

## 6. UPPER-AIR METEOROLOGY MEASUREMENTS

A key component of SCOS97 is the collection and validation of upper air meteorological data. The upper air data is intended to allow for the generation of gridded 3-dimensional wind and temperature fields sufficient for use to understand complex source-receptor relationships in southern California. Several sites are planned to have monitoring by more than one type of instrument (e.g., radar wind profiler and rawinsonde); this allows for daily comparisons of collocated measurements as well as help in data validation after the field study concludes.

This quality assurance plan is based principally upon guidelines from the report "Draft Guidelines for the Quality Assurance and Management of PAMS Upper-Air Meteorological Data (STI, 1995). Quality assurance for upper air monitoring has the following components: 1) siting and installation (includes testing); 2) periodic review of data (frequent inspection of collected data and evaluation of its reasonableness); 3) system audits and performance audits; 4) a plan for quickly correcting problems; 5) data acquisition and processing; and 6) data validation and archival.

Aerovironment Environmental Services, Inc. (AVES) will review the measurement groups standard operating procedures, siting and set-up, quality control procedures, and procedures for communication and resolution of problems. The review will compare proposed procedures with procedures detailed in this QA plan (based on PAMS upper-air guidelines). AVES will also review candidate monitoring sites and do system and performance audits of the upper-air meteorological network. AVES presented preliminary quality assurance methodologies in their proposal (AVES, 1996); these proposed methods are consistent with procedures listed in this QA plan and the PAMS upper-air guidelines. Final procedures shall be approved by the SCOS97 upper-air quality assurance manager.

NOAA's Environmental Technology Laboratory (ETL) will be the data manager for the upper-air meteorology data. ETL will be responsible for data acquisition and processing, periodic review of data, and data validation and archival. The procedures are given in the ETL proposal (NOAA/ETL, 1996).

### 6.1 Sampling Site Selection Criteria

The general locations of upper-air meteorological monitoring sites (Table 1-3) have been selected by the Meteorology Working Group. Detailed criteria for precisely locating sites are given in this section.

Site needs include:

- A flat location, clear of obstacles, and with good drainage
- Sufficient electrical power
- An environmentally controlled instrument shelter

- A fence around the equipment and shelter, or other sufficient security measures
- A remote communications link

Sodar and RWP/RASS sites have additional needs:

- Locate sodars and RASS away from areas that would result in annoyances due to the sound waves emitted from these instruments. Thus, before locating instruments, evaluate the expected effects (intensity, exposed population, time of day) of the instruments upon sensitive receptors.
- Avoid noise sources (roads, industrial processes, air conditioners, etc.) that may interfere with sodars and RASS. Provide sufficient acoustic shielding to minimize the effects of noise. Measure noise levels at the potential site during the expected highest noise period of the day, if possible. Noise levels should be below 60 dBA; below 50 dBA is preferable.
- Building, trees, power lines, etc. may reflect sodar and radar pulses and contaminates the data. Sites should be chosen that minimize obstructions taller than 15 degrees above the horizon. If objects extend above 15 degrees elevation, the beams should be located away from these objects.

At Rawinsonde sites:

- The vicinity of the site should be free of trees, tall buildings, power lines, and other objects that may snag the balloon or instrument package or interfere with tracking the sonde.
- If a Loran system is used, sufficient signal coverage should be established before establishing the site.

## 6.2 Installation

- Sodar, RWP, and radio theodolite system antennas should be aligned to true north using the solar siting technique (USEPA, 1989).
- Determine the latitude, longitude, and elevation of the site using detailed maps or a Global Positioning System (GPS) instrument.
- Site documentation: Take photographs in each of four cardinal directions, and of all shelter, instruments, and other equipment. Videotape the site, including a 360 degree view of the surrounding area. Produce a detailed site layout plan documenting location of the instruments, shelter, and other equipment. Produce a diagram that describes all objects and topographic features around the site in 30 to 45 degree

increments. Include potential sources of clutter and noise sources, and distance to and elevation angle of objects.

- After installation, perform acceptance testing of the instrument following the manufacturer's procedures.
- When system becomes operational, check data for reasonableness. This is best done using collocated meteorological data from surface or upper air meteorological data. If collocated data is not available, nearby upper air data and the judgement of a person familiar with expected conditions at the site can be used.

### **6.3 Monitoring Site Locations**

Proposed upper-air monitoring site locations were listed in Table 1-3. Locating precise locations is in process. Some modifications may be made to the site listing due to the potential inability to find suitable sites in the desired areas.

### **6.4 Sampling Procedures**

#### **6.4.1 Sodars**

The optimum type of sodar and sampling procedure depends upon the intended use of the data. If high vertical resolution is needed over a relatively shallow layer, high frequency mini-sodars are appropriate. Mini-sodars give vertical resolution on the order of 5-20 m up to about 300 m or less AGL. If a greater depth is needed, with less resolution required, standard sodars with vertical resolution of 20-50 m and coverage typically to about 1000 m, are appropriate. For sodars collocated with radar wind profilers, a lower maximum height with greater vertical resolution may be appropriate because coverage above the sodar range is given by the RWP. For sodars located without collocated RWP, higher vertical range is usually needed. For SCOS97, the flows of interest should be sufficiently resolved by using standard sodars. For sites collocated with radar wind profilers it may be desired to operate the sodars to maximize vertical resolution.

#### **6.4.2 Radar Wind Profilers/RASS**

RWP/RASS are typically operated in the RASS mode for the first 5-10 minutes of the hour, then in the RWP mode for the remaining 50-55 minutes. At the end of each hour, hourly consensus wind and temperature profiles are computed, although they are not true hourly averages. The data can then be reviewed on a near real-time basis for forecasting purposes and quality assurance. For more reliable wind and temperature data, and a closer representation of a true hourly average, continuous, interleaved sampling of wind and RASS derived temperature may be done. In this mode, the oblique beams are sampled for 20-30 seconds, then the vertical beam with RASS is sampled for 20-30 seconds; this creates a profile for each 20-30 second sampling period. Post-processing must then be performed to obtain hourly averaged data. This

post-processing has not yet been developed to routinely provide near real-time hourly averaged data, as is needed for the forecasting aspects of SCOS97. NOAA/ETL is working to make this available in time for application to SCOS97 .

The data objectives are to provide upper-level wind and temperature data meeting the data quality objectives within 3 hours of collection. Due to the higher quality and better representativeness of the continuous, interleaved data, this is the preferred method. However, if continuous, interleaved hourly averaged data cannot be provided within a few hours of collection, the standard method of 5-10 minutes RASS, followed by 50-55 minutes of wind data should be used.

### **6.4.3 Rawinsondes**

Rawinsondes should be released at least 4 times per day (USEPA, 1995b). They should be timed to capture the early morning stable boundary layer conditions, convective boundary layer (CBL) development in mid-morning, the fully developed CBL in mid-day, and the nocturnal boundary layer (STI, 1995). For SCOS97, these times may be modified or supplemented to capture important features of local flows, such as the sea-breeze front, return flows aloft, and valley and slope flows.

## **6.5 Periodic Review of Data**

Upper air data for SCOS97 should be evaluated daily for operational status and reasonableness. Each day (at least Monday through Friday) a meteorologist or other person knowledgeable about upper air meteorological patterns in southern California should examine the data for each site for the past 24 hours for reasonableness. Time-height cross-sections plots provide for an efficient way of inspecting data at one site. Spatial patterns at a few selected heights would also be helpful for noting suspicious data. Data from collocated and nearby sites should be compared for consistency. If data are not being received, or appear to be invalid during part or all of the 24 hour period, the organization responsible for collecting the data should be contacted immediately. The responsible organization should promptly evaluate whether a problem does exist, and remedy any problems as soon as possible. Organizations responsible for periodic review of data are specified in Section 6.10.

## **6.6 System Audits**

System audits are used to evaluate whether a system is set-up correctly and that standard operating procedures are being followed. System audits should be conducted at all upper air monitoring sites shortly after start-up of the SCOS97 field work and again shortly before ending the field work component of the study. System audits will be performed by Aerovironment Environmental Services, Inc. The list of system audit checks for rawinsondes, sodars, and RWP/RASS from the STI (1995) draft report should be used. It appears below:

### 6.6.1 Remote Profiler Instrumentation (Sodar, Radar Wind Profiler/RASS)

A routine check of the monitoring station should be performed to ensure that the local technician is following all the standard operating procedures. In addition, the following items should be checked:

- The antenna and controller interface cables should be inspected for proper connection. If multi-axis antennas are used, this will include checking for the proper direction of the interface connections.
- Orientation checks should be performed on the individual antennas, or phased-array antenna. The checks should be verified using solar sitings when possible. The measured orientation of the antennas should be compared with the system software settings of the system. The antenna alignment should be maintained within  $\pm 2^\circ$ , which is consistent with wind direction vane alignment criteria specified by the USEPA (1995b).
- For multi-axis antennas, the inclination angle, or zenith angle from the vertical, should be verified against the software settings and the manufacturer's recommendations. The measured zenith angle should be within  $\pm 0.5^\circ$  of the software settings in the data system.
- For phased-array antennas, and for the vertical antenna in a multi-axis system, the level of the antenna should be within  $\pm 0.5^\circ$  of the vertical.
- For multi-axis sodar systems, a separate distinct pulse, or pulse train in the case of frequency coded pulse systems, should be heard from each of the antennas. In a frequency-coded pulse system, there may be a sound pattern that can be verified. The instrument manual should be checked to see if there is such a pattern.
- For sodar systems, general noise levels should be measured, in dBA, to assess ambient conditions and their potential influence on the altitude capabilities of the sodar. In general, levels below 50 dBA indicate a quiet site, while levels above 60 dBA are quite noisy. The altitude coverage of the sodar will be directly related to the ambient noise at the site.
- A tabular vista diagram should be prepared documenting the surroundings of the site in  $30^\circ$  to  $45^\circ$  increments. The diagram should identify any potential sources clutter and reflective and active noise sources in each of the directions, as well as the approximate distance to the objects and their elevation angle above the horizon. This information is useful in assessing the effects of the environment on the data collected. As part of this documentation, photographs in various directions may be helpful for interpreting information in the tabular diagram. If this documentation exists in the monitoring plan for the site, it should be reviewed for accuracy.

- The controller and data collection devices should be checked to ensure the instruments are operating in the proper mode and that the data being collected are those specified by the SOP's.
- Station logbooks, checklists, and calibration forms should be reviewed for completeness and content to assure the entries are commensurate with the expectations in the procedures for the site.
- The site operator should be interviewed to determine his/her knowledge of system operation, maintenance, and proficiency in the performance of QC checks.
- The antenna enclosures should be inspected for structural integrity that may cause failures as well as any sign of debris or animal or insect nests that may cause drainage problems in the event of rain or snow.
- Preventative maintenance procedures should be reviewed for adequacy and implementation.
- The time clocks on the data acquisition systems should be checked and compared to a standard of  $\pm 2$  minutes.
- The data processing procedures and the methods for processing the data from sub-hourly to hourly intervals should be reviewed for appropriateness.
- Data collected over a several-day period should be reviewed for reasonableness and consistency. The review should include vertical consistency within given profiles and temporal consistency from period to period. For radar wind profilers and sodars, special attention should be given to the possibility of ground clutter (i.e., fixed echoes) and/or active noise source contamination in the data.

### **6.6.2 Rawinsondes**

An entire launch cycle should be observed, from the operator's arrival at the site through completion of the sounding and securing of the station, to ensure that the site technician is following the appropriate procedures. The following items should be checked:

- Ground station initialization procedures for proper setup.
- Sonde initialization procedures for proper sonde calibration.
- Balloon inflation for proper ascent rate.
- Orientation check of a radio theodolite's antenna using solar sightings when possible. Procedures for solar sightings are described in USEPA (1995b). The antenna alignment

should be maintained within  $\pm 2$  , which is consistent with wind direction vane alignment criteria provided in USEPA (1995b).

- Verification that the vertical angle of a radio theodolite's antenna is within  $\pm 0.5$
- Data acquisition procedures and on-site inspection of the acquired data.
- Data archiving and backup procedures.
- Flight termination and shutdown of the system.
- Preventive maintenance procedures and implementation.
- Data processing and validation procedures to check that questionable data are appropriately flagged and that processing algorithms do not excessively smooth the data.
- Data from several representative launches should be reviewed for reasonableness and consistency.

## **6.7 Performance Audits**

A performance audit is intended to provide a measure of the performance of a measurement system. With upper air measurements, the concept of performance audits is somewhat altered, because there is not typically a known reference value for each measurements. Sodars and radar wind profilers measure winds over varying spatial and temporal (typically 1 hour) domains. Rawinsondes measure winds that are closer to instantaneous in time and spatially averaged over a small, nearly vertical path. Thus, direct comparisons are not possible. However, comparisons among the different measurement types (RWP, sodar and rawinsonde winds; RASS and rawinsonde derived virtual temperature) can give an overall indication of instrument performance and can be useful in data validation for periods with collocated data. The SCOS97 study plan calls for collocated upper air measurements using different instrument type at several locations. These can serve as long term performance audits for the radar wind profilers. Performance audits will be conducted by Aerovironment Environmental Services, Inc.

### **6.7.1 Sodars**

An acoustic pulse transponder (APT) shall be used in sodar performance audits to test the ability of the instrument to correctly interpret test signals representing known wind speeds. Audit results should be within  $\pm 0.2 \text{ ms}^{-1}$  on a component basis. Audits using an APT should be conducted over at least three averaging intervals and over a range of wind speeds corresponding to those normally observed. These audits should be conducted near the beginning of the field study at each sodar site, simultaneously with the first system audit.

### **6.7.2 Radar Wind Profilers**

Collocated sodars and rawinsondes at several sites can be used for performance audits. If additional performance audits are needed, sodars and/or rawinsondes may be used. If rawinsondes are used, at least 3 soundings covering the diurnal cycle should be taken. If sodars are used, the sodars should be configured to match the RWP data in temporal and spatial averaging as much as possible. The sodars should be run for at least 24 hours, and data compared to the RWP data while on-site. Comparisons between sodars and rawinsondes and RWP should be done when winds are at least  $2 \text{ ms}^{-1}$ .

### **6.7.3 Rawinsondes**

Performance audits of rawinsondes are of little value because the instruments (radiosondes) are used only once, and their general performance characteristics are well established. However, instruments that provide ground truthing prior to launch (thermometer, RH sensor, psychrometer, barometric pressure sensor) should be audited by reference instruments traceable to a known standard. Performance audits of each rawinsonde site should be performed along with the system audit at the beginning of the SCOS97 field study.

### **6.7.4 RASS**

RASS performance audits shall be done using collocated rawinsondes to provide virtual temperature.

## **6.8 Corrective Actions**

If problems are identified through system or performance audits, inspection of the data, or by other methods, a plan of action is needed to quickly correct such problems and avoid any further loss or corruption of data. Each contractor or agency responsible for collecting upper-air meteorological data shall submit a plan for identification and remediation of problems. Any problems noted by the audit contractor during system and performance audits shall be reported to the station operator before leaving the site. For sites without station operators on site, the contractor (principal investigator) responsible for the site will be contacted while at the site. For problems not corrected immediately, the auditor will also notify the SCOS97 Upper-air Quality Assurance Manager. If the audit results suggest that previously or currently collected data are suspect, the auditor shall notify the principal investigator and Upper-air Quality Assurance Manager and supply copies of audit reports as soon as practical.

## **6.9 Data Acquisition and Processing**

The upper-air data acquisition and processing procedures for SCOS97 are described in the NOAA/ETL proposal (NOAA/ETL, 1996). A summary of procedures are presented here. Each contractor or agency responsible for RWP/RASS data collection shall provide for the near real-time transfer of consensus hourly-averaged data to the NOAA/ ETL (SCOS97 Upper air database manager). ETL shall coordinate data submittals from each upper-air meteorology

measurement group and receive and evaluate sample data submittals before the beginning of the field study (June 15, 1997). ETL will process the data and make it available on the Internet via the World Wide Web, after performing Level-1 validation. All data used for determining vertical temperature and wind profiles shall be stored, including complete spectral moment data. All spectral moment data shall be transferred to ETL on a schedule to be determined by ETL.

#### **6.10 Data Validation**

Level-1 validation will be performed automatically by ETL shortly after the data is received using time/height consistency checks for the RWP/RASS and sodar, and height consistency checks for the rawinsondes. Graphical displays of level-1 validated upper level winds and temperatures will be inspected by ETL. Level-2 validation includes comparing collocated measurements in time and height and network-wide consistency in time, and space. Automated procedures for level-2 will be applied to the data and made available within 3 hours of receipt. After completion of the field study, all data products will be reviewed by trained personnel familiar with the study area.

On a daily basis, ETL will review data from each site to determine if any problems are likely to exist. ETL will contact the site operator who will confirm or deny suspected problems and to remedy any problems. Additional data validation will occur during data analysis activities, when data may appear inconsistent with other analysis and modeling results.

Also on a daily basis, personnel at the South Coast Air Quality Management District familiar with upper-air meteorological patterns in the study area shall review the upper-air data made available by ETL via the Internet. The data shall be visually inspected for reasonableness; any suspected problems shall be reported to the organization responsible for the measurement.

#### **6.11 Data Archival**

Upper air data archival format and location should be specified by the SCOS97 Data Manager in consultation with the Upper-Air Quality Assurance Manager. STI (1995) identified the following desired features of upper-air data:

- Ability to use the data across a range of computer systems.
- The format should be independent of the instruments used to collect the data.
- Ability to store quality control information. Data validation level should be identified and stored with the data.
- Ability to store the data in ASCII and/or binary formats.
- Ability to include self-documentation that describes the content of the data sets.
- Ability to use commercial off-the-shelf software to read, sort, and manipulate the data.

## 7. VOLATILE ORGANIC COMPOUND MEASUREMENTS

Title I, Section 182, of the Clean Air Act Amendments of 1990 required the Environmental Protection Agency to revise existing current ambient air quality surveillance regulations. The rule required States with areas classified as serious, severe, or extreme for ozone nonattainment to establish enhanced ambient air monitoring stations called Photochemical Assessment Monitoring Stations (PAMS) as part of their State Implementation Plan (SIP) (Federal Register, 1993). Each station measures speciated hydrocarbons and carbonyl compounds, ozone, oxides of nitrogen, and surface meteorological data. Provisions of the rules require the operation of up to five PAMS stations in each nonattainment area depending on population. Additionally, each area must monitor upper air meteorology at one representative site. In California, PAMS is required in Ventura County, and the South Coast, Southeast Desert and San Diego air basins. The program began in 1994, and is being phased-in over a five year schedule at a rate of at least one station per area per year.

The plan for measurements of volatile organic compounds (VOC) for the SCOS97-NARSTO program is built upon the foundation provided by the PAMS networks in the study region. PAMS ozone precursor monitoring is conducted annually in California during the peak ozone season (July 1 to September 30). As is shown in Table 1-1, there will be 13 PAMS in operation during SCOS97-NARSTO (three in Ventura County; five in the South Coast Air Basin, one in the Southeast Desert Air Basin, and four in the San Diego Air Basin). Four 3-hour samples are collected every third day during the monitoring period at all PAMS sites for speciated hydrocarbon and at Type 2 sites only for carbonyl compounds. In addition to the regularly scheduled measurements, samples are collected on a forecast basis during five high-ozone episodes of at least two consecutive days. Episodic measurements consist of four samples per day for speciated hydrocarbon at all PAMS sites and for carbonyl compounds at Type 2 sites. Ventura County Air Pollution Control District and the San Diego Air Pollution Control District will supplement their existing sampling schedule to include all SCOS97 IOP days. Field operators from the University of California, Riverside College of Engineering – Center for Environmental Research and Technology (CE-CERT) will collect VOC samples in the SoCAB during SCOS97 IOPs. Airborne VOC samples will also be collected onboard the four instrumented aircrafts that will be deployed during the study. These samples will be analyzed at Biospheric Research Corporation (BRC) for hydrocarbon and at Atmospheric Assessment Associates, Inc. (AtmAA) for carbonyl compounds. VOC samples will also be collected in Mexicali and Tijuana, Mexico and analyzed at the Desert Research Institute (DRI).

Intended applications for the PAMS database include ozone and precursor trends, emission inventory reconciliation and verification, population exposure analyses, photochemical modeling support, and control strategy evaluation. The overlapping objectives and air quality and meteorological data requirements for PAMS and SCOS97-NARSTO provide an opportunity to address the quality assurance and data validation need of both programs, and to evaluate PAMS with respect to EPA's stated goals and objectives.

## **7.1 Sampling Site Selection Criteria**

Design criteria for the PAMS network are based on selection of an array of site locations relative to ozone precursor source areas and predominant wind directions associated with high ozone events. Specific monitoring objectives are to characterize precursor emission sources within the area, transport of ozone and its precursors into and out of the area, and the photochemical processes related to ozone nonattainment, as well as developing an initial urban toxic pollutant database. A maximum of five PAMS sites are required in affected nonattainment areas, depending on the population of the Metropolitan Statistical Area/Consolidated Metropolitan Statistical Area (MSA/CMSA) or nonattainment area, whichever is larger. Specific monitoring objectives associated with each of these sites result in four distinct site types.

Type 1 sites are established to characterize upwind background and transported ozone and its precursor concentrations entering the area and to identify those areas which are subjected to overwhelming transport. Type 1 sites are located in the predominant morning upwind direction from the local area of maximum precursor emissions during the ozone season. Typically, Type 1 sites will be located near the edge of the photochemical grid model domain in the predominant upwind direction from the city limits or fringe of the urbanized area.

Type 2 sites are established to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions are expected. These sites also are suited for the monitoring of urban air toxic pollutants. Type 2 sites are located immediately downwind of the area of maximum precursor emissions and are typically placed near the downwind boundary of the central business district. Additionally, a second Type 2 site may be required depending on the size of the area, and will be placed in the second-most predominant morning wind direction.

Type 3 sites are intended to monitor maximum ozone concentrations occurring downwind from the area of maximum precursor emissions. Typically, Type 3 sites will be located 10 to 30 miles downwind from the fringe of the urban area.

Type 4 sites are established to characterize the extreme downwind transported ozone and its precursor concentrations exiting the area and identify those areas which are potentially contributing to overwhelming transport in other areas. Type 4 sites are located in the predominant afternoon downwind direction, as determined for the Type 3 site, from the local area of maximum precursor emissions during the ozone season. Typically, Type 4 sites are located near the downwind edge of the photochemical grid model domain.

## **7.2 Installation**

Sampling equipment are installed in available buildings in temperature-controlled environments with sample inlet systems and manifolds, air conditioning, and power distribution.

## **7.3 Sampling Site Locations**

The current status of the implementation of PAMS by local air pollution control districts in southern California is outlined in Table 1-1. Thirteen PAMS sites will be operational by 1997 (three in Ventura County; five in the South Coast Air Basin, one in the Southeast Desert Air

Basin, and four in the San Diego Air Basin). Supplemental VOC samples will be collected by CE-CERT at San Clemente, Azusa, Los Angeles – North Main, and Burbank. VOC samples will also be collected at Mexicali and Tijuana, Mexico to characterize the southern boundary of the SCOS97-NARTSO study domain.

#### **7.4 Measurement Methods and Procedures**

EPA methods TO-14 and TO-11 are specified by the EPA for sampling and analysis of speciated hydrocarbons and carbonyl compounds, respectively (EPA, 1991). Table 7-1 lists the species that are currently in the DRI calibration table and PAMS target hydrocarbon species. For carbonyl compounds, state and local agencies are currently required to report only formaldehyde, acetaldehyde and acetone. The districts may be able to quantify and report several C<sub>3</sub> to C<sub>7</sub> carbonyl compounds that appear in the HPLC chromatograms. The EPA rule requires eight 3-hour hydrocarbon samples (midnight-3 am, 3-6 am, 6-9 am, 9-noon, noon-3 pm, 3-6 pm, 6-9 pm, and 9-midnight PDT) every day at Type 2 sites and every third day at all other PAMS sites. Sampling for carbonyl compounds is required at Type 2 sites only. In addition, one 24-hour sample is required every sixth day year-round at Type 2 sites and during the summer monitoring period at all other sites. Under the California Alternative Plan, four 3-hour samples (3-6 am, 6-9 am, 1-4 pm, and 5-8 pm, PDT) are collected every third day during the monitoring period at all PAMS sites for speciated hydrocarbons and at Type 2 sites only for carbonyl compounds. In addition to the regularly scheduled measurements, samples are collected on a forecast basis during up to five high-ozone episodes of at least two consecutive days. Episodic measurements consist of four samples per day (6-9 am, 9-noon, 1-4 pm and 5-8 pm, PDT) for speciated hydrocarbons at all PAMS sites and for carbonyl compounds at Type 2 sites. The VCAPCD and SDAPCD operate their PAMS sites according to the alternative plan, while SCAQMD operates theirs according to the EPA Rule. SCAQMD's 3-hour sampling schedule (on PST year round) begins one hour later than sampling times used by VCAPCD and SDAPCD (on PDT for PAMS). The PAMS 3-hour VOC sampling schedule should be consistent throughout the SCOS97 study area.

Total nonmethane hydrocarbon (NMHC) concentrations are monitored at some PAMS sites by automated-Preconcentration Direct Injection Flame Ionization Detection (PDFID) (e.g., Xontech 850). Total NMHC is measured by passing the air sample through a chromatographic column to separate methane from other hydrocarbons and analyzing the bulk hydrocarbon sample by FID. In the FID, sample air is burned in a hydrogen flame creating a quantity of ions from the hydrogen molecules in the air sample. The ions conduct a small electrical current which is measured by an electrometer, which in turn produces an electronic signal proportional to the number of ions collected. Thus, the total hydrocarbon data are reported as parts per billion carbon (ppbC).

##### **7.4.1 Hydrocarbons Sampling and Analysis Methods (Biospheric Research Corporation)**

Whole-air samples for hydrocarbon analysis are collected in passivated stainless steel canisters with the aid of a pump regulated to achieve a final canister pressure above atmospheric pressure. The flow rate and sample duration are matched in order to maintain constant flow

**Table 7-1**

**DRI Laboratory Calibration Species**

<b>Retention Time</b>	<b>Retention Index</b>	<b>Name</b>	<b>PAMS Compound</b>
<b>Quantitated from GS-A column:</b>			
		ethene	p
		acetylene	p
		ethane	p
		propene	p
		propane	p
		1-butene	p
		iso-butene	
<b>Quantitated from DB-1 column:</b>			
3.85		C2 compounds	
6.84		propene	p
7.10	300.00	propane	p
8.55	316.39	freon 12	
10.87	361.34	iso-butane	p
12.41	389.71	1-butene+iso-butene	p
12.67	393.91	1,3-butadiene	
12.94	400.00	n-butane	p
13.15	404.08	methanol	
13.62	411.32	t-2-butene	p
14.03	418.74	1&2-butyne	
14.43	426.16	c-2-butene	p
16.18	456.77	3-methyl-1-butene	
16.44	461.60	ethanol	
16.88	470.87	acetonitrile	
17.12	474.21	isopentane	p
17.27	476.99	acetone	
17.95	489.24	1-pentene	p
18.31	495.92	2-methyl-1-butene	
18.53	500.00	n-pentane	p
18.75	504.44	isoprene	p
18.97	508.67	t-2-pentene	p
19.35	516.33	c-2-pentene	p
19.59	520.77	2-methyl-2-butene	p
20.21	532.86	Freon 113	
20.30	535.08	2,2-dimethyl-butane	p
20.72	543.55	2-methylpropanal	
21.11	552.02	cyclopentene	
21.24	554.64	methacrolein	
21.35	556.85	4-methyl-1-pentene	
21.62	562.30	cyclopentane	p
21.78	565.32	2,3-dimethylbutane	p

**Table 7-1**  
**DRI Laboratory Calibration Species**

Retention Time	Retention Index	Name	PAMS Compound
21.85	566.90	MTBE	
22.02	569.96	2-methylpentane	P
22.16	572.98	butanal	
22.41	578.02	butanone	
22.68	583.47	3-methylpentane	P
22.92	588.31	2-methyl-1-pentene	P
22.99	589.31	1-hexene	
23.18	593.95	C6 Olefin	
23.51	600.00	n-hexane	P
23.57	601.34	chloroform	
23.63	602.68	t-3-hexene	
23.72	604.70	c-3-hexene	
23.84	607.38	t-2-hexene	
23.97	610.29	2-methyl-2-pentene	
24.15	614.32	c-2-hexene	
22.40	620.58	3-methyl-2-pentene	
22.59	624.83	2,2-dimethylpentane	
24.69	627.07	methylcyclopentane	P
24.89	631.32	2,4-dimethylpentane	P
25.09	635.35	mechloroform	
25.35	641.61	2,2,3-trimethylbutane	
25.61	647.43	1-methylcyclopentene	
25.77	651.01	benzene	P
25.99	655.93	3,3-dimethylpentane	
26.18	660.85	cyclohexane	P
26.37	665.10	4-methylhexene	
26.54	668.46	2-methylhexane	P
26.63	670.69	2,3-dimethylpentane	P
26.78	674.05	cyclohexene	
26.92	677.18	3-methylhexane	P
27.02	680.31	C7 Olefin	
27.20	684.34	1,3-dimethylcyclopentane	
27.35	687.02	3-ethylpentane	
27.51	690.60	2,2,4-trimethylpentane	P
27.70	694.85	C7 Olefin	
27.83	697.76	t-3-heptene	
27.94	700.00	n-heptane	P
28.08	704.46	C8 Olefin	
28.18	706.93	C8 Olefin	
28.31	709.90	C8 Olefin	
28.43	712.13	2,4,4-trimethyl-1-pentene	
28.89	724.75	methylcyclohexane	P

Table 7-1

DRI Laboratory Calibration Species

Retention Time	Retention Index	Name	PAMS Compound
29.06	728.96	C8 Paraffin	
29.24	733.42	2,5-dimethylhexane	
29.34	735.89	2,4-dimethylhexane	
29.69	743.81	C8 Paraffin	
30.08	753.47	2,3,4-trimethylpentane	p
30.28	758.66	toluene	p
30.45	762.87	2,3-dimethylhexane	
30.65	767.33	2-methylheptane	p
30.73	769.31	4-methylheptane	
30.86	772.52	C8 Paraffin	
30.96	775.25	3-methylheptane	p
31.08	778.22	hexanal	
31.31	783.91	2,2,5-trimethylhexane	
31.40	786.14	1-octene	
31.51	788.86	1,1-dimethylcyclohexane	
31.96	800.00	n-octane	p
32.67	819.29	2,3,5-trimethylhexane	
32.80	822.83	2,4-dimethylheptane	
32.90	825.54	4,4-dimethylheptane	
33.13	831.79	2,6-dimethylheptane	
33.38	838.59	2,5-dimethylheptane	
33.58	844.29	3,3-dimethylheptane	
33.68	847.01	C9 Olefin	
32.87	852.17	C9 Olefin	
33.98	855.16	ethylbenzene	p
34.15	859.78	C9 Olefin	
34.28	863.59	m&p-xylene	p
34.45	868.38	2-methyloctane	
34.66	873.91	3-methyloctane	
34.84	878.80	C9 Paraffin	
34.95	881.79	styrene	p
35.15	887.23	o-xylene	p
35.40	894.02	1-nonene	
35.52	897.28	C9 Paraffin	
35.61	900.00	n-nonane	p
35.73	903.55	C9 Paraffin	
35.89	908.28	C9 Olefin	
36.39	914.79	C9 Paraffin	
36.56	926.04	isopropylbenzene	p
36.84	928.11	isopropylcyclohexane	
36.67	932.83	alpha-pinene	
36.86	937.28	benzaldehyde	

**Table 7-1**

**DRI Laboratory Calibration Species**

<b>Retention Time</b>	<b>Retention Index</b>	<b>Name</b>	<b>PAMS Compound</b>
36.98	940.83	2,6-dimethyloctane	
37.08	943.79	C10 Olefin	
37.18	946.75	3,6-dimethyloctane	
37.31	950.59	n-propylbenzene	p
37.54	957.40	m-ethyltoluene	p
37.62	959.76	p-ethyltoluene	p
37.79	964.79	1,3,5-trimethylbenzene	p
37.92	968.64	C10 Paraffin	
38.08	973.27	beta-pinene	
38.19	976.63	o-ethyltoluene	p
38.41	983.14	C10 Paraffin	
38.68	991.42	1,2,4-trimethylbenzene	p
38.97	1000.00	n-decane	p
39.08	1003.51	C10 Aromatic	
39.30	1010.54	isobutylbenzene	
39.53	1017.89	C10 Olefin	
39.66	1022.04	1,2,3-trimethylbenzene	p
39.78	1025.88	C10 Paraffin	
39.94	1030.99	indan	
40.12	1036.74	indene	
40.32	1043.13	m-diethylbenzene	p
40.42	1046.33	C10 Aromatic	
40.50	1048.88	p-diethylbenzene	p
40.68	1054.63	n-butylbenzene	
40.88	1061.02	o-diethylbenzene	p
41.08	1067.41	C10 Aromatic	
41.34	1075.72	1,3-dimethyl-4-ethylbenzene	
41.42	1078.27	C10 Aromatic	
41.60	1084.03	isopropyltoluene	
42.07	1100.00	n-undecane	p
42.27	1106.90	C10 Aromatic	
42.50	1114.83	C11 Paraffin	
42.62	1118.97	1,2,4,5-tetramethylbenzene	
43.13	1122.76	1,2,3,5-tetramethylbenzene	
43.38	1131.38	C11 Paraffin	
43.75	1144.14	2-methylindan	
44.15	1157.93	1-methylindan	
44.27	1162.07	C11 Aromatic	
44.36	1179.66	C11 Aromatic	
44.72	1192.07	naphthalene	
44.95	1200.00	n-dodecane	

during the sampling period. Prior to sample collection, the canisters are evacuated to less than 0.1 torr vacuum, and placed in a 125 °C oven for three hours. A fraction of the cleaned canisters were filled with zero air and analyzed by TO-12. The batch acceptance criteria for the canisters is less than 0.2 ppbC per hydrocarbon peak.

The C<sub>2</sub> and C<sub>3</sub> hydrocarbons are analyzed by BRC using a Hewlett Packard 5790 gas chromatograph with an FID detector. Sample aliquots are loaded onto a glass bead freezeout loop immersed in liquid oxygen. The components are desorbed from the cryofocus loop, and separated using a packed column of phenylisocyanate/Porasil C at 45 °C. The C<sub>4</sub> and C<sub>10</sub> hydrocarbons are analyzed by OGI using a Hewlett Packard 5890A gas chromatograph with FID detector. Sample aliquots of 500 ml are loaded onto a 1/8 inch by 6 inch glass bead freezeout loop immersed in liquid oxygen. The components are desorbed with 90 °C hot water onto a capillary cryofocus loop at the head of the column at -60 °C. They are then desorbed from the cryofocus loop, and separated using a 60-meter 0.25-micron J&W Scientific DB-1 capillary column with a 1.0-micron coating. The column is programmed from -60 °C to 200 °C at 4 °C/min. The chromatograms are integrated using the HP ChemStation computer data station and stored onto a hard disk. Data from the integrator are entered into a spreadsheet to generate the final report. The detection limits for this method are 0.1 ppbC for the hydrocarbon target compounds and the precision of the analysis at 5 ppbC is 10 percent.

The calibration by BRC is in terms of mass (area response/ng) of neohexane, which is used as an internal standard in each sample. The neohexane is traced to NIST benzene SRM (0.254 ppmv). For comparative purposes, OGI converts their hydrocarbon concentrations from µg/m<sup>3</sup> units to ppbC. A problem exists in selecting the most suitable conversion factor(s). The factors that convert mixing ratios in ppbC to mass concentration in µg/m<sup>3</sup> will vary among hydrocarbons because the molecular weight/number of carbon atoms ratios are not constant for all hydrocarbons. At 1 atm pressure and 25 °C, the (µg/m<sup>3</sup>) to ppbC conversion factor for methane is 1.5 and 1.88 for benzene. The conversion factor for propane (1.67) is selected OGI. If conversion factors specific to each hydrocarbon are employed instead, the corresponding concentrations will be up to 5 percent higher for alkane, 5 to 10 percent higher for alkenes and cycloalkane, and 10 to 15 percent higher for aromatic hydrocarbons.

BRC recently participated in a hydrocarbon audit and laboratory comparison as part of the NARSTO-Northeast Study. The other participants were the State University of New York at Albany (SUNYA), EPA Region I, and eight of the Photochemical Assessment Monitoring Station (PAMS) networks in the northeastern U.S. (Maine, Connecticut, Massachusetts, Maryland, City of Philadelphia, New Jersey, New York, and Virginia). The Desert Research Institute (DRI), which conducted measurements in roadway tunnels in New York and Boston during the summer of 1995 also participated in the performance audits. The results were evaluated and reported by Fujita et al. (1996). The hydrocarbon measurement comparison consisted of two synthetic samples used by the Environmental Protection Agency in the Photochemical Assessment Monitoring Station (PAMS) program, and two ambient samples collected by EPA in the Research Triangle Park area. The samples were analyzed by the contracting laboratory and by the Environmental Protection Agency Atmospheric Research and Exposure Assessment Laboratory, which served as the referee laboratory. The main findings of the audit listed below.

- In general, the values reported by the audited laboratories were well correlated with the values obtained by EPA. Eight of the twelve, including both BRC and DRI, reported values that were within 10 percent of EPA for all four audit samples. Mean values greater than 1.0 ppbC with Laboratory/EPA ratio greater than 0.7 and less than 1.3 were used for the calibration checks in order to minimize the effect of inconsistent identifications on the correlations.
- Because calibration differences are generally within 10 percent, the outliers (i.e., data pairs with mean concentrations greater than 1.0 ppbC with Laboratory/EPA ratio less than 0.7 and greater than 1.3) are likely due to differences in peak identification between the audited laboratory and EPA. The ratios of outliers to number of compounds in the sample with concentrations greater than 1 ppbC indicate the degree of inconsistency in peak identification. The average of the ratios of outliers for the four audit samples are less than 10 percent for four of the groups (including DRI), 10 to 20 percent for five of the groups (including BRC), and 20 to 30 percent for three of the groups.
- The sum of the PAMS target compounds and total NMHC in the PAMS region of the chromatogram reported by the audited laboratories were generally within 10 percent of the corresponding EPA values.
- Examination of the other subtotals reported by EPA provided an indication of the relative importance of organic compounds that are not PAMS target compounds. For the ambient samples used in the audit, which reflect mostly motor vehicle emissions, sums of identified compounds that are not PAMS target compounds are 10 to 25 percent of the total NMHC (up to n-undecane). Semi-volatile hydrocarbons beyond n-undecane that can be measured from canisters are equivalent to 4-9 percent of the total NMHC up to undecane. Concentrations of oxygenated compounds, mainly methanol, were variable and were probably artifacts that were introduced when the samples were diluted by EPA. Oxygenated compounds typically represent a larger fraction of total NMOC in receptor area.
- Without exception, all of the species in the synthetic mixtures, once in the transfer canisters, were stable (within 5 percent of the original values) throughout the duration of the comparison study (up to three months). Initial and repeat values for most species were also within 5 to 10 percent of the NIST-traceable values. These results provide confirmation of the accuracy of EPA's analyses. Several unstable and higher-molecular weight species showed decreases from their reference values. Acetylene and 2-methyl-1-pentene values were less than 50 percent of the reference value. Styrene, n-propylbenzene, m- and p-diethylbenzene were less than 80 percent, and p- and o-ethyltoluene and n-undecane were less than 90 percent of the reference values. However, even these species remained stable for up to three months once the dry synthetic mixtures were transferred to a humidified canister.

#### **7.4.2 Sampling and Analysis Methods for Carbonyl Compounds (AtmAA)**

The technique used by AtmAA to measure ambient carbonyl compounds is an established procedure using C<sub>18</sub> (octadecylsilane-bonded silica) Sep-Pak cartridges (Waters Associates, Milford, MA) which have been impregnated with purified acidified 2,4-dinitrophenylhydrazine

(DNPH). When ambient air is drawn through the cartridge, carbonyls in the air sample react with DNPH to form hydrazones, which are separated and quantified using HPLC in the laboratory (Fung and Grosjean 1981). This technique is the most commonly used method for measuring these compounds in ambient air. The variation of this methods used in the PAMS program replaces the C<sub>18</sub> substrate with DNPH-coated silica gel Sep-Pak cartridges and an upstream KI scrubber to remove ozone, which causes a negative interference with the method.

Cartridge samples are taken using an automated sampler with six channels to collect samples sequentially on an event basis. The sampler has a seventh channel for taking either a duplicate sample concurrently with one of the active channels, or a field blank. Since cartridges will naturally sorb carbonyl compounds from the surrounding air if left open, the sampler has been designed such that cartridges loaded into the sampler are isolated from the environment and from each other by check valves upstream and solenoid valves downstream. Memory protected programmable timers are used to control the operation of the pump and the solenoid valves according to the prescribed schedule. Duplicate samples can be collected on collocated cartridges by activating a parallel channel simultaneously. A mode selection switch converts the parallel channel for field blank collection as well. Sampling flow rates are controlled at ~0.9 liter/min using a differential flow controller with a typical precision of  $\pm 5\%$  or less.

The samples are analyzed in batches of 20 to 40 cartridges. Each cartridge is eluted with 3 ml of acetonitrile into a graduated polyethylene tube with a resealable cap. The exact volume is calibrated gravimetrically. An aliquot of the eluent is transferred into a 2-ml septum vial and injected with an autosampler into a high performance liquid chromatograph (Shimadzu LC-6) for separation and quantitation of the hydrazones. The samples are analyzed for formaldehyde, acetaldehyde, acetone, propanal, benzaldehyde, o-tolualdehyde, and C<sub>4</sub> to C<sub>6</sub> aliphatic carbonyls group by carbon number.

Derivation of carbonyl compounds by 2,4-dinitrodinitrophenylhydrazine (DNPH) followed by liquid chromatography and u.v. detection is currently the most widely used method for measurement of ambient carbonyl compounds. Two variations of this methods will be used during SCOS97-NARSTO. AtmAA and DRI both collected ambient carbonyl compounds using C18 Sep-Pak cartridges impregnated with acidified DNPH reagent while local air pollution agencies in the study area used similarly impregnated silica Sep-Pak cartridges recommended by EPA Compendium Method TO-11, which is the standard method used nationally at Photochemical Assessment Monitoring Stations (PAMS). The PAMS variant of the of the DNPH method includes an ozone scrubber upstream of the impregnated cartridge since silica cartridges were found to have significant negative ozone artifacts. Despite the acceptance and widespread use of the DNPH methods, questions still remain regarding interferences and sampling artifacts associated with the methods.

The questions regarding the accuracy of the DNPH method is mainly concerned with sampling. In order to address these questions, AtmAA participated in two measurement comparisons as part of an external quality assessment of carbonyl measurements for NARSTO-Northeast. Results of AtmAA's comparisons with the Massachusetts Department of Environmental Protection at Agawam, MA, and with ManTech during the 1995 Nashville/Middle Tennessee Ozone Study are summarized by Fujita et al., (1996). The factors

affecting carbonyl measurements by the DNPH method were review from published articles and discussion with investigators active in this area in order to provide a perspective for interpreting the results from the two comparison studies. Relevant parameters include the substrate (type, DNPH loadings, blank levels, and variability), sampling conditions (ambient ozone concentrations, temperature, relative humidity, sample volume measurements, breakthrough, type of sampling line and ozone scrubber), sample storage, and handling (exposure to light and heat, type of storage and duration of storage), sample preparation and analysis.

- Reagent Loading and Blank Levels. Blank levels are related to the loading level of DNPH on cartridges in that higher loading levels almost always lead to higher blank levels. The formaldehyde average blank level for the Waters DNPH-coated ready-to-use silica Sep-Pak cartridges, which have a typical loading of 5  $\mu\text{mol}$  of DNPH per cartridge (1 mg/cartridge) is 1.18 nmol/cartridge. The average formaldehyde blank level for C18 cartridges prepared by AtmAA, which have DNPH loadings of 10  $\mu\text{mol}$ /cartridge (2 mg/cartridge), is  $2.38 \pm 0.51$  nmol/cartridge. While the absolute blank level for the C18 cartridges is a factor of two higher than the silica gel cartridges, the relative standard deviation is in the same range as that found for commercial silica gel cartridges.
- Reagent pH. The rate and extent of reactions of DNPH with carbonyl compounds is pH dependent and vary with the compound.
- Relative Humidity. Decrease in collection efficiency of carbonyl compounds on C18 cartridges have been observed in dry air (RH = 3-7%) for ketones but not for aldehydes. The decrease in collection efficiency due to change in relative humidity should only be of concern in a limited number of applications since DNPH-coated cartridge measurements of carbonyls are seldom made in very dry air.
- Breakthrough. During the NARSTO-Northeast 1995 Ozone Study, 48 tandem C18 cartridges were collected to assess breakthrough in ambient samples. Except for acetone, all species up to C6 carbonyls average 95% efficiency or greater. Acetone collection efficiency averaged approximately 79%, with most of the lower values (45 to 65%) corresponding to the nighttime period when 6-hour samples were collected rather than 3 hour samples during the daylight hours. Average collection efficiency for acetone during daytime periods was over 90%.
- Ozone Artifacts A number of studies have reported that DNPH-coated silica gel cartridges show a dramatic negative interference by ozone in the determination of formaldehyde. Most of these studies have observed no interference for formaldehyde with C18 substrates. The negative artifact arises from the reaction of ozone with the DNPH derivative. In the case of C18 cartridges, the radicals generated by the ozone attack can be scavenged by the C18 phase, thus limiting further attack on DNPH or hydrazone. With the C18 cartridge, a positive ozone interference was detected with the formation of a peak which coelutes with the HCHO hydrazone. Several chromatographic conditions were used without success to separate the coeluting peak, which suggests the possibility that the artifact is the HCHO hydrazone itself. The magnitude of the interference is approximately 1.7% of the number of moles of ozone that pass through the cartridge. The presence of ozone in the system does not lead to formation of peaks which

are coincident to the hydrazones for the acetaldehyde or propionaldehyde. Artifacts reported have been on the cartridges prepared by individual researchers, and the cartridge composition were not addressed in each case. The artifacts observed may not have been attributed solely to the substrate. Multiple factors, such as, among others, reagent formulation, loading, and acidity of the DNPH, are important in determining the extent of the artifacts that may occur. An experiment in which atmospheric samples were collected by collocated C18 and silica gel cartridges that were prepared by AtmAA at the same time under identical conditions gave comparable formaldehyde levels which also compared well to the TDLAS measurements. These results suggest that the type of substrate (C<sub>18</sub> versus silica gel) is less critical than how the cartridge is prepared.

- Comparison of the DNPH Method with Spectroscopic Measurements Previous studies in California prior to and during the Southern California Air Quality Study (SCAQS) indicated that formaldehyde concentrations determined using C18 DNPH cartridges similar to those used in NARSTO-Northeast and planned for SCOS97-NARSTO compare well to those from continuous instruments such as long-path FTIR, DOAS, and TDLAS. Measurements of formaldehyde by C18 DNPH cartridges during SCAQS generally tracked ozone concentrations and were in reasonably good agreement with TDLAS measurements. In contrast, SCAQS measurements of HCHO by silica gel DNPH cartridges were substantially lower in comparison to the TDLAS during the middle of the day, when ozone reached maximum concentrations. Similar results were also obtained during the 1993 Los Angeles Atmospheric Free Radical Experiment and in the NCAR/SOS Formaldehyde Intercomparison Study in Boulder.
- Ozone Removal For relative humidity less than approximately 5%, packed-KI scrubbers have extremely low capacity for ozone removal and breakthrough occurs within a few minutes at a flow of 1 L min<sup>-1</sup>. Scrubbing efficiency increases substantially even at low levels of relative humidities (ca. 10%). In contrast, KI-coated copper tube denuders show negligible breakthrough even under dry conditions. At moderate to high RH, the ozone denuders have high capacity for ozone removal. Results show an efficiency of at least 24,000 ppbv-h for these devices. For an average ozone concentration (day and night) of 60 ppbv the devices are expected to be effective for at least 16 days when used at a flow rate of 1 L min<sup>-1</sup>. Carbonyl compounds are generally quite soluble in water and KI is a highly hygroscopic chemical. In test conducted at RH of 75%, there is no evidence of formaldehyde retention on KI scrubbers over typical sampling times. Other carbonyls have not been tested, and it is possible that carbonyl compounds with carbon number higher than C<sub>4</sub> might be retained by the scrubber or denuder in some cases. Method TO-11 specifies heating the KI denuders to approximately 50 °C to avoid formaldehyde loss.
- Sample Handling and Storage The amount of exposure is reduced significantly by using a protective closure compared to an open cartridge. For formaldehyde, a polyethylene cap provides about ten times more protection than PVC caps and about twice as much protection as plugs. Screw-capped vials offer additional protection. Hydrazones of stable carbonyls, such as formaldehyde, acetaldehyde, and acetone maintain their integrity on silica gel and C<sub>18</sub> cartridges for over a month under refrigerated storage. However, the olefinic aldehydes such as acrolein and crotonaldehyde degrade partially on the

cartridges, either during sampling or storage, and form unknown products. Exposure to sunlight causes significant production of carbonyls which can be eliminated by wrapping the cartridges in aluminum foil during sampling and storage.

- Lower Quantifiable Limits and Measurement Precision Factors that may cause a bias in this measurement, such as breakthrough, blank variability, hydrazone product stability were evaluated and conducted as part of the QA/QC activities in NARSTO-Northeast. Based on field blanks and their variability, lower quantifiable limits (LQL) for 3-hour samples were approximately 0.4 ppbv or less for all but the >C6 carbonyls, which was estimated at 1 ppbv. The LQLs for 6-hour samples are half those values. Analytical precisions derived from repeat analysis range from 0.014 µg for propanal to 0.16 µg for >C6 carbonyls, corresponding to a coefficient of variation of 3 to 4% for the major components such as formaldehyde, acetaldehyde, and acetone. There were 26 pairs of collocated samples, which provided an estimation of the carbonyl measurement precision. Most species had a CV of 4 to 8%, except propanal (10.6%), C5 carbonyls (9%), and >C6 carbonyls (15.0%).

In summary, there are few measurement techniques which can be used to evaluate the accuracy of the carbonyl species concentrations made by the DNPH method. Previous studies in California prior to and during the Southern California Air Quality Study (SCAQS) indicated that formaldehyde concentrations determined using C<sub>18</sub> DNPH cartridges similar to those used in NARSTO-Northeast compare well to those from continuous instruments such as long-path FTIR, DOAS, and TDLAS. There was a small negative bias of 0.7 ppb, corresponding to -6.9% at the mean formaldehyde concentration (10.2 ppb) observed during the study (Fung and Wright 1990, Lawson et al 1990). The average peak ozone concentration for the ten day study was approximately 195 ppb (Lawson et al 1990). Measurements of HCHO by C<sub>18</sub> DNPH cartridges during SCAQS generally tracked ozone concentrations and were in reasonably good agreement with TDLAS measurements. Also, the HCHO data showed good agreements between the C<sub>18</sub> DNPH cartridge and the TDLAS in the 1993 Los Angeles Atmospheric Free Radical Experiment (Mackay, 1994) and in the NCAR/SOS Formaldehyde Intercomparison Study (Calvert et al., 1996). In contrast, SCAQS measurements of HCHO by silica gel DNPH cartridges were substantially lower in comparison to the TDLAS during the middle of the day, when ozone reached maximum concentrations. Arnts and Tejada (1989) reported a significant ozone interference associated with EPA Method TO-11 using DNPH-coated silica gel cartridges. They observed a significant reduction in the level of formaldehyde measured in the presence of ozone. In the same study, they also evaluated cartridges prepared with the C<sub>18</sub> substrate, and observed no interference for formaldehyde from ozone at the 120 ppb level used in the experiment. Arnts and Tejada concluded that the ozonolysis of formaldehyde hydrazone is apparently substrate dependent (silica gel vs C<sub>18</sub>). These results were subsequently reproduced by Mantech (Kleindienst, 1994).

Positive ozone artifacts have also been reported (Rodler and Birks, 1994) on formation of HCHO, methyl vinyl ketone, and methacrolein from isoprene, and several higher carbonyls from the C<sub>18</sub> substrate. The C<sub>18</sub> artifact observed by Rodler and Birks (1994) is contrary to the field

data collected from the studies cited above in which daily ozone levels of 260 to 280 ppb were observed. An experiment in which atmospheric samples were collected by collocated C<sub>18</sub> and silica gel cartridges that were prepared at the same time under identical conditions gave comparable formaldehyde levels which also compared well to the TDLAS measurements (Fung, 1993). These results suggest that the type of substrate (C<sub>18</sub> versus silica gel) is less critical than how the cartridge is prepared. Artifacts reported have been on the cartridges prepared by individual researchers, and the cartridge composition were not addressed in each case. The artifacts observed may not have been attributed solely to the substrate. Multiple factors, such as, among others, reagent formulation, loading, and acidity of the DNPH, are important in determining the extent of the artifacts that may occur.

With the exception of nighttime acetone values, it is likely that nominal accuracy of the DNPH carbonyl data is better than 20 percent for measured carbonyl species with concentrations above 2 ppb.

#### **7.4.3 Airborne Sampling of Hydrocarbons and Carbonyl Compounds**

Hydrocarbon sampling onboard aircraft is essentially the same as on the surface. However, because of the longer sampling times required for the DNPH-cartridge method, ambient samples are first collected in Tedlar bags. The air samples are transferred from the bags to cartridges soon after the flight has ended. Other than the transfer bag, the sampling procedures are identical to the collection of surface samples.

#### **7.4.4 Carbon Monoxide, Carbon Dioxide and Methane**

Methane (CH<sub>4</sub>), carbon monoxide (CO), and carbon dioxide (CO<sub>2</sub>) are measured from the canister samples using GC/FID. Since the FID does not respond to CO and CO<sub>2</sub>, these species are converted to methane by a methanator, positioned after the GC column but ahead of the FID. The methanator comprises a firebrick powder impregnated with nickel catalyst, through which a stream of hydrogen gas flows continuously at ~550 °C. For compound separation, a 20-foot x 1/8-inch inner-diameter (i.d.) column packed with a 60/80 mesh of Carboxen 1000 (Supelco) is used. This column provides sufficient separation between CH<sub>4</sub> and CO, without retaining CO<sub>2</sub>. Five ml samples are injected using a constant-volume loop. The detection limit for both CO and CH<sub>4</sub> is ~20 ppbv, whereas for CO<sub>2</sub> it is ~3 ppmv. The precision is generally better than 10%.

#### **7.4.5 Oxygenated Organic Compounds**

Methyl t-butyl ether is quantified from canister samples, using the method of analysis for C<sub>3</sub>-C<sub>11</sub> hydrocarbons. The individual response factor is determined for MTBE and its concentration is reported in ppbv. It is particularly important to obtain good separation of the MTBE peak, which normally elutes just before 2-methylpentane and after 2,3-dimethylbutane.

#### **7.4.6 Halogenated Hydrocarbons**

Halogenated compounds can be also quantified from canister samples, with the same column as used for C<sub>3</sub>-C<sub>11</sub> hydrocarbons. However, electron capture detection is used rather than flame ionization due to the weaker and variable response of halogenated compounds on the FID.

This method will be used by DGA to measure peroxyacetylnitrate (PAN) as well as perchloroethylene and methylchloroform at Azusa and Simi Valley. A minimum of three canister samples from Azusa should also be analyzed by the Desert Research Institute with their semi-continuous halocarbon analyzer and compared to values reported by DGA.

## **7.5 Systems Audits**

The quality assessment of SCOS97-NARSTO VOC data included system audits of the two main VOC laboratories (AtmAA for carbonyl compounds and BRC for hydrocarbons). These audits include review of operational and quality control procedures to assess whether they are adequate to assure valid data which meet the specified levels of accuracy and precision. An on-site systems audit of AtmAA was conducted in 1995 by Dr. Eric Fujita. The results of this audit will be summarized in lieu of an audit for SCOS97-NARSTO.

An on-site systems audit of BRC was not performed by DRI during the 1995-96 NARSTO-Northeast study. However, two separate systems audits were performed by DRI staff within the last ten years at Dr. Rasmussen's laboratory at Oregon Graduate Institute (OGI). The first audit in 1987 during the Southern California Air Quality Study, and the second audit in 1990 during the San Joaquin Valley Air Quality Study. While the standard operating procedure for hydrocarbon analysis at BRC has not changed during this time, seven years is sufficient time to warrant a new systems audit. An on-site systems audit will be conducted at BRC by Dr. Zielinska of the DRI in May, 1997.

## **7.6 Performance Audits**

### **7.6.1 Hydrocarbons**

The hydrocarbon performance audits will consist of two ambient samples. A draft protocol is included as Appendix C. Participating laboratories include ARB, EPA, BRC, DRI, SDAPCD, SCAQMD, VCAPCD, and BAAQMD. Each participating laboratory will supply to ARB, Monitoring and Laboratory Division two cleaned, evacuated 6-liter canisters by April 25, 1997. EPA, ARB and DRI will supply two additional canisters (four in all). ARB will fill the two sets of canisters to 20-25 psi with ambient air from the Los Angeles area using a manifold sampling system supplied by the Desert Research Institute. One set of canisters will be collected in the morning (after 6:00 a.m. and before 9:00 a.m., PDT) in an area heavily influenced by mobile source emission. The other set will be collected in the afternoon (after 1:00 p.m. and before 4:00 p.m., PDT) in a downwind area with maximum ozone levels. Duplicate samples will be collected for EPA, ARB and DRI (total of eleven simultaneous canister samples at each site). ARB will send the two (or four) ambient audit samples to each participating laboratory by May 6, 1997. Each laboratory will analyze the audit samples within five working days after receiving the audit canisters. EPA, ARB and DRI will reanalyze their samples after one and two months to monitor the stability of the audit samples. Analytical results will be compiled by the California Air Resources Board, Research Division and results will be summarized by DRI.

### **7.6.2 Carbonyl Compounds**

The carbonyl performance audit will consist of sampling under field conditions with addition of a standard mixture of carbonyls from a 6-liter stainless steel canister to an ambient sample. A draft protocol is included in Appendix E. The can will also contain benzene for quality control purposes. The main supply of the standard mixture will be prepared at the Desert Research Institute in a 33-liter tank. The standard mixture in a 6-liter canister and a dilution apparatus will be supplied by the Desert Research Institute, along with operating instructions. The standard audit protocol will consist of a 3-hour ambient sample using two DNPH cartridges in series (same as a breakthrough experiment) with addition of the standard mixture, with appropriate dilution, between the two cartridges. The front cartridge serves to scrub ambient carbonyl compounds and ozone. Each group will collect two samples and pass the 6-liter canister and gas dilution system on to the next group. The 6-liter canisters will hold sufficient sample for two groups. The Air Resources Board, Monitoring and Laboratory Division will analyze the contents of the canister by DNPH/HPLC prior to shipment and upon its return. The contents of the main tank will be periodically analyzed by both DNPH/HPLC and GC/FID (for higher MW carbonyls). These audits will be performed in June 1997.

A similar audit was conducted for the 1996 NARSTO-Northeast Study. The results of the audit are currently under review by the Dr. Eric Fujita of the DRI. Preliminary results indicate that formaldehyde, acetaldehyde and acetone are stable in both the main tank and in the 6-liter transfer canisters. Two higher aldehyde, pentanal and benzaldehyde, while stable in the 33-liter canister under high pressure (60-80 psi), show significant loss in the 6-liter transfer canisters (10-25 psi).

### **7.6.3 Airborne Sampling of Carbonyl Compounds**

The performance audit for the aircraft sampling of carbonyl compounds will be similar to surface-based measurements. The main procedural difference is that the Tedlar bag will be filled with zero-air with addition of the standard carbonyl mixture.

## **7.7 Corrective Action**

The systems and performance audits will be conducted prior to the field study in May and should be available in June, 1997. This schedule is probably optimistic based on experiences of past audit program of this type. Firm commitments from participating laboratories and sponsoring organizations will be required to minimize delays in disseminating the results of the audits that may lead to corrective actions.

The QA team will provide the results of the VOC performance audits and laboratory comparisons to participants as soon as they are available. It will be the obligation of each laboratory to examine the results, diagnose the cause for disagreements of their data with those reported by the majority of other laboratories, and take the necessary corrective actions.

## 7.8 Data Acquisition and Processing

Gas chromatographs and HPLC systems are connected to data acquisition systems that perform data acquisition, peak integration and identification, hardcopy output, post-run calculations, calibrations, and user interfacing. Acquired data are automatically stored on a hard disk. Typically the chromatographic information from the data acquisition system is post-processed to confirm peak identifications and to transfer the data to a spreadsheet or database format. In the case of carbonyl compounds, blank values are subtracted and blank uncertainties are combined with volume and analytical uncertainties.

## 7.9 Data Validation

The data validation process consists of procedures that identify deviations from measurement assumptions and procedures. Three levels of validation are applied which will result in the assignment to each measurement of one of the following ratings: 1) valid; 2) valid but suspect; or 3) invalid. Level 1 data validation normally takes place in the field or in the laboratory and consists of: 1) flagging samples when significant deviations from measurement assumptions have occurred; 2) verifying computer file entries against data sheets; 3) eliminating values for measurements which are known to be invalid because of instrument malfunctions; 4) adjustment of measurement values for quantifiable calibration or interference biases; 5) determining measurement precision by replicate analyses and by collection of field blanks and collocated samples.

Level 2 validation takes place after the data from various measurement methods have been assembled in a master database. Level 2 applies consistency tests based on known physical relationships between variables to the assembled data. These tests fall into three categories: detection of extreme values; consistency between redundant measurements and co-pollutants; and examination of temporal and spatial variations. The following are examples of level 2 validations for VOC measurements.

### Detection of Extreme Values

- Derive summary statistics (mean, maximum, standard deviation) for all species and species groups, both for concentration and weight fractions. Sort the database by concentration and weight fraction of each species (including the less abundant species) and note any unusually high concentrations or fractions (any species) or unusually low concentrations or fractions of normally abundant species.
- Develop box-whisker plots of abundant species and species groups stratified by site, time of day.
- Stratify data by site and time of day and flag values above 5 ppbC for hydrocarbons and 2 ppbv for carbonyl compounds if the ratio of the absolute difference between sample and mean values to the standard deviation among values within the stratified group is greater than three (i.e.,  $|\text{value-mean}|/\sigma > 3$ ). Examine patterns in occurrence of extreme points in

time relative to wind direction, mixing height or some other physical variables, and determine if the unusual value is due to measurement error or a valid result of an environmental cause.

### Consistency Checks

- Compare total nonmethane hydrocarbons derived from the sum of species measured by gas chromatography with flame ionization detection (TO-14 Method) and preconcentration direct Injection flame ionization detection (PDFID), TO-12 Method.
- Prepare scatter plots of NMOC and NMHC versus CO, benzene, toluene, and other abundant species; benzene versus toluene; propane versus n-butane and note outliers. For each site and sampling period, examine distributions of the following ratios: benzene/CO, methane/NMOG, olefins/NMOG, aromatics/NMOG, carbonyls/NMOG, CO/NO<sub>x</sub> and NMOG/NO<sub>x</sub> ratios. We will apply appropriate range limits (e.g., differences of no greater than three standard deviation of all values for each site and period), and identify outliers).

### Temporal and Spatial Variability

- Prepare time-series plots of abundant species and compare sample-to-sample, site-to-site, date-to-date, and sampling period-to-sampling period variations.
- Plot monthly mean diurnal variations by site and examine consistency of diurnal patterns with respect to patterns in emissions, atmospheric chemistry, and seasonal meteorological changes.

Level 3 validation is part of the subsequent data interpretation process. Receptor modeling, factor and other statistical analyses, and photochemical air quality simulation models are several examples. Unusual values are identified during the data interpretation process as: 1) extreme values; 2) values which would otherwise normally track the values of the other variables in a time series; and 3) values for observables which would normally follow a qualitatively predictable spatial or temporal pattern.

### **7.10 Data Archival**

Data from the Air Pollution Control Districts are archived in AIRS format and are submitted to ARB and EPA. Data from the supplemental measurements will be archived in accordance with the format specified by the SCOS97-NARSTO Data Manager.

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**Appendix A**  
**Surface Air Quality Sites**

Appendix A. Surface Air Quality Sites

Site ID	Data Source	Site Name	Site Number	Latitude			Longitude			Elev. m	Variables Measured						
				DD	MM	SS	DD	MM	SS		O3	NO	NOx	CO	THC	CI14	NMHC
ARVN	CARB	ARVIN-20401 BEAR MTN BLVD	60295001	35	12	28	118	47	2	145	E	E	E	E	E	E	E
BLFC	CARB	BAKERSFIELD-5558 CALIFORNIA ST	60290014	35	21	21	119	2	23	???	E	E	E	E	E	E	E
CALE	CARB	CALEXICO-CALEXICO HS ETHEL ST	60250005	32	40	33	115	28	58	1	E	E	E	E	E	E	E
EDSN	CARB	EDISON-JOHNSON FARM	60290007	35	20	45	118	51	3	425	E	E	E	E	E	E	E
MOJP	CARB	MOJAVE-923 POOLE ST	60290011	35	3	3	118	8	45	853	E	E	E	E	E	E	E
THOS	CARB	OAK VIEW-5500 CASITAS PASS RD	61110005	34	23	13	119	24	57	320	E	E	E	E	E	E	E
OLDL	CARB	OILDALE-3311 MANOR ST	60290232	35	26	20	119	0	57	180	E	E	E	E	E	E	E
PSRB	CARB	PASO ROBLES-235 SANTA FE AVE	60790005	35	37	55	120	41	23	100	E	E	E	E	E	E	E
SLWC	CARB	SAN LUIS OBISPO-1160 MARSH ST	60792002	35	17	2	120	39	14	66	E	E	E	E	E	E	E
SBWC	CARB	SANTA BARBARA-3 W CARRILLO ST	60830010	34	25	15	119	42	3	71	E	E	E	E	E	E	E
SMSB	CARB	SANTA MARIA-500 S BROADWAY	60831007	34	56	52	120	26	2	???	E	E	E	E	E	E	E
CPGB	CHVRON	CARPINTERIA-GOBERNADOR RD	60831021	34	24	10	119	27	28	137	E	E	E	E	E	E	E
GAVE	CHVRON	GAVIOTA EAST-N OF CHEVRON PLAN	60831016	34	28	40	120	12	21	105	E	E	E	E	E	E	E
GAVW	CHVRON	GAVIOTA WEST-NW OF CHEVRON PLA	60831015	34	28	40	120	12	39	91	E	E	E	E	E	E	E
PTCL	CHVRON	POINT CONCEPTION LIGHTHOUSE	60831012	34	27	7	120	27	28	40	E	E	E	E	E	E	E
SLPL	EMC	SAN LUIS OBISPO-7020 LEWIS	60791004	35	12	25	120	37	4	80	E	E	E	E	E	E	E
UCSB	EXXON	UCSB WEST CAMPUS-ARCO TANK, IS	60831020	34	24	53	119	52	44	9	E	E	E	E	E	E	E
CLXC	ICAPCD	CALEXICO-900 GRANT ST	60250004	32	40	26	115	30	10	0	E	E	E	E	E	E	E
ECYS	ICAPCD	EL CENTRO-150 9TH ST	60251003	32	47	31	115	33	43	0	E	E	E	E	E	E	E
WEST	ICAPCD	WESTMORLAND-202 W FIRST ST	60254003	33	1	58	115	37	22	0	E	E	E	E	E	E	E
BARS	MDAQMD	BARSTOW-401 MOUNTAIN VIEW	60710001	34	53	41	117	1	26	690	E	E	E	E	E	E	E
HESP	MDAQMD	HESPERIA-17288 OLIVE ST	60714001	34	25	4	117	17	5	1006	E	E	E	E	E	E	E
PHEL	MDAQMD	PHELAN-BEEKLEY & PHELAN RDS	60710012	34	25	33	117	33	46	1250	E	E	E	E	E	E	E
TRNA	MDAQMD	TRONA-83732 TRONA ROAD	60710015	35	46	29	117	22	1	498	E	E	E	E	E	E	E
29PM	MDAQMD	TWENTYNINE PALMS-6136 ADOBE DR	60710017	34	8	31	116	3	17	607	E	E	E	E	E	E	E
VICT	MDAQMD	VICTORVILLE-14029 AMARGOSA RD	60710014	34	3	46	117	19	8	876	E	E	E	E	E	E	E
JOSH	NPS	JOSHUA TREE NATIONAL MONUMENT	60719002	34	4	15	116	23	27	1244	E	E	E	E	E	E	E
UCDC	RIVER	UC RIVERSIDE-4919 CANYON CREST	60650004	33	57	43	117	20	55	236	E	E	E	E	E	E	E
ECSP	SBAPCD	EL CAPITAN STATE PARK	60830008	34	27	39	120	1	44	24	E	E	E	E	E	E	E
GLWF	SBAPCD	GOLETA-380 W FAIRVIEW AVE	60832011	34	26	41	119	49	40	4	E	E	E	E	E	E	E
LPSH	SBAPCD	LOMPOC-128 S H ST	60832004	34	38	16	120	27	21	24	E	E	E	E	E	E	E
SYAP	SBAPCD	SANTA YNEZ-AIRPORT RD	60833001	34	36	10	120	4	15	213	E	E	E	E	E	E	E
ANAH	SCAQMD	ANAHEIM-1610 S HARBOR BLVD	60590001	33	49	11	117	54	46	45	E	E	E	E	E	E	E
AZSA	SCAQMD	AZUSA-803 N LOREN AVE	60370002	34	8	9	117	55	22	183	E	E	E	E	E	E	E
BANN	SCAQMD	BANNING-135 N ALLESANDRO	60650002	33	55	40	116	52	26	722	E	E	E	E	E	E	E
BRBK	SCAQMD	BURBANK-228 W PALM AVE	60371002	34	10	33	118	18	57	168	E	E	E	E	E	E	E
CMNV	SCAQMD	COSTA MESA-2850 MESA VERDE DR	60591003	33	40	29	117	55	47	25	E	E	E	E	E	E	E
LGRE	SCAQMD	CRESTLINE-LAKE GREGORY-LAKE DR	60710005	34	14	38	117	16	26	1384	E	E	E	E	E	E	E
ELTR	SCAQMD	EL TORO-23022 EL TORO RD	60592001	33	37	37	117	41	23	137	E	E	E	E	E	E	E
FONT	SCAQMD	FONTANA-14360 ARROW BLVD	60712002	34	6	0	117	30	17	381	E	E	E	E	E	E	E
GLDR	SCAQMD	GLENORA-840 LAUREL	60370016	34	8	38	117	51	3	275	E	E	E	E	E	E	E
HAWH	SCAQMD	HAWTHORNE-5234 W 120TH ST	60375001	33	55	51	118	22	8	21	E	E	E	E	E	E	E
HEMT	SCAQMD	HEMET-880 STATE ST	60651002	33	44	31	116	57	28	409	E	E	E	E	E	E	E
INDO	SCAQMD	INDIO-46-990 JACKSON ST	60652002	33	42	32	116	12	50	-6	E	E	E	E	E	E	E
LHAB	SCAQMD	LA HABRA-621 W LAMBERT	60595001	33	55	33	117	57	3	82	E	E	E	E	E	E	E
LELS	SCAQMD	LAKE ARROWHEAD (Open by 1/96)	60710007								E	E	E	E	E	E	E
LELS	SCAQMD	LAKE ELSINORE-506 W FLINT ST	60659001	33	40	29	117	20	9	440	E	E	E	E	E	E	E
LANC	SCAQMD	LANCASTER-315 W PONDERSA ST	60379002	34	41	23	118	7	55	725	E	E	E	E	E	E	E
NLCB	SCAQMD	LONG BEACH-3648 N LONG BEACH	60374002	33	49	26	118	11	20	6	E	E	E	E	E	E	E
LAINM	SCAQMD	LOS ANGELES-1630 N MAIN ST	60371103	34	4	1	118	14	31	87	E	E	E	E	E	E	E
LYNW	SCAQMD	LYNWOOD-11220 LONG BEACH BLVD	60371301	33	55	44	118	12	35	27	E	E	E	E	E	E	E



**Appendix A. Surface Air Quality Sites**

Site ID	Data Source	Site Name	Site Number	Latitude		Longitude		Elev. m	Variables Measured					
				DD	MM	SS	DD		MM	SS	O3	NO	NOx	CO

R - Recommended for SCOS97  
A - Augment existing resource for SCOS97  
L - Relocated resource for SCOS97

**Appendix B**  
**Surface Meteorology Sites**

Appendix B. Surface Meteorology Sites

Site ID	Data Source	Site Name	Site			Latitude			Longitude			Elev. m	Variables Measured					
			Number	DD	MM	SS	DD	MM	SS	SS	T		WD	WS	Pr	SR	Vis	
BARA	BLM	BARAGAN WASH	327D53AC	32	58	3	113	26	58	148	E	E	E	E				
BEAR	BLM	BEAR PEAK	32554592	35	53	3	118	3	6	2509	E	E	E	E				
BIGB	BLM	BIG BEND	325CA03C	35	7	30	114	42	30	305	E	E	E	E				
BORO	BLM	BORON	3277B10C	35	5	39	117	34	55	882	E	E	E	E				
BURN	BLM	BURNS CANYON	325775FC	34	12	30	116	37	15	1829	E	E	E	E				
CALI	BLM	CALIENTE	325472F2	35	5	20	119	48	45	1349	E	E	E	E				
CARR	BLM	CARRIZO	325472F2	35	5	47	119	46	22	759	E	E	E	E				
CHRI	BLM	CHRISTMAS TREE PAS	325077C8	35	16	13	114	46	58	1052	E	E	E	E				
FISH	BLM	FISH CREEK MOUNTAIN	3277A27A	32	59	0	116	3	28	232	E	E	E	E				
GOOD	BLM	GOODWIN MESA	324C02BC	34	45	0	113	18	0	1280	E	E	E	E				
GRAN	BLM	GRANITE MOUNTAIN	325254D0	34	32	8	117	1	33	1439	E	E	E	E				
HAVA	BLM	HAVASU	3279B564	34	47	14	114	33	42	145	E	E	E	E				
HORS	BLM	HORSE THIEF SPRING	325185B6	35	46	14	115	54	33	1524	E	E	E	E				
JAWB	BLM	JAWBONE	32538042	35	17	40	118	13	30	1381	E	E	E	E				
MID	BLM	MID HILLS	3254C17C	35	9	58	115	24	55	1650	E	E	E	E				
MOHA	BLM	MOHAVE MOUNTAIN	327A777A	34	32	53	114	11	38	1433	E	E	E	E				
MOJA	BLM	MOHAVE RIVER SINK	3277C79C	35	3	30	116	5	0	290	E	E	E	E				
MOSS	BLM	MOSS BASIN	327D364A	35	2	1	113	53	33	1805	E	E	E	E				
MOUN	BLM	MOUNT LOGAN	324CA7A2	36	20	50	113	11	56	2195	E	E	E	E				
MUSI	BLM	MUSIC MOUNTAIN	3279707A	35	35	48	113	48	22	1768	E	E	E	E				
NXFT	BLM	NIXON FLATS PORTAB	327C4220	36	23	24	113	9	8	1982	E	E	E	E				
OLAF	BLM	OLAF KNOLLS	324CB14E	36	30	0	113	49	0	884	E	E	E	E				
OPAL	BLM	OPAL MOUNTAIN	3257960E	35	9	20	117	11	0	988	E	E	E	E				
PAHR	BLM	PAHRUMP	325CB34A	36	10	12	116	6	40	793	E	E	E	E				
PANA	BLM	PANAMINT	3277D4EA	36	7	0	117	5	0	2098	E	E	E	E				
PICA	BLM	PICACHO WASH	328E+173	32	57	0	114	43	56	256	E	E	E	E				
RED	BLM	RED ROCK	32516644	36	8	7	115	25	38	1146	E	E	E	E				
RICE	BLM	RICE VALLEY	3277F206	34	3	45	114	42	26	250	E	E	E	E				
STWH	BLM	SACATONE WASH	324DD3C8	35	34	25	114	40	28	665	E	E	E	E				
SMRV	BLM	SANTA MARIA RIVER	327AF160	34	17	25	113	21	35	427	E	E	E	E				
SMIT	BLM	SMITH PEAK	327D7540	34	6	57	113	20	50	762	E	E	E	E				
SOLK	BLM	SQUAW LAKE	327C34B0	32	54	30	114	29	40	91	E	E	E	E				
SOSP	BLM	SQUAW SPRINGS	3256429C	35	22	12	117	34	6	1104	E	E	E	E				
UNIO	BLM	UNION PASS	3277246E	35	13	48	114	22	57	1073	E	E	E	E				
WALK	BLM	WALKER PASS	3253B5D8	35	39	53	118	3	25	1699	E	E	E	E				
YELL	BLM	YELLOW JOHN MOUNTA	325FB444	36	9	15	113	32	30	1878	E	E	E	E				
ARVN	CARB	ARVIN-20401 BEAR MTN BLVD	60295001	35	12	28	118	47	2	145	E	E	E	E				
BLFC	CARB	BAKERSFIELD-558 CALIFORNIA ST	60290014	35	21	21	119	2	23	777	E	E	E	E				
CALE	CARB	CALEXICO-CALEXICO HS ETHEL ST	60250005	32	40	33	115	28	58	1	E	E	E	E				
EDSN	CARB	EDISON-JOHNSON FARM	60290007	35	20	45	118	51	3	425	E	E	E	E				
MOJP	CARB	MOJAVE-923 POOLE ST	60290011	35	3	3	118	8	45	853	E	E	E	E				
THOS	CARB	OAK VIEW-5500 CASITAS PASS RD	61110005	34	23	13	119	24	57	320	E	E	E	E				
OLDL	CARB	OILDALIE-3311 MANOR ST	60290232	35	26	20	119	0	57	180	E	E	E	E				
PSRB	CARB	PASO ROBLES-235 SANTA FE AVE	60790005	35	37	55	120	41	23	100	E	E	E	E				
SLOM	CARB	SAN JUIS OBISPO-1160 MARSH ST	60790002	35	17	2	120	39	14	66	E	E	E	E				
SBWC	CARB	SANTA BARBARA-3 W. CARRILLO ST	60830010	34	25	15	119	42	3	71	E	E	E	E				
SM5B	CARB	SANTA MARIA-500 S BROADWAY	60831007	34	56	52	120	26	2	777	E	E	E	E				
SHFT	CARB	SHAFTER-548 WALKER ST	60296001	35	30	14	119	16	19	126	E	E	E	E				
TOMP	CARB	THOUSAND OAKS-9 2323 MOORPARK	61110007	34	12	35	118	52	8	232	E	E	E	E				
VISA	CARB	VISALIA-2310 N CHURCH ST	61072002	36	19	55	119	17	23	97	E	E	E	E				
ACN	CDF	ACTON		34	26	0	118	12	0	793	E	E	E	E				

Appendix B. Surface Meteorology Sites

Site ID	Data Source	Site Name	Site Number	Latitude		Longitude		Elev. m	Variables Measured										
				DD	MM	SS	MM		DD	MM	SS	WS	WD	T	Td	RH	Pr	SR	Vis
ANZ	GDF	ANZA		33	33	0	116	40	0	1195									
ARG	CDF	ARROYO GRANDE		35	11	0	120	25	0	183									
BEC	CDF	BELL CANYON		33	32	0	117	35	0	213									
CAH	CDF	CAHOON		36	20	0	121	30	0	683									
CSS	CDF	CASE SPRINGS		33	26	0	117	25	0	707									
DEV	CDF	DEVORE		34	13	0	117	24	0	631									
FIS	CDF	FOUNTAIN SPRINGS		35	55	0	118	54	0	64									
FMC	CDF	FREMONT CANYON		33	48	0	117	42	0	543									
JUL	CDF	JULIAN		33	4	0	116	35	0	1293									
JUN	CDF	JUNIPER FLAT		33	46	0	117	5	0	646									
LPZ	CDF	LA PANZA		35	22	0	120	11	0	497									
LSF	CDF	LAS FLORES		33	17	0	117	26	0	30									
LTB	CDF	LAS TABLAS		35	39	0	120	55	0	290									
PKF	CDF	PARKFIELD		35	53	0	120	25	0	468									
POT	CDF	POTRERO		32	36	0	116	36	0	716									
RAN	CDF	RANCITA		33	12	0	116	30	0	1274									
SAF	CDF	SANTA FE		34	7	0	117	56	0	152									
SAR	CDF	SANTA ROSA PLATEAU		33	31	0	117	13	0	604									
CMR	CDF	TARGET RANGE		33	22	0	117	21	0	280									
VAL	CDF	VALLEY CENTER		33	13	0	116	59	0	418									
YUC	CDF	YUCCA VALLEY		34	7	0	116	24	0	994									
CPGB	CHVRN	CARPINTERIA-GOBERNADOR RD	60831021	34	24	10	119	27	28	137									
GAVE	CHVRN	GA VIOTA EAST-N OF CHEVRON PLAN	60831016	34	28	40	120	12	21	105									
GA/VW	CHVRN	GA VIOTA WEST-NW OF CHEVRON PLA	60831015	34	28	40	120	12	33	91									
VDMR	CHVRN	GA VIOTA-ODOR EAST	60831024	34	28	19	120	10	39	35									
ODOR	CHVRN	GA VIOTA-ODOR WEST-S OF PLANT	60831023	34	28	15	120	13	15	29									
PTCL	CHVRN	POINT CONCEPTION LIGHTHOUSE	60831012	34	27	7	120	27	28	55									
ARED	CIMIS	ARVIN-EDISON	125	35	12	22	118	46	40	152									
BKWC	CIMIS	BLACKWELLS CORNER	54	35	38	59	119	57	30	215									
CAMB	CIMIS	CALIPATRIA/MULBERRY	41	33	2	37	115	24	56	-34									
CLRM	CIMIS	CLAREMONT	82	34	7	48	117	41	46	494									
CUYA	CIMIS	CUYAMA	88	34	55	54	119	36	17	698									
ESCD	CIMIS	ESCONDIDO	74	33	5	24	116	58	52	137									
FVPT	CIMIS	FIVEPOINTS/WSES USDA	2	36	20	11	120	6	47	87									
GAPH	CIMIS	GOLETA FOOTHILLS	94	34	28	18	119	52	4	195									
IRVI	CIMIS	IRVINE	75	33	41	19	117	43	14	125									
KETT	CIMIS	KETTLEMAN	21	35	52	8	119	53	39	104									
LIND	CIMIS	LINDCOVE	86	36	21	26	119	3	31	146									
MELO	CIMIS	MELOLAND	87	32	48	24	115	26	46	-15									
NBSP	CIMIS	NEWBERRY SPRINGS	110	34	50	26	116	38	30	588									
OCSD	CIMIS	OCEANSIDE	49	33	15	21	117	19	11	15									
PLVD	CIMIS	PALO VERDE	72	33	23	15	114	43	21	70									
POMO	CIMIS	POMONA	78	34	3	30	117	48	42	223									
PTHU	CIMIS	PORT HUENEME	97	34	10	24	119	12	0	5									
RAMO	CIMIS	RAMONA	98	33	2	58	116	56	18	409									
SLTE	CIMIS	SALTON SEA EAST	128	33	13	12	115	34	48	-69									
SLTW	CIMIS	SALTON SEA WEST	127	33	19	38	115	57	0	-69									
SAND	CIMIS	SAN DIEGO	66	32	43	59	117	8	5	113									
SLOP	CIMIS	SAN LUIS OBISPO	52	35	18	22	120	39	37	101									
SNBA	CIMIS	SANTA BARBARA	107	34	26	16	119	44	10	76									
SNTM	CIMIS	SANTA MARIA	38	34	57	16	120	23	3	82									

Appendix B. Surface Meteorology Sites

Site ID	Data Source	Site Name	Site Number			Latitude			Longitude			Elev. m	Variables Measured									
			DD	MM	SS	DD	MM	SS	DD	MM	SS		WS	WD	T	Td	RH	Pr	SR	Vis		
STAM	CIMIS	SANTA MONICA	34	2	28	118	28	34	104	E	E	E	E	E	E	E	E	E	E			
SNTV	CIMIS	SANTA YNEZ	34	34	59	120	4	41	149	E	E	E	E	E	E	E	E	E	E			
SELY	CIMIS	SEELEY	32	35	43	115	43	34	12	E	E	E	E	E	E	E	E	E	E			
SHAF	CIMIS	SHAFTER/USDA	35	31	59	119	16	52	110	E	E	E	E	E	E	E	E	E	E			
TEME	CIMIS	TEMEGULA	33	29	25	117	13	20	433	E	E	E	E	E	E	E	E	E	E			
THER	CIMIS	THERMAL	33	38	47	116	14	30	-30	E	E	E	E	E	E	E	E	E	E			
UCR	CIMIS	U.C. RIVERSIDE	33	57	54	117	20	8	311	E	E	E	E	E	E	E	E	E	E			
VTRV	CIMIS	VICTORVILLE	34	28	42	117	15	40	881	E	E	E	E	E	E	E	E	E	E			
VSLA	CIMIS	VISALIA/CI AMERICAS	36	18	3	119	13	23	107	E	E	E	E	E	E	E	E	E	E			
SLPL	EMC	SAN LUIS OBISPO-7020 LEWIS	35	12	25	120	37	4	80	E	E	E	E	E	E	E	E	E	E			
LFC1	EXXON	CAPTAN-LFC #1 LAS FLORES CNYN	34	29	23	120	2	45	189	E	E	E	E	E	E	E	E	E	E			
LFC2	EXXON	CAPTAN-LFC #2 LAS FLORES CNYN	34	28	44	120	1	58	237	E	E	E	E	E	E	E	E	E	E			
LFC3	EXXON	CAPTAN-LFC #3 LAS FLORES CNYN	34	28	8	120	2	20	146	E	E	E	E	E	E	E	E	E	E			
LFC4	EXXON	CAPTAN-LFC #4 LAS FLORES CNYN	34	28	51	120	2	34	109	E	E	E	E	E	E	E	E	E	E			
UCSB	EXXON	UCSB WEST CAMPUS-ARCO TANK, IS	34	24	53	119	52	44	9	E	E	E	E	E	E	E	E	E	E			
	LACFCD	ANAHEIM BASE	33	48	04	117	53	29	45													
	LACFCD	BAKERSFIELD BASE	35	25	12	119	01	10	143													
	LACFCD	BEAUMONT BASE	33	55	18	116	58	43	780													
	LACFCD	BRANFORD BASE	34	15	22	118	23	13	122													
	LACFCD	CANOVA BASE	34	12	40	118	35	51	249													
	LACFCD	GOLETA STATION	34	25	09	119	49	17	23													
	LACFCD	JUANITA BASE	34	04	11	118	17	19	84													
	LACFCD	LANCASTER BASE	34	41	26	118	07	39	726													
	LACFCD	MONTEBELLO BASE	34	01	47	118	06	38	159													
	LACFCD	MONTECLAIR BASE	34	05	37	117	40	54	368													
	LACFCD	PLAYA DEL REY	33	59	54	118	24	05	12													
	LACFCD	RIVERSIDE BASE	33	58	20	117	22	12	267													
	LACFCD	SAN LUIS OBISPO	35	16	11	120	39	17	64													
	LACFCD	SAN LUIS OBISPO	36	20	02	119	17	01	101													
BARS	MDAQMD	BARSTOW-401 MOUNTAIN VIEW	34	53	41	117	1	26	690	E	E	E	E	E	E	E	E	E	E			
HESP	MDAQMD	HESPERIA-17288 OLIVE ST	34	25	4	117	17	5	1006	E	E	E	E	E	E	E	E	E	E			
PHEL	MDAQMD	PHELAN-BEEKLEY & PHELAN RDS	34	25	33	117	33	46	1250	E	E	E	E	E	E	E	E	E	E			
TRNA	MDAQMD	TRONA-83732 TRONA ROAD	35	46	29	117	22	1	498	E	E	E	E	E	E	E	E	E	E			
29PM	MDAQMD	TWENTYNINE PALMS-6136 ADOBE DR	34	8	31	116	3	17	607	E	E	E	E	E	E	E	E	E	E			
VICT	MDAQMD	VICTORVILLE-14029 AMARGOSA RD	34	3	46	117	19	8	876	E	E	E	E	E	E	E	E	E	E			
	NAWC	LAGUNA PEAK	34	06	31	119	03	54	441													
	NAWC	MOUNT VISTA (SCLMI)	32	52	33	118	25	57	608													
	NAWC	POINT MUGU	34	06	46	119	07	09	2													
	NAWC	PORT HUENEME	34	08	47	119	12	49	28													
	NAWC	SAN MIGUEL ISLAND	34	01	59	120	21	51	254													
	NAWC	SAN NICOLAS ISLAND	33	15	36	119	34	20	9													
	NAWC	SANTA CRUZ ISLAND	33	59	43	119	38	06	458													
JOSH	NPS	JOSHUA TREE NATIONAL MONUMENT	34	4	15	116	23	27	379	E	E	E	E	E	E	E	E	E	E			
LOST	NPS	LOST HORSE	34	1	4	116	11	16	1280	E	E	E	E	E	E	E	E	E	E			
RATT	NPS	RATTLESNAKE	36	24	42	118	25	18	2622	E	E	E	E	E	E	E	E	E	E			
SCIS	NPS	SANTA BARBARA ISLAND	33	29	00	119	02	00	54													
	NPS	SANTA CRUZ ISLAND	33	59	45	119	43	20	76	E	E	E	E	E	E	E	E	E	E			
	NPS	SANTA ROSA ISLAND	33	58	00	120	04	30	396													
L27	NWS	AVALON	33	21	0	118	19	0	42	E	E	E	E	E	E	E	E	E	E			
BFL	NWS	BAKERSFIELD	33	35	0	119	3	0	150	E	E	E	E	E	E	E	E	E	E			
BUO	NWS	BEAUMONT	35	56	0	116	56	0	792	E	E	E	E	E	E	E	E	E	E			

Appendix B. Surface Meteorology Sites

Site ID	Data Source	Site Name	Site Number			Latitude			Longitude			Elev. m	Variables Measured						
			DD	MM	SS	DD	MM	SS	DD	MM	SS		WS	WD	T	Td	RH	Pr	SR
BLH	NWS	BLYTHE	33	37	0	114	43	0	36	E	E	E	E	E	E	E	E	E	E
BUR	NWS	BURBANK	34	12	0	118	21	30	223	E	E	E	E	E	E	E	E	E	E
CMA	NWS	CAMERILLO	34	12	48	119	5	36	23	E	E	E	E	E	E	E	E	E	E
CZZ	NWS	CAMPO	32	26	0	116	28	0	245	E	E	E	E	E	E	E	E	E	E
CRQ	NWS	CARLSBAD	33	7	42	117	16	48	100	E	E	E	E	E	E	E	E	E	E
AVX	NWS	CATALINA AIRPORT	33	24	18	118	24	57	488	E	E	E	E	E	E	E	E	E	E
NID	NWS	CHINA LAKE NWC	35	41	0	117	41	0	681	E	E	E	E	E	E	E	E	E	E
CNO	NWS	CHINO	33	58	30	117	38	12	198	E	E	E	E	E	E	E	E	E	E
DAG	NWS	DAGGETT/BARSTOW AP	34	52	0	116	47	0	540	E	E	E	E	E	E	E	E	E	E
DRA	NWS	DESERT ROCK	36	30	0	115	50	0	365	E	E	E	E	E	E	E	E	E	E
EDW	NWS	EDWARDS AFB	34	54	0	117	52	12	702	E	E	E	E	E	E	E	E	E	E
SFE	NWS	EL CAJON/GILLESPIE AP	32	49	42	116	58	18	117	E	E	E	E	E	E	E	E	E	E
NJK	NWS	EL CENTRO	32	49	0	115	40	0	14	E	E	E	E	E	E	E	E	E	E
EMT	NWS	EL MONTE	34	4	12	118	2	0	91	E	E	E	E	E	E	E	E	E	E
NZI	NWS	EL TORO MCAS	33	42	0	117	42	0	117	E	E	E	E	E	E	E	E	E	E
BYS	NWS	FORT IRWIN/BARSTOW/BICYCLE LK	35	18	0	116	39	0	764	E	E	E	E	E	E	E	E	E	E
FUL	NWS	FULLERTON	33	52	12	117	58	54	29	E	E	E	E	E	E	E	E	E	E
HHR	NWS	HAWTHORNE	33	55	24	118	20	6	19	E	E	E	E	E	E	E	E	E	E
IPL	NWS	IMPERIAL BEACH	32	50	12	115	34	30	-17	E	E	E	E	E	E	E	E	E	E
NRS	NWS	IMPERIAL BEACH	32	34	0	117	7	0	8	E	E	E	E	E	E	E	E	E	E
IGM	NWS	KINGMAN, AZ	35	15	24	113	56	24	1051	E	E	E	E	E	E	E	E	E	E
WJF	NWS	LANCASTER	34	45	0	118	13	0	715	E	E	E	E	E	E	E	E	E	E
LAS	NWS	LAS VEGAS, NV	36	5	0	115	9	12	663	E	E	E	E	E	E	E	E	E	E
POC	NWS	LE VERNE/BRACKETT AP	34	6	0	117	47	0	305	E	E	E	E	E	E	E	E	E	E
NLC	NWS	LEMOORE	36	20	0	119	57	0	73	E	E	E	E	E	E	E	E	E	E
LGB	NWS	LONG BEACH	33	49	6	118	9	0	17	E	E	E	E	E	E	E	E	E	E
SLI	NWS	LOS ALAMITOS	33	48	0	118	7	0	9	E	E	E	E	E	E	E	E	E	E
LAX	NWS	LOS ANGELES INTERN AP	33	56	36	118	24	24	38	E	E	E	E	E	E	E	E	E	E
RIV	NWS	MARCH AFB	33	54	0	117	15	0	468	E	E	E	E	E	E	E	E	E	E
MXL	NWS	MEXICALLI	32	37	33	115	13	25	7	E	E	E	E	E	E	E	E	E	E
MHV	NWS	MOJAVE AP	35	3	30	118	9	0	850	E	E	E	E	E	E	E	E	E	E
MYF	NWS	MONTGOMERY FIELD	32	48	0	117	6	0	125	E	E	E	E	E	E	E	E	E	E
WED	NWS	MOUNT WILSON	34	13	30	118	3	30	1739	E	E	E	E	E	E	E	E	E	E
NEE	NWS	NEEDLES	34	46	6	114	37	30	302	E	E	E	E	E	E	E	E	E	E
LSV	NWS	NELLIS AFB, NV	36	15	0	115	2	0	569	E	E	E	E	E	E	E	E	E	E
NFG	NWS	OCEANSIDE/CAMP PENDLETON	33	13	0	117	24	0	19	E	E	E	E	E	E	E	E	E	E
ONT	NWS	ONTARIO	34	3	22	117	36	11	290	E	E	E	E	E	E	E	E	E	E
OXR	NWS	OXNARD	34	12	0	119	12	0	13	E	E	E	E	E	E	E	E	E	E
PSP	NWS	PALM SPRINGS	33	50	0	116	30	0	146	E	E	E	E	E	E	E	E	E	E
PMD	NWS	PALMDALE	34	38	0	118	5	0	774	E	E	E	E	E	E	E	E	E	E
PRB	NWS	PASO ROBLES	35	40	24	120	37	36	255	E	E	E	E	E	E	E	E	E	E
NTD	NWS	POINT ARGUELLO	34	35	00	120	39	00	12	E	E	E	E	E	E	E	E	E	E
FTV	NWS	POINT MUGU NAS	34	7	12	119	7	0	2	E	E	E	E	E	E	E	E	E	E
RAL	NWS	PORTERVILLE	36	1	48	119	3	42	135	E	E	E	E	E	E	E	E	E	E
NUC	NWS	RIVERSIDE	33	57	6	117	26	42	249	E	E	E	E	E	E	E	E	E	E
SAN	NWS	SAN CLEMENTE ISLAND AP	33	1	0	118	35	0	55	E	E	E	E	E	E	E	E	E	E
SAN	NWS	SAN DIEGO	32	44	0	117	11	12	5	E	E	E	E	E	E	E	E	E	E
SDM	NWS	SAN DIEGO/BROWN FIELD	32	34	18	116	58	48	160	E	E	E	E	E	E	E	E	E	E
NKX	NWS	SAN DIEGO/MIRAMAR NAS	32	52	0	117	7	0	141	E	E	E	E	E	E	E	E	E	E
NZY	NWS	SAN DIEGO/NORTH ISLAND	32	43	0	117	12	0	15	E	E	E	E	E	E	E	E	E	E
NSI	NWS	SAN NICOLAS ISLAND	33	14	0	119	27	0	14	E	E	E	E	E	E	E	E	E	E

Appendix B. Surface Meteorology Sites

Site ID	Data Source	Site Name	Site Number	Latitude		Longitude		Elev. m	Variables Measured										
				DD	MM	SS	MM		DD	MM	SS	WS	WD	T	Td	RH	Pr	SR	Vis
87Q	NWS	SAN SIMEON/PT PIEDRAS		35	26	56	121	16	48		E	E	E	E	E	E	E	E	E
SDB	NWS	SANDBERG		34	45	0	118	44	0	1379	E	E	E	E	E	E	E	E	E
SNA	NWS	SANTA ANA		33	40	30	117	52	0	16	E	E	E	E	E	E	E	E	E
SBA	NWS	SANTA BARBARA		34	26	0	119	50	0	6	E	E	E	E	E	E	E	E	E
SMD	NWS	SANTA MONICA		34	0	54	118	27	0	53	E	E	E	E	E	E	E	E	E
IZA	NWS	SANTA YNEZ		34	36	30	120	4	30	205	E	E	E	E	E	E	E	E	E
TRM	NWS	THERMAL		33	38	0	116	10	0	-34	E	E	E	E	E	E	E	E	E
TJU	NWS	TIJUANA		32	32	4	116	57	2	46	E	E	E	E	E	E	E	E	E
TOA	NWS	TORRANCE		33	48	12	118	20	48	31	E	E	E	E	E	E	E	E	E
NTK	NWS	TUSTIN MCAS		33	42	0	117	49	48	5	E	E	E	E	E	E	E	E	E
NXP	NWS	TWENTYNINE PALMS		34	7	48	115	56	36	381	E	E	E	E	E	E	E	E	E
VNY	NWS	VAN NUYS		34	12	36	118	29	18	244	E	E	E	E	E	E	E	E	E
VBG	NWS	VANDENBERG AFB		34	45	0	120	34	12	111	E	E	E	E	E	E	E	E	E
VIS	NWS	VISALIA		36	19	6	119	23	30	89	E	E	E	E	E	E	E	E	E
YUM	NWS	YUMA		32	39	0	114	36	0	19	E	E	E	E	E	E	E	E	E
NYL	NWS	YUMA, AZ		32	39	24	114	36	18	65	E	E	E	E	E	E	E	E	E
NWS/NBD	ENVIRONM	ENVIRONM BUOY 46011		34	52	12	120	52	12	3	E	E	E	E	E	E	E	E	E
NWS/NBD	ENVIRONM	ENVIRONM BUOY 46023		34	15	00	120	40	00	3	E	E	E	E	E	E	E	E	E
NWS/NBD	ENVIRONM	ENVIRONM BUOY 46025		33	45	00	119	04	12	3	E	E	E	E	E	E	E	E	E
NWS/NBD	ENVIRONM	ENVIRONM BUOY 46028		35	44	24	121	52	48	3	E	E	E	E	E	E	E	E	E
NWS/NBD	ENVIRONM	ENVIRONM BUOY 46045		33	50	24	118	27	00	3	E	E	E	E	E	E	E	E	E
NWS/NBD	ENVIRONM	ENVIRONM BUOY 46051		34	28	48	120	41	24	3	E	E	E	E	E	E	E	E	E
NWS/NBD	ENVIRONM	ENVIRONM BUOY 46053		34	14	24	119	51	00	3	E	E	E	E	E	E	E	E	E
NWS/NBD	ENVIRONM	ENVIRONM BUOY 46054		34	16	12	120	27	00	3	E	E	E	E	E	E	E	E	E
LFCC	POPCO	LAS FLORES-12100 CALLE REAL	60831040	34	28	55	120	2	31	34	E	E	E	E	E	E	E	E	E
ECSP	SBAPCD	EL CAPITAN STATE PARK	60830008	34	27	39	120	1	44	39	E	E	E	E	E	E	E	E	E
GOLF	SBAPCD	GOLETA-380 N FAIRVIEW	60832002	34	26	41	119	47	38	50	E	E	E	E	E	E	E	E	E
LFSH	SBAPCD	LOMPOC-128 S 'H' ST	60832004	34	38	16	120	27	21	32	E	E	E	E	E	E	E	E	E
SYAP	SBAPCD	SANTA YNEZ-AIRPORT RD	60833001	34	36	10	120	4	15	210	E	E	E	E	E	E	E	E	E
	SBAPCD	GOLETA WEATHER STA.	3090-3096	34	25	09	119	49	12	23	E	E	E	E	E	E	E	E	E
	SBAPCD	LA CUMBRE PEAK	2500-2507	34	30	8	119	43	6	1187	E	E	E	E	E	E	E	E	E
	SBAPCD	MARIA YGNACIO RIDGE	2563-2574	34	28	40	119	47	10	305	E	E	E	E	E	E	E	E	E
	SBAPCD	MT. CAL. MONASTERY	2537-2540	34	32	00	120	05	10	796	E	E	E	E	E	E	E	E	E
	SBAPCD	REFUGIO (GAVIOTA VOR)	2510-2517	34	27	14	119	41	15	381	E	E	E	E	E	E	E	E	E
	SBAPCD	S. BARBARA/POTRERO	577-584	34	46	14	119	39	07	1616	E	E	E	E	E	E	E	E	E
	SBAPCD	SUDDEN PEAK	2542-2545	34	33	30	120	30	16	646	E	E	E	E	E	E	E	E	E
ANAH	SCAQMD	ANAHIM-1610 S HARBOR BLVD	60590001	33	49	11	117	54	46	45	E	E	E	E	E	E	E	E	E
AZSA	SCAQMD	AZUSA-803 N LOREN AVE	60370002	34	8	9	117	55	22	183	E	E	E	E	E	E	E	E	E
BANN	SCAQMD	BANNING-135 N ALLESANDRO	60650002	33	55	40	116	52	26	722	E	E	E	E	E	E	E	E	E
BRBK	SCAQMD	BURBANK-228 W PALM AVE	60371002	34	10	33	118	18	57	168	E	E	E	E	E	E	E	E	E
CMVY	SCAQMD	COSTA MESA-2850 MESA VERDE DR	60591003	33	40	29	117	55	47	25	E	E	E	E	E	E	E	E	E
LGRE	SCAQMD	CRESTLINE-LAKE GREGORY-LAKE DR	60710005	34	14	38	117	16	26	1384	E	E	E	E	E	E	E	E	E
ELTR	SCAQMD	EL TORO-23022 EL TORO RD	60592001	33	37	37	117	41	23	137	E	E	E	E	E	E	E	E	E
FONT	SCAQMD	FONTANA-14360 ARROW BLVD	60712002	34	6	0	117	30	17	381	E	E	E	E	E	E	E	E	E
GLDR	SCAQMD	GLENDORA-840 LAUREL	60370016	34	8	38	117	51	3	275	E	E	E	E	E	E	E	E	E
GDLO	SCAQMD	GLENDORA-LIVE OAK & WHITCOMB	60374001	34	8	41	117	50	56	271	E	E	E	E	E	E	E	E	E
HAWH	SCAQMD	HA WTHORNE-5234 W. 120TH ST	60375001	33	55	51	118	22	8	21	E	E	E	E	E	E	E	E	E
HEMT	SCAQMD	HEMET-880 STATE ST	60651002	33	44	31	116	57	28	469	E	E	E	E	E	E	E	E	E
INDO	SCAQMD	INDIO-46-990 JACKSON ST	60652002	33	42	52	116	12	50	-6	E	E	E	E	E	E	E	E	E
LHAB	SCAQMD	LA HABRA-621 W. LAMBERT	60595001	33	55	33	117	57	3	82	E	E	E	E	E	E	E	E	E
LELS	SCAQMD	LAKE ELSINORE-506 W FLINT ST	60659001	33	40	29	117	20	9	440	E	E	E	E	E	E	E	E	E

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Site ID	Data Source	Site Name	Site				Latitude				Longitude				Elev. m	Variables Measured						
			Number	DD	MM	SS	DD	MM	SS	DD	MM	SS	WS	WD		T	Td	RH	Pr	SR	Vis	
LANC	SCAQMD	LANCASTER-315 W. PONDERA ST	60379002	34	41	23	118	7	55	725	E	E	E	E	E	E	E	E	E			
NLGB	SCAQMD	LONG BEACH-13648 N LONG BEACH	60374002	33	49	26	118	11	20	6	E	E	E	E	E	E	E	E	E			
LANM	SCAQMD	LOS ANGELES-1630 N MAIN ST	60371103	34	4	1	118	14	31	87	E	E	E	E	E	E	E	E	E			
LYNW	SCAQMD	LYNWOOD-11220 LONG BEACH BLVD	60371301	33	55	44	118	12	35	27	E	E	E	E	E	E	E	E	E			
NORC	SCAQMD	NORCO-NORCONIAN-US NEAC	60650003	33	55	15	117	34	15	220	E	E	E	E	E	E	E	E	E			
PALM	SCAQMD	PALM SPRINGS-FS 590 RACQUET CL	60655001	33	51	17	116	32	31	171	E	E	E	E	E	E	E	E	E			
PDSW	SCAQMD	PASADENA-752 S. WILSON AVE	60372005	34	5	2	118	6	28	250	E	E	E	E	E	E	E	E	E			
PERR	SCAQMD	PERRIS-237 5 N "D" ST	60656001	33	47	27	117	14	31	439	E	E	E	E	E	E	E	E	E			
PICO	SCAQMD	PICO RIVERA-3713 SAN GABRIEL	60371601	34	0	46	118	3	32	75	E	E	E	E	E	E	E	E	E			
POMA	SCAQMD	POMONA-924 N. GAREY AVE	60371701	34	4	1	117	45	3	270	E	E	E	E	E	E	E	E	E			
RDLJ	SCAQMD	REDLANDS-500 N. DEARBORN	60714003	34	3	35	117	9	35	481	E	E	E	E	E	E	E	E	E			
RSDA	SCAQMD	RESEDA-18310 GAULT ST	60371201	34	11	56	118	31	58	226	E	E	E	E	E	E	E	E	E			
RUBI	SCAQMD	RUBIDOUX-5888 MISSION BLVD	60658001	34	0	35	117	25	33	250	E	E	E	E	E	E	E	E	E			
SANB	SCAQMD	SAN BERNARDINO-24302 4TH ST	60719004	34	6	28	117	16	22	336	E	E	E	E	E	E	E	E	E			
SNBO	SCAQMD	SAN BERNARDINO-ARB	60711004	34	5	56	117	40	26	369	E	E	E	E	E	E	E	E	E			
CLAR	SCAQMD	SANTA CLARITA-SAN FERNANDO RD	60376002	34	23	16	118	32	2	375	E	E	E	E	E	E	E	E	E			
VALA	SCAQMD	W LOS ANGELES-VA HOSPITAL	60370113	34	3	3	118	27	17	91	E	E	E	E	E	E	E	E	E			
WCOV	SCAQMD	WEST COVINA-820 PHILLIPS ST	60372301	34	4	55	118	1	1	155	E	E	E	E	E	E	E	E	E			
ALPN	SDAQMD	ALPINE-2300 VICTORIA DR	60731006	32	49	58	116	45	0	603	E	E	E	E	E	E	E	E	E			
CHVT	SDAQMD	CHULA VISTA-80 E "J" ST	60730001	32	37	22	117	3	21	56	E	E	E	E	E	E	E	E	E			
DMMC	SDAQMD	DEL MAR-MIRACOSTA COLLEGE	60731001	32	57	10	117	15	46	35	E	E	E	E	E	E	E	E	E			
ECAJ	SDAQMD	DEL CAJON-1155 REDWOOD AVE	60730003	32	47	27	116	56	31	143	E	E	E	E	E	E	E	E	E			
ESCO	SDAQMD	ESCONDIDO-600 E. VALLEY PKWY	60730002	33	7	40	117	22	1	37	E	E	E	E	E	E	E	E	E			
OCEA	SDAQMD	OCEANSIDE-1701 MISSION AVE	60730005	33	12	10	117	22	1	37	E	E	E	E	E	E	E	E	E			
OTAY	SDAQMD	OTAY-1100 PASEO INTERNATIONAL	60732007	32	35	2	116	56	16	155	E	E	E	E	E	E	E	E	E			
SD12	SDAQMD	SAN DIEGO-330A 12TH AVE	60731007	32	42	32	117	9	10	6	E	E	E	E	E	E	E	E	E			
SDOV	SDAQMD	SAN DIEGO-5555 OVERLAND AVE	60730006	32	49	40	117	7	58	135	E	E	E	E	E	E	E	E	E			
SDCFCD	SDCFCD	OCOTILLO STATE PARK		33	10	00	116	10	00	128	E	E	E	E	E	E	E	E	E			
BRGS	SIVUCD	BAKERSFIELD-1138 GOLDEN STATE	60290010	35	23	5	119	0	53	151	E	E	E	E	E	E	E	E	E			
MRCF	SIVUCD	SCHOOL-755 STANISLAUS ST. MARI	60290008	35	3	14	119	24	14	289	E	E	E	E	E	E	E	E	E			
ATAS	SLOCO	ATASCADERO-6005 LEWIS AVE	60798001	35	29	27	120	40	4	262	E	E	E	E	E	E	E	E	E			
GCTY	SLOCO	GROVER CITY-9 LE SAGE DR	60792001	35	7	30	120	37	58	5	E	E	E	E	E	E	E	E	E			
MOBY	SLOCO	MORRO BAY-MORRO BAY BL. & KERNR	60793001	35	22	4	120	47	38	18	E	E	E	E	E	E	E	E	E			
NPSW	SLOCO	NIPOMO-148 S. WILSON ST	60794001	35	2	31	120	30	0	101	E	E	E	E	E	E	E	E	E			
GTCC	TEXACO	GAYOTA-GTC C1 MI E OF PLANT	60831019	34	28	29	120	11	20	82	E	E	E	E	E	E	E	E	E			
GTGB	TEXACO	NOJQUI PASS-GTC B HWY 101	60831018	34	31	40	120	11	45	305	E	E	E	E	E	E	E	E	E			
UCSD	UCSD	GAIL OIL PLATFORM		34	06	00	119	24	00	30	E	E	E	E	E	E	E	E	E			
UCSD	UCSD	HERMOSA OIL PLATFORM		34	30	00	120	36	00	40	E	E	E	E	E	E	E	E	E			
UCSD	UCSD	HONDO OIL PLATFORM		34	24	00	120	06	00	44	E	E	E	E	E	E	E	E	E			
UCSD	UCSD	SANTA CRUZ ISLAND		34	03	35	119	55	37	20	E	E	E	E	E	E	E	E	E			
UCSD	UCSD	SANTA ROSA ISLAND		34	00	29	120	14	14	17	E	E	E	E	E	E	E	E	E			
LPFS	UNOCAL	LOMPOC-HS&P FACILITY 500 M SW	60831013	34	43	33	120	25	40	220	E	E	E	E	E	E	E	E	E			
LOSP	UNOCAL	LOS PADRES NF-PARADISE RD	60831014	34	32	27	119	47	27	547	E	E	E	E	E	E	E	E	E			
CHIL	USFS	CHILAO	32486786	34	20	0	118	2	0	1662	E	E	E	E	E	E	E	E	E			
GLEN	USFS	GLEN ANNIE	3247F476	34	28	24	119	52	10	232	E	E	E	E	E	E	E	E	E			
KEEN	USFS	KENWILD	32675560	33	42	47	116	42	48	1500	E	E	E	E	E	E	E	E	E			
MILL	USFS	MILL CREEK	3248416A	34	23	0	118	4	0	1070	E	E	E	E	E	E	E	E	E			
ROSE	USFS	ROSE VALLEY	3242A3CA	34	32	35	119	11	3	1016	E	E	E	E	E	E	E	E	E			
SNMC	USFS	SAN MARCOS	3247E700	34	30	45	119	49	23	671	E	E	E	E	E	E	E	E	E			
TANB	USFS	TANBARK	324837FA	34	10	0	117	46	0	793	E	E	E	E	E	E	E	E	E			
WARM	USFS	WARM SPRINGS	3248521C	34	35	0	118	33	0	1226	E	E	E	E	E	E	E	E	E			

Appendix B. Surface Meteorology Sites

Site ID	Data Source	Site Name	Site Number	Latitude				Longitude				Elev. m	Variables Measured						
				DD	MM	SS	DD	MM	SS	WS	WD		T	Td	RH	Pr	SR	V/s	
	VBG AFB	VBG TWR4		34	31	51	120	33	55	120	33	E	E						
	VBG AFB	VBG TWR5		34	45	13	120	34	16	101	101	E	E						
	VBG AFB	VBG TWR7		34	43	57	120	32	01	136	136	E	E						
	VBG AFB	VBG TWR8		34	49	32	120	30	30	280	280	E	E						
	VBG AFB	VBG TWR14		34	36	31	120	31	31	442	442	E	E						
	VBG AFB	VBG TWR15		34	46	16	120	31	51	174	174	E	E						
	VBG AFB	VBG TWR17		34	52	56	120	38	12	38	38	E	E						
	VBG AFB	VBG TWR18		34	50	42	120	34	57	91	91	E	E						
	VBG AFB	VBG TWR20		34	36	27	120	27	52	94	94	E	E						
	VBG AFB	VBG TWR50		34	48	02	120	35	55	41	41	E	E						
	VBG AFB	VBG TWR51		34	42	36	120	33	55	122	122	E	E						
	VBG AFB	VBG TWR52		34	44	09	120	35	43	88	88	E	E						
	VBG AFB	VBG TWR53		34	33	24	120	36	42	17	17	E	E						
	VBG AFB	VBG TWR54		34	38	31	120	35	28	137	137	E	E						
	VBG AFB	VBG TWR55		34	35	14	120	35	39	466	466	E	E						
	VBG AFB	VBG TWR56		34	34	59	120	33	40	652	652	E	E						
	VBG AFB	VBG TWR57		34	40	01	120	35	21	90	90	E	E						
	VBG AFB	VBG TWR58		34	41	50	120	32	17	114	114	E	E						
	VBG AFB	VBG TWR59		34	48	08	120	34	52	69	69	E	E						
	VBG AFB	VBG TWR60		34	50	59	120	35	57	37	37	E	E						
	VBG AFB	VBG TWR61		34	38	33	120	33	21	154	154	E	E						
	VBG AFB	VBG TWR64		34	36	50	120	33	03	372	372	E	E						
	VBG AFB	VBG TWR65		34	33	59	120	29	59	626	626	E	E						
	VBG AFB	VBG TWR66		34	39	54	120	33	17	8	8	E	E						
	VBG AFB	VBG TWR101		34	36	38	120	33	58	329	329	E	E						
	VBG AFB	VBG TWR102		34	45	30	120	37	18	66	66	E	E						
	VBG AFB	VBG TWR200		34	36	28	120	37	35	95	95	E	E						
	VBG AFB	VBG TWR300		34	38	01	120	36	50	117	117	E	E						
	VBG AFB	VBG TWR301		34	34	48	120	37	57	116	116	E	E						
VBPP	VBG AFB	VANDENBERG AFB-ST5 POWER PLANT	60834003	34	35	45	120	37	47	100	100	E	E						E
VBWT	VBG AFB	VANDENBERG AFB-WATT RD	60835001	34	46	51	120	36	21	87	87	E	E						E
ELRO	VCAPCD	EL RIO-RIO MESA SCHOOL	61113001	34	15	53	119	8	2	34	34	E	E						E
EMMA	VCAPCD	EMMA WOOD STATE BEACH	61112003	34	17	23	119	19	50	3	3	E	E						E
OJAI	VCAPCD	OJAI-OJAI AVENUE	61117777	34	26	49	119	16	11	231	231	E	E						E
PRTG	VCAPCD	PIRU-25W, 2815 TELEGRAPH RD	61110004	34	23	56	118	49	26	182	182	E	E						E
SVAL	VCAPCD	SIMI VALLEY-5400 COCHRAN ST	61112002	34	16	40	118	41	5	310	310	E	E						E
	VCAPCD	CIRCLE X WEATHER		34	06	33	118	56	10	500	500	E	E						E
	VCAPCD	COUNTY CENTER		34	16	05	119	12	32	85	85	E	E						
	VCAPCD	EL RIO CNTY. YARD		34	14	30	119	11	38	34	34	E	E						
	VCAPCD	FILLMORE FISH H.		34	23	38	118	53	02	142	142	E	E						
	VCAPCD	HUNGRY VALLEY		34	45	33	118	52	20	1220	1220	E	E						
	VCAPCD	LA CUMBRE PEAK		34	30	08	119	43	36	1188	1188	E	E						
	VCAPCD	LA GRANADA MT		34	02	02	119	25	25	680	680	E	E						
	VCAPCD	LANG RANCH WTHR. STN.		34	12	27	118	48	08	488	488	E	E						
	VCAPCD	LAS LLAJAS WEATHER		34	18	07	118	41	14	363	363	E	E						
	VCAPCD	LAS POSAS HILLS		34	14	58	118	55	07	201	201	E	E						
	VCAPCD	LOCKWOOD VLY. YRD		34	44	02	119	06	02	1570	1570	E	E						
	VCAPCD	ROSE VALLEY		34	32	22	119	11	14	1037	1037	E	E						
	VCAPCD	S. BAR. BOTAN. GARDEN		34	27	00	119	40	48	381	381	E	E						
	VCAPCD	SOUTH MT. WEST		34	16	58	119	05	36	201	201	E	E						
	VCAPCD	STEWART CYN. WTHR.		34	27	36	119	14	48	274	274	E	E						



**Appendix C**

**Protocol for SCOS97-NARSTO  
Performance Audit and Laboratory Comparison  
for Speciated Hydrocarbon Measurements**

**Protocol for SCOS97-NARSTO  
Performance Audit and Laboratory Comparison  
for Speciated Hydrocarbon Measurements**

**1.0 Purpose and Overview**

- 1.1 Performance audits of hydrocarbon measurements are being conducted as part of an external quality assessment program for the SCOS97-NARSTO Study. The purpose of the audits are to document differences that may exist between laboratories in the SCOS study area (greater than 30% for concentrations of individual species above 1.0 ppbC).
- 1.2 The audits will consist of a review by Desert Research Institute (DRI) of standard operating procedures (SOPs) used by each measurement group, and performance audits consisting of two ambient samples.

**2.0 Participants**

2.1 Coordination, Data Compilation and Analysis

Desert Research Institute (Eric Fujita, e-mail: [ericf@sage.dri.edu](mailto:ericf@sage.dri.edu), 702/677-3311 FAX - 702/677-3157) P.O. Box 60220 (Street Address: 5625 Fox Ave.) Reno, NV 89506

California Air Resources Board (Randy Pasek, e-mail: 916/323- FAX 916/322-4357) P.O. Box 2815 Sacramento, CA 95812

2.2 Collection of Ambient Audit Samples

Air Resources Board, Monitoring and Laboratory Division (Contact Person, Voice - phone; FAX - phone; e-mail) address.

2.3 Participating Laboratories

(1.) California Air Resources Board, Monitoring and Laboratory Division (Contact Person, Voice - phone; FAX - phone; e-mail) address.

(2.) ? U.S. EPA National Exposure Research Laboratory (Bob Seila, 919/541-2214; FAX - 919/541-4787) mailing address: MailDrop 84 Research Triangle Park, NC 27711 shipping address for canisters: EPA Tech Center Alexander Drive & Highway 54 Research Triangle Park, NC 27711

(3.) Biospheric Research Corporation (Rei Rasmussen, 503/690-1077; FAX - 503/690-1029) 19600 N.W. Von Neumann Drive Beaverton, Oregon 97006-1999

(4.) Desert Research Institute (Barbara Zielinska, e-mail: [barbz@sage.dri.edu](mailto:barbz@sage.dri.edu), 702/6773198; FAX - 702/677-3157) mailing address: P.O. Box 60220 Reno, NV 89506 shipping address: 5625 Fox Avenue Reno, NV 89506

(5.) San Diego Air Pollution Control District (Contact person, Voice - phone; FAX - phone; e-mail) address.

(6.) South Coast Air Quality Management District (Contact Person, Voice - phone; FAX - phone; e-mail) address.

(7.) Ventura County Air Pollution Control District (Contact Person, Voice - phone; FAX - phone; e-mail) address.

(8.) Bay Area Air Quality Management District (Contact Person, Voice - phone; FAX - phone; e-mail) address.

### **3.0 Specific Objectives and Approach**

3.1 Review SOPs to identify differences in analytical methods and procedures that may cause differences in the data produced by participating laboratories. Aspects of SOPs to be reviewed by DRI will include cleaning and certifying canisters and samplers, calibration methods and reference materials, use and maintenance of dryers for water management, sample trapping and injection methods, choice of chromatographic column and operating conditions, peak integration procedure and selection of threshold, peak identification procedures, and data processing and management.

3.2 Assess stability of specific compounds in canisters over a time period comparable to the average holding time during the field study.

3.3 Determine significant systematic biases (greater than 30% for concentrations above 1.0 ppbC for individual compounds and greater than 20% for total nonmethane hydrocarbons) due to analytical methods and procedures. DRI will determine consistency in peak identification for individual species, total NMHC, and fraction of unidentified NMHC.

### **4.0 Management and Communication Protocol**

4.1 Air Resources Board, Monitoring and Laboratory Division will arrange for collection of ambient samples.

4.2 Randy Pasek of the ARB will receive forward data from participants to DRI for analysis.

4.2 Eric Fujita of DRI will prepare a summary report for review by participants.

### **5.0 Documentation**

Each laboratory is to submit the following documentation to Eric Fujita: 1) description of collection and analysis methods and standard operating procedures for canister and sampler cleaning and certification, sample collection, sample analysis, data processing and management, quality control and assessment; 2) list of compounds in the retention time library; and 3) definition of minimum detection limits and measurement precision.

### **6.0 Performance Audit Samples**

6.1 Each participating laboratory will supply to ARB in Sacramento, CA two cleaned, evacuated 6-liter canisters by April 25, 1997. EPA, ARB and DRI will supply two additional canisters (four in all).

- 6.2 ARB will fill the two sets of canisters to 20-25 psi with ambient air from the Los Angeles area using a manifold sampling system supplied by the Desert Research Institute. One set of canisters will be collected in the morning (after 6:00 a.m. and before 9:00 a.m., PDT) in an area heavily influenced by mobile source emission. The other set will be collected in the afternoon (after 1:00 p.m. and before 4:00 p.m., PDT) in a downwind area with maximum ozone levels. Duplicate samples will be collected for EPA, ARB and DRI (total of eleven simultaneous canister samples at each site).
- 6.3 ARB will send the two (or four) ambient audit samples to each participating laboratory by May 6, 1997.
- 6.4 Each laboratory will analyze the audit samples within five working days after receiving the audit canisters. EPA, ARB and DRI will reanalyze their samples after one and two months to monitor the stability of the audit samples.

## **7.0 Data Submittal and Analysis**

- 7.1 Each laboratory will send copies of chromatograms and a data report (species identification, retention times, individual species concentrations in ppbC, and total nonmethane organic gases including unidentified hydrocarbons) to Randy Pasek by June 6, 1997. The list of identified compounds should be those normally reported by each group (PAMS target list in most cases).
- 7.2 Corrections to originally submitted data must be accompanied by sufficient documentation of the reasons.
- 7.3 Analysis of the data by DRI will include linear regression of data for each participating laboratory versus the average values (individual values exceeding two standard deviations of the mean of all values will be removed from the average). Differences in species concentrations of greater than 30% (for concentrations above 1 ppbC) between individual laboratories versus the adjusted mean values. Chromatograms will be examined to identify possible discrepancies in species identification.
- 7.4 Results will be sent to all participants for review and comments within three weeks after all data reports have been submitted. Each of the laboratories will be identified in the report by code only (letter code selected at random).

**Appendix D**

**DRI 12-Port Manifold Canister Sampling System  
Operator Instructions**

## **DRI 12-Port Manifold Canister Sampling System**

### **Operator Instructions**

Revised August 20, 1996

#### **1.0 CONTACT**

Questions or comments regarding the manifold canister sampling system should be addressed to Larry Sheetz of the Desert Research Institute (e-mail [larrys@sage.dri.edu](mailto:larrys@sage.dri.edu), 702/677-3199).

#### **2.0 GENERAL DESCRIPTION**

The manifold canister sampler is designed to collect up to twelve 6-liter canister samples simultaneously at a maximum flow rate of approximately 1.6 liters/min. A stainless steel Viton pump draws in ambient air from a 316 stainless steel 12-port manifold to fill and pressurize the canisters. A flow control device maintains a constant flow into the canisters over the desired sampling period. The sampling system is shipped in two pieces, which are both contained in one shipping box. The sampler is contained in a white 2'x2'x2' box. This box also contains the manifold assembly which is packed in an aluminum box, and a plastic bag containing all necessary fittings and tools. The twelve 1/8-inch stainless steel sampling lines that are used to connect the canisters to the sampling manifold are contained in a separate brown cardboard box.

#### **3.0 QUALITY ASSURANCE STATEMENT**

Prior to shipment of the manifold sampler, the 12-port manifold, fittings and stainless steel sampling lines are cleaned with deionized water and baked at 170°C for 24 hours. The canister sampling system is cleaned prior to field sampling by purging them with humidified zero air for 48 hours, followed by purging with dry UHP zero air for 1 hour. The canister sampling system is certified clean by the GC/FID analysis of humidified zero air collected through the sampling system. The system is considered clean if the concentration of any individual targeted compound is less than 0.2 ppbv and total NMOC concentration is less than 20 ppbC. In addition, a challenge sample, consisting of a blend of organic compounds of known concentration in clean humidified zero air, is collected through the sampling system and analyzed by the GC/FID method. The sampling system is considered non-biasing if recoveries of each of the challenge compounds is in the range of 80-120% (EPA document EPA/600-8-91/215). The 12-port manifold sampler is also pressure tested for possible leaks.

#### **4.0 PREPARATION FOR SAMPLING**

1. Before departing for the field, ensure that all sampling components that are described in section 2 are accounted for. Verify that all canisters are properly labeled and have at least -25 psi vacuum. Take appropriate number of blank field data sheets.

## **5.0 SAMPLER SETUP**

2. Remove aluminum case and plastic bag from white sampling box.
3. Remove the 12-port sampling manifold from the aluminum case and place on the right edge of the white sampling box using the thumb screws to fasten in place (note photograph). The thumb screws can be left loose at this point to allow the manifold to slide until ¼-inch tubings are installed.
4. Remove the longer of the two ¼-inch tubing (marked with purple tape on one end) from the aluminum case. Use the 9/16-inch wrench (contained in the plastic bag) to remove the cap from the pump in the sampling box, and attach the end of the ¼-inch tubing with the purple tape. Connect the opposite end of the tube to the T-fitting on the 12-port sampling manifold (the connection pointing to the back of the sampler).
5. Remove the remaining ¼-inch tubing (marked with gray tape on one end) from the aluminum case. Remove the cap from the port marked canister on the sampler assembly, and attach the end of the ¼-inch tubing with the gray tape. Connect the opposite end of the tube to the 3-way T-fitting on the 12-port sampling (the connection pointing to the front of the sampler).
6. Tighten thumb screws on the sampling manifold after aligning the ¼-inch tubing. Attach the sampling line to filter holder. Adjust alignment of the filter holder before tightening.
7. Remove the 110-v power cord from plastic bag and plug cord into the power socket located in the right rear of the sample
8. Plug power cord into wall power source. Sampling fan and timer clock should come on.
9. Remove cap from sample exhaust (located above timer).

## **6.0 ATTACHING CANISTERS TO THE 12-PORT SAMPLING MANIFOLD**

1. Place up to twelve cans in four rows of three as shown in the photograph.
2. After placing cans in position, remove 1/8-inch stainless steel canister sampling lines from cardboard box. Note that the shortest lines are marked lines 1 through 3. These numbers correspond to the position on the 12-port sampling manifold. Remove aluminum foil from both ends of the sampling line and connect the lines to the sampling manifold and canisters starting with the canisters closest to the sampler. Remove caps on the 12-port sampling manifold as each sampling line is installed. Check that caps on all unused ports are tightly fasten.

## 7.0 OPERATION OF MANIFOLD SAMPLER

The valve (marked with a white arrow) on the 12-port sampling manifold has two positions: atmosphere and pressure. The sampling lines are open to the atmosphere when the arrow points to the back of the sampler. To pressurize the canister, the arrow is position to point to the front of the sampler.

1. Place manifold valve in pressure position (i.e., pointing to front of sampler).
2. Open canister valves one at a time noting that each canister is under vacuum by reading the pressure gauge nearest to the front of the sampler. All canisters should have been checked for vacuum back in the laboratory prior to going out to the field. Connecting a canister that is not under vacuum can cross contaminate all other open canisters that are connected to the manifold.
3. After connecting all canisters and turn manifold valve to atmosphere position (i.e., pointing to back of sampler). All canisters will come up to zero (ambient) pressure. Check pressure gauge.
4. Turn manifold valve to pressure position (i.e., pointing to front of sampler).
5. Turn pump on by positioning the toggle switch (located front left of the timer box) to the on position (right). Pump will come on and the red and green lights on the timer will come on. Red light means that the pump in on, and the green light means that the sampling solenoid is open.
6. Leave pump on until the gauge pressure reads 15 psi. At a flow rate of 1.6 liters/min, it should take approximately 40 minutes to fill twelve canisters.
7. To terminate sampling, turn toggle switch to the off position and immediately close all canister valves. Sampling is complete.
8. Fill out the appropriate information on the field data sheets.
9. Carefully reinstall all parts, manifold and sampling tubes.

**Appendix E**

**Protocol for SCOS97  
Performance Audit and Laboratory Comparison  
for Carbonyl Compound Measurements**

**Protocol for SCOS97  
Performance Audit and Laboratory Comparison  
for Carbonyl Compound Measurements**

**1.0 Purpose and Overview**

- 1.1 Performance audits of carbonyl measurements are being conducted as part of an external quality assessment program for the SCOS97-NARSTO. The purpose of these audits are to document differences that may exist between measurement groups.
- 1.2 The audit consists of a review by Desert Research Institute (DRI) of standard operating procedures (SOPs) used by each measurement group, and collection of samples from a standard mixture of carbonyl compounds under field condition.

**2.0 Participants**

1.1 Coordination, Data Compilation and Analysis

Desert Research Institute (Dr. Eric Fujita, ericf@sage.dri.edu, 702/677-3311 FAX - 702/677-3157) P.O. Box 60220 (Street Address: 5625 Fox Ave.) Reno, NV 89506. Questions regarding the audit protocol should be addressed to Dr. Fujita.

California Air Resources Board, Research Division (Dr. Randy Pasek)

1.2 Audit Equipment

Desert Research Institute (Larry Sheetz, larrys@sage.dri.edu, office - 702/677-3199, cellular - 702/742-0986 FAX - 702/677-3157) P.O. Box 60220 (Street Address: 5625 Fox Ave.) Reno, NV 89506.

1.3 Preparation of Carbonyl Standard

Desert Research Institute (Dr. Barbara Zielinska, barbz@sage.dri.edu, 702/677-3198 FAX - 702/677-3157) P.O. Box 60220 (Street Address: 5625 Fox Ave.) Reno, NV 89506.

1.4 Reference Laboratory

Air Resources Board, Monitoring and Laboratory Division?

1.5 Laboratories to be Audited

**Note: Before shipping the standard gas mixture and dilution system to the next group on the list, please call to verify that the group is participating in the audit and is ready to conduct the audit.**

(1) AtmAA DNPH-impregnated C<sub>18</sub> cartridges/HPLC-UV - AtmAA Sampler) Laboratory - Atmospheric Assessment Associates, AtmAA (Kochy Fung, 818/223-3277; FAX - 818/223-8250) 23917 Craftsman Rd. Calabasas, CA 91302

San Diego Air Pollution Control District (Contact Person, Voice - phone; FAX - phone; e-mail) address.

South Coast Air Quality Management District (Contact Person, Voice - phone; FAX - phone; e-mail) address.

Ventura County Air Pollution Control District (Contact Person, Voice - phone; FAX - phone; e-mail) address.

### **3.0 Specific Objectives and Approach**

- 3.1 Review Standard Operating Procedures (SOP) to identify differences in sampling and analytical methods and procedures that may cause differences in the data produced by participating laboratories. Aspects of SOPs to be reviewed by DRI will include cleaning and certifying samplers, sample volume determination, sample handling and storage, extraction efficiency and associated variability, analytical calibration methods and reference materials, blank levels and variability, and data processing and management.
- 3.2 The carbonyl performance audit will consist of sampling under field conditions with addition of a standard mixture of carbonyls from a 6-liter stainless steel canister to an ambient sample. The canister also contains benzene for quality control purposes. The main supply of the standard mixture is maintained at the Desert Research Institute in a 33-liter canister. DRI will supply a standard mixture of carbonyl compounds in a 6-liter transfer canister and a dilution system. Each group will collect two replicate samples from the transfer canister according to their normal PAMS or SCOS97 sampling protocol with the following restrictions. The standard audit protocol will consist of a 3-hour ambient sample using two DNPH cartridges in series (same as a breakthrough experiment) at a nominal flow rate of 1 liter of ambient air per minute. Contact DRI if you wish to use any other sampling interval or flow rate. The standard mixture is added at a nominal flow rate of 5 milliliters per minute in between the two cartridges. The front cartridge serves to scrub ambient carbonyl compounds and ozone. Each group will collect two samples and pass the 6-liter canister and gas dilution system on to the next group listed in section 1.3. Blank shipping labels are provided (see Section 5). Because there is only one dilution system, it is essential that all groups be prepared to conduct the audit expeditiously when it is their turn. The 6-liter canisters will hold sufficient sample for three groups. A new supply of standard gas will be sent to the 4<sup>th</sup>, 7<sup>th</sup>, and 10<sup>th</sup> groups. These groups should exchange the new canister with the one in the dilution system and return the older canister to DRI.
- 3.3 DRI will analyze the contents of the transfer canisters by DNPH cartridge sampling and HPLC analysis prior to shipment and upon its return. The contents of the main tank will be periodically analyzed by both DNPH/HPLC and GC/FID (for higher MW carbonyls).

#### **4.0 Preparation and Transfer of the Carbonyl Gas Standard**

Five carbonyl compounds and benzene were directly injected by microsyringe into a one-liter glass bulb. The mixture in the glass bulb was transferred into a 33-liter stainless steel canister by sweeping the contents of the bulb into the canister with humidified nitrogen gas to a pressure of 30 psi. Dry nitrogen gas was then added to the canister to bring the total canister pressure up to 80 psi. The mixture was prepared on month xx, 1997 and analyzed by gas chromatography with flame ionization detection on month xx, 1997.

Three aliquots of the standard mixture were withdrawn from the 33-liter canisters into three 6-liter transfer canisters on month xx, 1997. Samples were collected on DNPH C<sub>18</sub> cartridges from each of the three 6-liter canisters and the 33-liter canister. Samples were analyzed on month xx, 1997.

#### **5.0 General Description of the Gas Standard Dilution and Delivery System**

The gas standard dilution and delivery system is designed to allow the addition of standard gas mixtures from a 6-liter canister at a constant flow of up to 20 sccm (70° F and 29.92 in. Hg). It consists of a Sierra Instruments, Inc. Gas-Trak mass flow controller, model number 810C-SQR-249 (Serial No. C1261), a 6-liter stainless steel gas standard transfer canister, and a 3-way valve and tee assembly. The flow controller was adapted by Sierra Instruments, Inc. from an existing model to meet the specific requirements of this audit. The flow controller is preset to provide a flow of 5.0 ml per minute. Prior to shipment of the gas dilution and delivery system, the fittings and stainless steel sampling lines are cleaned with deionized water and baked at 170°C for 24 hours.

The dilution and delivery system and all accessories are self contained in a blue 1'x1'x2' fiberglass box, which is shipped in a wooden crate. A storage compartment located in the top portion of the blue box contains a plastic bag with all necessary fittings, fuses and tools, sampling log book, instruction manual, and blank shipping labels.

#### **6.0 Preparation for Sampling**

- 6.1 Before departing for the field, ensure that all sampling components that are described in section 2 are accounted for. Verify that all cartridges are properly labeled. Take appropriate number of blank field data sheets.
- 6.2 Check the operation of your carbonyl sampler in accordance with your own standard operating procedures, and set the flow of the sampler to approximately 1 liter/min.
- 6.3 Prepare the number of blank DNPH cartridges that are specified in the audit protocol and a fresh KI denuder or scrubber, if it is part of your normal sampling procedure.

## **7.0 Gas Standard Dilution and Delivery System Setup**

- 7.1 Remove the blue fiberglass box containing the dilution and delivery system from the wooden shipping crate.
- 7.2 Before opening the blue box, install the rear support by inserting the support peg into the rear of the box. Unlock the latches in the front of the box, and carefully open the lid to its full open position.
- 7.3 Pull power cord from the upper portion of the box and connect the plug to a 118 V AC, 60 cycle power source (standard 110 volt outlet).
- 7.4 Remove the sampling line system from the storage compartment which is located on the upper half of the blue box. Install the ¼ inch stainless steel tubing that is connected to the 3-way valve and tee assembly to the flow controller outlet marked sample line. Using the ¼ inch Teflon line provided, connect one open end of the tee to your sampling system, upstream of the KI denuder or scrubber and the sample DNPH cartridge, and the other open end of the tee to the sample inlet. Attach a second DNPH cartridge to the inlet to remove any carbonyl compounds present in the ambient air.

## **8.0 Flow Controller Measurements and Initial Purge**

- 8.1 Place the valve in a position pointing to the left (open to atmosphere, labeled QA gas purge). Turn the power on and let the flow controller zero stabilize. Record five readings at ten second intervals. Do not attempt to adjust if reading is within -0.5 and 0.5 ml/min.
- 8.2 Open the 6-liter transfer gas standard canister and record canister pressure in the log book. The flow of standard gas will begin to purge the sample line. Allow the system to purge for at least five minutes to stabilize the flow. Record five readings at ten second intervals. The flow should read about 5 ml/min. Allow the flow to stabilize further if the variability of the five readings exceeds  $\pm 0.1$  ml/min. (Adjustments should be made only if the indicated flow is greater than 7 or less than 3 ml/min. Adjustment can be made by turning the screw labeled local set point with the screwdriver provided in the storage compartment.

## **9.0 Collection of the Audit Sample**

- 9.1 Turn your carbonyl sampler on and begin ambient sampling through your cartridge sampling line. Measure and record the sampler flow rate.
- 9.2 Start the flow of standard gas to the carbonyl sampling line by turning the valve to the right (labeled QA gas sampling). Continue sampling for the sampling time prescribed in the audit protocol.
- 9.3 At the end of the sampling period, turn off the flow of standard gas by turning the valve to the left (QA gas purge). Immediately record flow rate and canister pressure, and close canister (turning handle on the canister valve clockwise).

- 9.4 Turn power off and finish recording appropriate information on the field data sheets.
- 9.5 Replace all items to the storage box and lock "s" hook.
- 9.6 Push power cord in, close the box, and remove the stabilizing peg from rear of the box.
- 9.7 Replace the blue fiberglass box into the shipment crate and send the crate to the next laboratory according to the audit protocol
- 9.8 A minimum of three field blanks will be collected during the audit. During the audit, cartridge end-caps for the blank cartridges will be removed and left off for the time required to place new cartridges in the sampler (typically a few minutes). After this brief exposure the blank cartridges will be sealed again with the end-caps (check that plugs are tight), and placed inside the sampler until the end of the audit.

## **10.0 Laboratory Analysis**

- 10.1 Each analytical laboratory will process and analyze all samples for this audit within five working days after sample collection. Each laboratory will perform two replicate measurements for each of the two samples in order to determine analytical precision.

## **11.0 Data Submittal and Exchange Protocol**

- 11.1 Each laboratory will report their data to Eric Fujita in hardcopy and electronic form (either ASCII, dbf, excel or lotus) within one month of receipt of audit sample. The submittal will include: concentration data and associated uncertainties for individual carbonyl compounds in the standard mixture; field data needed to calculate sample volumes including temperature and pressure if volume adjustments are made and nominal volume uncertainties; and laboratory data (mass of analyte per sample, extraction volume and corrections, if any, for extraction efficiency, and all blank samples used in deriving the mean blank subtraction and uncertainty).
- 11.2 DRI will recalculate concentrations based on the field and analysis data and associated uncertainties. DRI will send the final database to participants for review and resolve any discrepancies with concentration data reported by each group prior to performing the data analysis. Corrections by participants to originally submitted data must be accompanied by sufficient documentation of the reasons.

## **12.0 Data Analysis and Preparation of Summary Report**

- 12.1 The results of the carbonyl measurement performance audit will be summarized in a report that will be sent to all participants for review and comments .