reprocessing of the moments data using algorithms to correct for vertical velocity at the moments level. The data were reviewed for meteorological consistency and obvious erroneous data hand edited out of the database. A conservative approach was used to ensure that bird contamination was removed, and under some circumstances there may have been good data flagged as bad. This was deemed more acceptable than letting potentially invalid data pass through the process as valid.

During the course of the program the software for the sodars operated by ETL was undergoing revisions. It was indicated that the radial values of winds were being collected and that the data would be reprocessed at the program conclusion. At the time of this report there was no further information on the status of the processing procedures for the sodars.

# SECTION 7

# LABORATORIES

The laboratories performing analysis for CCOS were audited in part during the through-the-probe audits conducted by the ARB. However, many of the laboratories were also audited as part of the CRPAQS laboratory QA effort conducted by the Desert Research Institute (DRI). These involved system and performance audits of key laboratories involved with CCOS and CRPAQS. Results of these audits will be presented in a stand-alone report issued by DRI.

# SECTION 8

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