# Quality Assurance Final Report

# for the

# Fresno Supersite


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**Table of Contents**

## List of Tables



## List of Figures

# 1 INTRODUCTION

The intention of the U.S. Environmental Protection Agency's (EPA) Supersites Program was to operate research-grade air monitoring stations to improve understanding of measurement technologies, source contributions and control strategies, and effects of suspended particles on health. The Fresno Supersite was established with focus on the following objectives (Watson et al., 2000):

1. Testing and evaluation of non-routine monitoring methods, with the intent to establish their comparability with existing methods and determine their applicability to air quality planning, exposure assessment, and health impact determination;
2. Increasing the knowledge base of aerosol characteristics, behavior, and sources so regulatory agencies can develop standards and strategies that protect public health; and
3. Acquiring measurements that can be used to evaluate relationships between aerosol properties, co-factors, and observed health end-points.

Specific hypotheses were formulated related to each of these objectives (Watson et al., 2000). Measurement methods were selected to provide the variables needed to test these hypotheses. Supersite measurements were coordinated with health and toxicological studies in the region, specifically a multi-million dollar effort by the state of California to better understand the relationships between air quality and asthma. Previous studies show that emissions, aerosol composition, and meteorology change substantially over the course of a day, between seasons, and between different years in central California where Fresno is located. It was conjectured that relationships between different measurement methods, aerosol characteristics, and health end-points are contingent upon these changes. Evaluating these relationships required frequent sampling over short durations for a multi-year monitoring period.

The Supersite observables included *in-situ*, continuous, and short duration measurements of:

- $PM_{2.5}$, $PM_{10}$, and coarse ($PM_{10}$ minus $PM_{2.5}$) mass;
- $PM_{2.5}$ sulfate, nitrate, carbon, light absorption, and light extinction;
- Number of particles in discrete size bins ranging from 0.01 µm to ~10 µm;
- Criteria pollutant gases ($O_3$, CO, $NO_x$);

- Reactive gases ($NO_y$, $NO_2$, $HNO_3$, $NH_3$); and
- Single particle characterization by time-of-flight mass spectrometry.

Field sampling and laboratory analysis were applied for: 1) gaseous and particulate organic compounds (light hydrocarbons, heavy hydrocarbons, carbonyls, polycyclic aromatic hydrocarbons [PAH] and other semi-volatiles); and 2) $PM_{2.5}$ mass, elements, ions, and carbon.

The results obtained from the Supersite measurements have been published in various articles (California Air Resources Board, 2003,Chow et al., 2004,Chu et al., 2004,Evans et al., 2000,Gemmill, D. B., 2002b,Held et al., 2004,Howard-Reed et al., 2000,Lawless et al., 2001,Park et al., 2005,Poore, 2000,Poore, 2002,Schauer and Cass, 2000,Watson and Chow, 2002a,Watson and Chow, 2002b,Watson et al., 2002,Watson et al., 2002a,Watson et al., 2005a,Watson et al., 2005b,Watson et al., 2005c). In addition, some manuscripts are in preparation. This report summarizes the quality assurance activities carried out at the Fresno Supersite and their findings.

# 2 DATA QUALITY OBJECTIVES

The Data Quality Indicators (DQIs) that were used to characterize measurements at the Fresno Supersite are listed and defined below. They were explained in detail in the Quality Assurance Project Plan (QAPP) (Watson et al., 2001a).

## 2.1 Precision

Precision represents the reproducibility of measurements as determined by collocated sampling using the same methods or by propagation of individual measurement precisions determined by replicate analysis, blank analysis, and performance tests (Watson et al., 2001b). The precision can thus be defined as deviations from the average response to the same measurable quantity. The precision of the continuous analyzers is typically determined from replicate analyses of calibration standards, span checks, and/or precision check records. The precision for filter-based instruments are propagated from precisions of the volumetric measurements, the chemical composition measurements, and the field blank variability using the methods of Bevington (1969) and Watson et al. (1995). The project goal for precision was ±10%, expressed as the coefficient of variation (CV), for values that exceed ten times their lower quantifiable limits. The precision goal for gravimetric mass was ±5% CV as determined from replicate weighing.

### 2.2 Bias

Bias is the systematic or persistent distortion of a measurement process that causes error in one direction. Bias is determined through performance audits and/or by inter-comparisons of the performance of similar instruments. Quantifiable biases that exceed precision intervals are corrected as part of the data validation process.

### 2.3 Accuracy

Accuracy is the correctness of data and refers to the degree of difference between a measured value and a known, or "true," value. For particulate measurements, there are no known true values. Relative accuracy may be determined by comparing a measured value with a presumed reference or standard, such as a $PM_{2.5}$ FRM sampler. Since no true reference samples exist for the chemistry of airborne particulate matter, the accuracy of other speciated atmospheric components cannot be inherently determined. Analytical accuracy of the analytes were determined by analyzing known reference materials in the laboratory. The accuracy of gravimetric and speciated fine particle samplers were measured by performance (flow rate) checks and audits between the sampler and a certified flow meter as follows:

$$\% \text{ Accuracy} = [(Q_m - Q_a)/Q_a] \times 100$$

where,

$Q_a$ is the flow rate measured using a NIST traceable flow device, and
$Q_m$ is the flow rate indicated by the sampler.

The goal of filter sampler accuracy was ±5% relative percent difference (RPD) or better.

The accuracy of the continuous analyzers was determined from performance audits conducted by the California Air Resources Board (CARB). The analyzers were challenged with standards from an independent, NIST-traceable source not used for calibration, encompassing the operational range of the instrument. A minimum of three data points, including zero comprised the performance audit. A linear regression analysis in the following form was used to determine the slope, intercept and correlation coefficient:

$$y = mx + b$$

where,

x the audit concentration
y is the reported analyzer response
m is the slope, and
b is intercept.

The deviation of the slope from unity was used as the measure of accuracy. The goal for the continuous analyzers was ± 10%, or a slope within the range of 0.900 to 1.100.

## 2.4 Detection Limits

The detection limit is the low range critical value that a method-specific procedure can reliably discern. Analytical procedures and sampling equipment impose specific constraints on the determination of minimum detection limits (MDLs). For the gaseous analyzers, MDLs are determined by repeatedly challenging the analyzer with zero air; and for filter-based methods, the MDLs are determined by the use of field and laboratory blanks. Generally, the MDL for measurements were determined as three times the standard deviation of field blanks or three times the standard deviation of the noise of an instrument when subjected to clean air. The instrument detection limit (IDL) represents the ability of the analytical instrument to differentiate a specific concentration from zero. The IDL was determined as three times the standard deviation of the laboratory blanks. There was no specific acceptance criteria set for MDLs.

## 2.5 Completeness

Completeness is the percentage of valid data reported, compared to the total number of samples/data that was possible to collect during the year. All data was subject to a rigorous validation procedure eliminating all invalid data. For this project, in which many of the instruments were prototypes, or newer technology, the completeness objective for all species and measurements was 75%.

## 2.6 Representativeness

Representativeness is the degree to which the data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environment condition. For this project, spatial and temporal data representativeness were achieved by following siting criteria for particulate monitoring sites (Watson et al., 1997) and by comparing measurements at the Fresno "First Street Site" (FSF) with those from other monitoring stations in the region, including the satellite sites shown in Figure 2-1 and Figure 2-2.

## 2.7 Comparability

Comparability reflects the extent to which measurements of the same observable agree among different methods. Comparability may vary by method, aerosol composition, and meteorological conditions. Several of the hypotheses tested at the Fresno Supersite included formal comparisons of measurements for different measurement configurations, aerosol compositions, and times of the year.

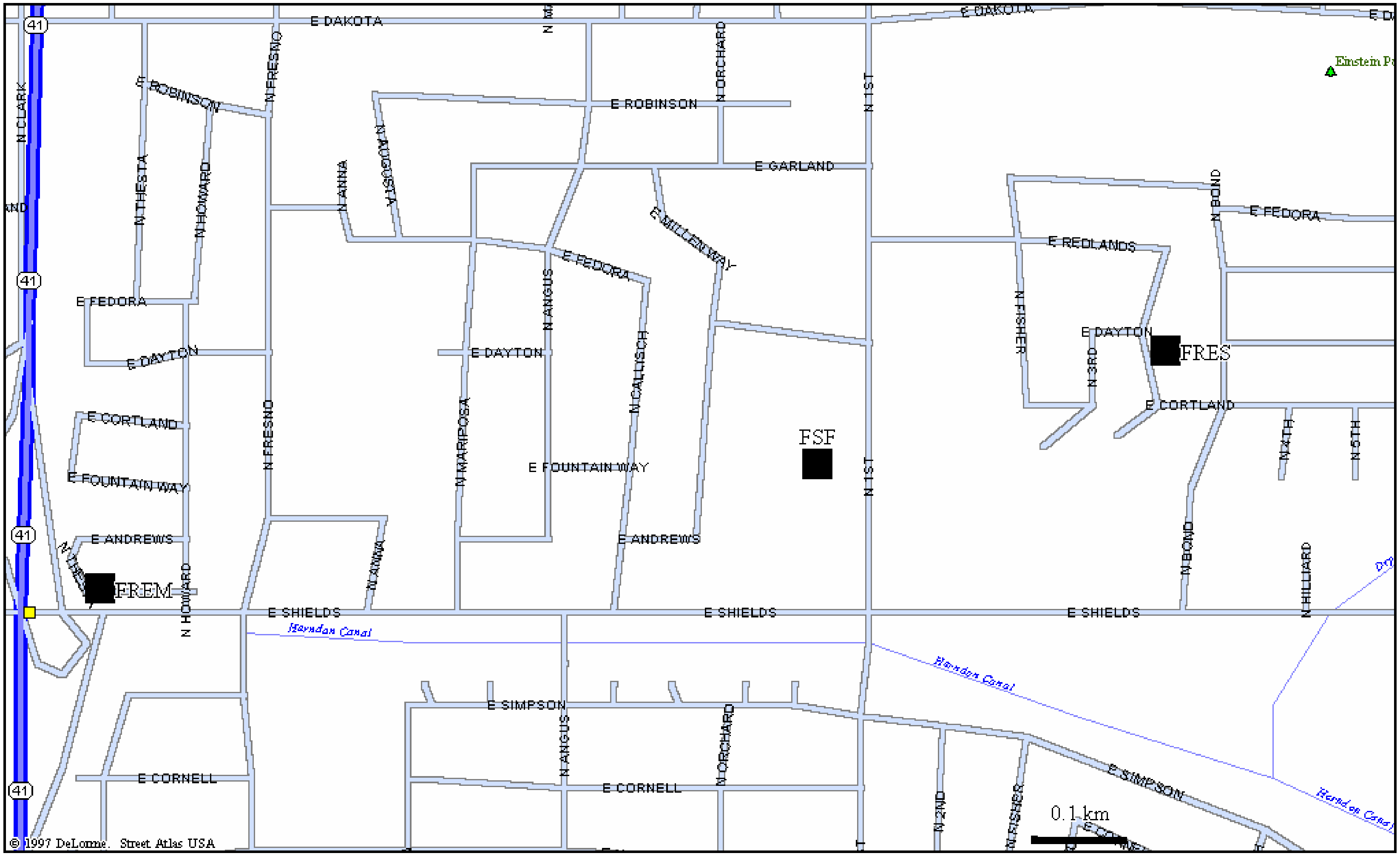


**Figure 2-1. Location of the Fresno First Street (FSF) Supersite with nearby satellite aites near a freeway on-ramp (FREM) and in a nearby residential neighborhood (FRES).**

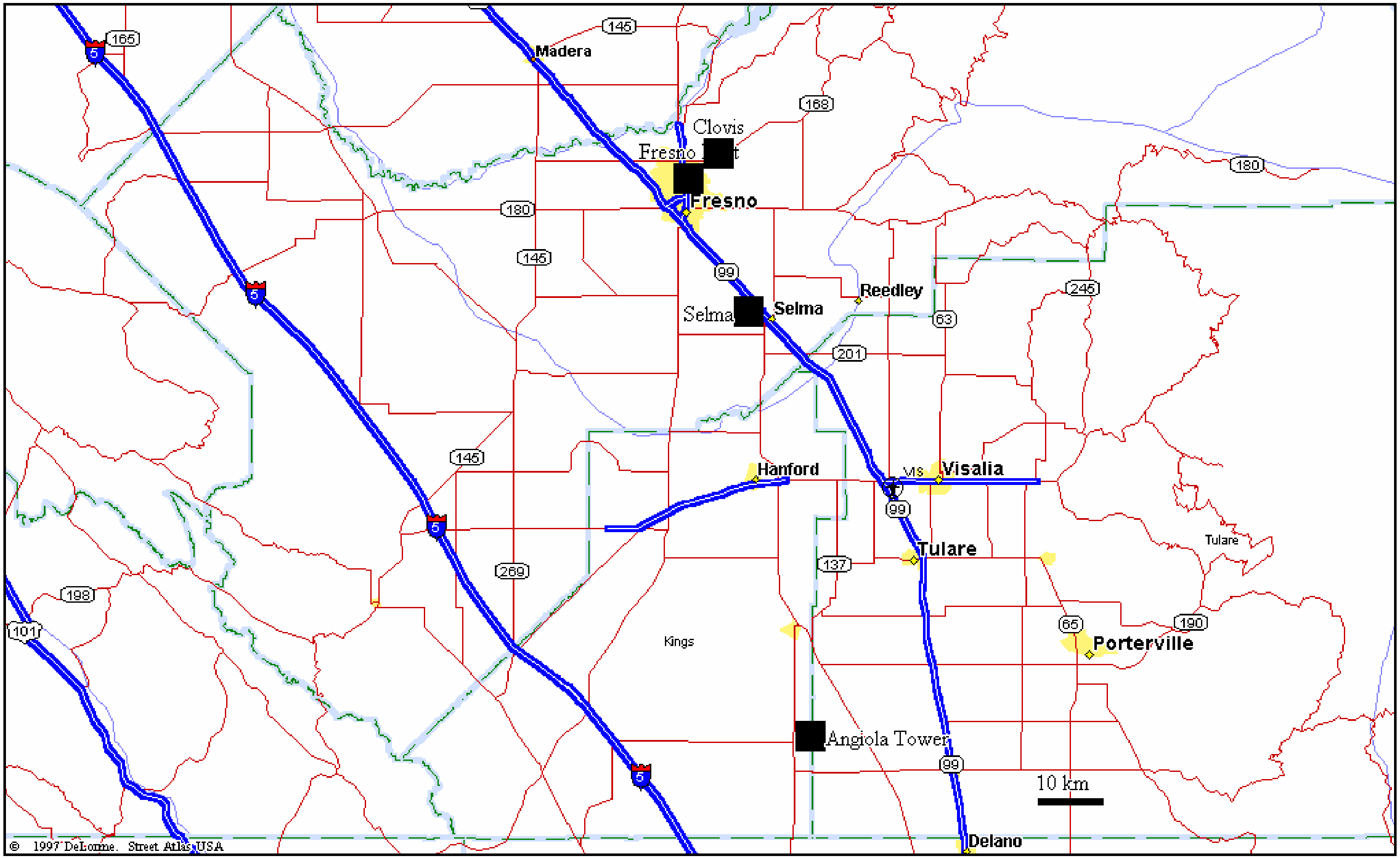


**Figure 2-2. The Fresno Supersite's location in California's San Joaquin Valley. Clovis (CLO) was a $PM_{2.5}$ compliance site. Selma (SELM) was a downwind transport site. Angiola (ANGI) was part of the California Regional $PM_{10}$/$PM_{2.5}$ Air Quality Study, located in a non-urban area, and acquired measurements similar to those at the supersite.**

# 3 QUALITY ASSURANCE RESULTS

## 3.1 Audits

### 3.1.1 Laboratory Systems Audit

The systems audit is intended to be a cooperative assessment resulting in improved data, rather than a judgmental activity. A laboratory systems audit was conducted on the Environmental Analysis Facility (EAF) and the Organic Analysis Laboratories (OAL) at the Desert Research Institute (DRI) in the fall of 2002. The complete audit report with detailed findings is available elsewhere (Engelbrecht, 2002). The laboratory systems audit was conducted on the following eight measurement laboratories: (1) Atomic Absorption Spectroscopy (AA) analysis, (2) Automated Colorimetry (AC) analysis, (3) Gravimetric analysis, (4) Ion Chromatography (IC) analysis, (5) Thermal Optical Reflectance (TOR) analysis, (6) X-ray Fluorescence Spectrometry (XRF) analysis, (7) Gas Chromatograph with Mass Spectrometry (GC/MS) analysis, and (8) Gas Chromatograph with Flame Ionization Detection (GC/FID) analysis. The systems audit examined all phases of measurement and data processing to evaluate if the Standard Operating Procedures SOPs were followed and that operational staff were properly trained.

Overall the systems audit findings were encouraging. The audit identified the personnel to be highly trained and extremely familiar with the instruments. Other noteworthy practices identified by the audit included meticulous handling of samples and meticulous data validation. The common deficiency pointed out by the audit was the need to review and update the SOPs periodically. In addition, the audit noted the need for developing corrective action plans and to maintain a record of training activities (Engelbrecht, 2002).

The SOPs are now continually reviewed and updated as and when necessary. Various SOPs have been updated since 2002 and are listed in Table 3-1.

**Table 3-1. Summary of Updated Laboratory-related Standard Operating Procedures (SOPs).**

| DRI SOP Number | SOP Title | Date of Last Revision |
|---|---|---|
| 2-102.5 | Gravimetric Analysis Procedure | 4th Quarter, 2004 |
| 2-106.4 | Pre-firing and Acceptance Testing of Quartz fiber Filters for Aerosol and Carbonaceous Material Sampling | 3rd Quarter, 2004 |
| 2-108.4 | Sectioning of Teflon and Quartz Filter Samples | 3rd Quarter, 2004 |
| 2-109.5 | Extraction of Ionic Species from Filter Samples | 3rd Quarter, 2004 |
| 2-112.2 | $PM_{2.5}$ FRM Filter Pack Assembly, Disassembly, and Cleaning | 3rd Quarter, 2004 |
| 2-113.2 | $PM_{2.5}$ FRM Sample Shipping, Receiving, and Chain-of-Custody | 3rd Quarter, 2004 |
| 2-114.2 | $PM_{2.5}$ FRM Gravimetric Analysis | 4th Quarter 2004 |
| 2-201.1 | Thermal/Optical Reflectance (TOR) and Thermal/Optical Transmittance (TOT) Carbon Analysis of Aerosol Filter Samples | 4th Quarter, 2004 |
| 2-202.1 | Analysis of Filter Extracts by Ion Coupled Plasma-Mass Spectroscopy (ICP-MS) | 2nd Quarter, 2005 |
| 2-203.5 | Anion Analysis of Filter Extracts and Precipitation Samples by Ion Chromatography | 3rd Quarter, 2004 |
| 2-204.6 | Thermal/Optical Reflectance Carbon Analysis of Aerosol Filter Samples | January, 2004 |
| 2-206.3 | Analysis of Filter Extracts and Precipitation Samples by Atomic Absorption Spectroscopy | January, 2004 |
| 2-208.1 | Cation Analysis of Filter Extracts and Precipitation Samples by Ion Chromatography | 3rd Quarter, 2004 |
| 2-209.1 | X-ray Fluorescence (XRF) Analysis of Aerosol Filter Samples (Panalytical Epsilon 5) | 4th Quarter 2004 |
| To be assigned | Temperature Calibration for Thermal/Optical Carbon Analysis by Certified Boiling Point | 2005 |
| To be assigned | In-injection Port Thermal Desorption and Subsequent GC/MS Analysis of Non-polar Organic Species in Aerosol Filter Samples* | July 2005 |

### 3.1.2 Inter-laboratory Comparisons

A technical systems audit (TSA) of the DRI EAF laboratory was conducted by USEPA in March 2005. This audit intended to establish consistency between DRI XRF, IC, and TOR/Thermal Optical Transmittance (TOT) measurements and EPA-certified laboratories. Inter-laboratory comparisons were made on performance evaluation (PE) samples prepared by the National Air and Radiation Environmental Laboratory (NAREL). Replicate sets of the PE samples were also analyzed by EPA, as well as three other laboratories that were part of the Speciation Trends Network (STN). Overall, the TSA concluded that the DRI laboratory performance met or exceeded compliance standards and no deficiencies were found in any of the inspected areas (Taylor and Boswell, 2005).

The results of PE sample inter-comparisons for mass, ions, elements and carbon fractions showed good overall analytical agreement between NAREL and DRI measurements. A comparison of the DRI Model 2001 carbon analyzer with NAREL's Sunset TOT/TOR analyzer showed good agreement when performing the Interagency Monitoring for Protected Visual Environment's *IMPROVE-A* method. Good inter-laboratory comparison was demonstrated for OC, EC, and TC as well as the sub-fractions. However, when performing the STN TOT method, good inter-laboratory agreement was seen for OC and TC, while not for EC and the carbon sub-fraction. It was noted that possible oxygen contamination of the DRI 2001 system during the non-oxidizing stage of analysis (He atmosphere) potentially had the greatest impact on the analysis. DRI already has procedures in place to minimize and monitor for oxygen in helium. The audit recommended that DRI should continue its efforts to eliminate or at least reduce oxygen contamination of the Model 2001 instruments, and required that instruments performing the STN method routinely analyze a sucrose standard solution as an additional check for excessive oxygen in helium (Taylor and Boswell, 2005).

DRI has done a comprehensive evaluation of the current Model 2001 system, particularly for the temperature bias and oxygen contamination, and the results have been reported to the IMPROVE committee (Chow et al., 2005). A temperature calibration procedure has been developed (Chow et al., 2005a) and is reflected in the most recent SOPs.

### 3.1.3 Field Audits

A field audit was conducted on March 06-07, 2002 by the Center for Environmental Research and Technology at University of California at Riverside, UCR (UC-CERT) (Gemmill, 2002b). The audit was conducted on the continuous gas analyzers (TEI 42, TEI42CY and UCR Luminol analyzer) that measured nitric oxide (NO), nitrogen dioxide ($NO_2$), oxides of nitrogen ($NO_x$), nitric acid ($HNO_3$), and total reactive nitrogen compounds ($NO_y$). Calibration standards of NO, $NO_2$ and $NO_x$ were generated and instrument readings were noted. In addition, flow rates of filter-based and continuous particulate monitors and light scattering instruments were audited. The California Air Resources Board (CARB) conducted an audit on July 15-17, 2002, the results of which are summarized by Gemmill (2002a). In addition, a follow-up audit was conducted by UC-CERT on September 17-19, 2002 (Gemmill, 2002a). The CARB audit covered sulfur dioxide ($SO_2$) and ozone ($O_3$) analyzers and the meteorological instruments. More information on these audits are available in Gemmill (2002b,2002a) and are attached in the Appendix.

The audit results showed that all the analyzers, except the UCR research instrument, were within the ±10% objective as mentioned in the QAPP (Watson et al., 2001a) and showed excellent performance. The UCR analyzer failed to meet the ±20% objective (Gemmill, 2002b,2002a). All the particulate samplers audited had flow rates within ±5%, except the Greentek GT640A which was off by 10-15% (Gemmill, 2002b,2002a). Overall, the audit found the samplers to be in good condition and to be working properly. An audit of the general system condition, operation and maintenance showed satisfactory results. All procedures were found to be consistent with that described in the QAPP. The meteorological instruments performed satisfactorily (Gemmill, 2002a).

## 3.2 Accuracy and Precision

Table 3-2 summarizes the different samplers discussed in this report along with the acronyms used to depict them. Table 3-3 summarizes the flow checks conducted during the different field audits. As may be seen, the samplers were accurate within 5% most of the time, except for the GreenTek GT640 photometer. Table 3-4 summarizes the performance of the various continuous gas analyzers during the field performance audits conducted by CARB and UC-CERT. The instruments were challenged against NIST traceable gases. The responses of the analyzers were within the ±10 to ±20% objective stated in the QAPP, except for the UCR instrument. Table 3-5 lists the performance of the meteorological instruments. As seen in the table, all the meteorological parameters were within the respective objectives stated in QAPP.

**Table 3-2. Sampler Descriptions.**

| Sampler Code | Model | Manufacturer |
|---|---|---|
| AE-1 | AE-16 (single wavelength) | Magee Scientific, Berkley, CA |
| AE-2 | AE-21 (dual wavelength) | Magee Scientific, Berkley, CA |
| AE-7 | AE-31 (seven wavelength) | Magee Scientific, Berkley, CA |
| AN100 | RAAS 100 | Andersen Instruments, Smyrna, GA |
| AN300 | RAAS 300 | Andersen Instruments, Smyrna, GA |
| AN400 | RAAS 400 | Andersen Instruments, Smyrna, GA |
| API 100A | API 100A | Advanced Pollution Instrumentation, Inc., San Diego, CA |
| API 400 | API 400 | Advanced Pollution Instrumentation, Inc., San Diego, CA |
| BAM | BAM-1020 | Met One Instruments, Granst Pass, OR |
| Climet | Climet Spectro .3 | Climet Instruments Company, Redlands, CA |
| Dasibi 3008 | Dasibi 3008 | Dasibi Environmental Corp., Glendale, CA |
| DICHOT | SA-246B Dichotomous Sampler | Andersen Instruments, Smyrna, GA |
| DUSTTRAK | DustTrak 8520 | TSI Inc., Shoreview, MN |
| GreenTek | Green Tek GT640A | Green Tek, Atlanta, GA |
| HIVOL10V | GMW-1200 | Andersen Instruments, Smyrna, GA |
| HIVOL25 | Andersen 321A | Andersen Instruments, Smyrna, GA |
| Lasair | PMS Lasair 1003 | Particle Measurement Systems, Inc. Boulder, CO |
| M1ST | SASS Speciation Sampler | Met One Instruments, Granst Pass, OR |
| MiniVol | Mini Vol Portable | Air Metrics Inc. Eugene, OR |
| MOUDI | Model 100 | MSP Corporation, Minneapolis, MN |
| NGN_2 | NGN2 ambient temperature nephelometer | Optec, Inc., Lowell, MI |
| PAH | EcoChem PAS2000 | EcoChem Analytics, League City, TX |
| R&P8400N | R&P 8400N | Rupprecht & Patashnick, Albany, NY |
| R&P8400S | R&P 8400S | Rupprecht & Patashnick, Albany, NY |
| RAD | M903 (nephelometer) | Radiance Research, Seattle, WA |
| RAD25 | M903 (nephelometer) with $PM_{2.5}$ inlet | Radiance Research, Seattle, WA |
| RP2K | R&P 2000 | Rupprecht & Patashnick, Albany, NY |
| RP5400 | R&P 5400 | Rupprecht & Patashnick, Albany, NY |
| SFS | Sequential Filter Sampler | Desert Research Institute (DRI), Reno, NV |
| Sunset | Sunset Continuous OC/EC analyzer | Sunset Laboratory, Inc., Tigard, OR |
| TEI 42C | TEI 42C | Thermo Electron Corporation, Franklin, MA |
| TEI 55C | TEI 55C | Thermo Electron Corporation, Franklin, MA |
| TEOM | TEOM 1400a | Rupprecht & Patashnick, Albany, NY |
| SMPS-Long | TSI 3936L10 | TSI Inc., Shoreview, MN |
| SMPS-nano | TSI 3936N25 | TSI Inc., Shoreview, MN |

**Table 3-3. Particulate Sampler Flow Accuracy.**

| Agency | Audit Date | Sampler | | Indicated Flow | | Audit Flow | | % Difference |
|---|---|---|---|---|---|---|---|---|
| UC-CERT | Mar 06-07, 2002 | AE-1 | | 7 | lpm | 6.77 | lpm | 3.4 |
| UC-CERT | Sep 17-19, 2002 | AE-1 | | 6.9 | lpm | 7.1 | lpm | -2.8 |
| UC-CERT | Mar 06-07, 2002 | AE-7 | | 7 | lpm | 7.13 | lpm | -1.8 |
| UC-CERT | Sep 17-19, 2002 | AE-7 | | 7 | lpm | 6.9 | lpm | 1.4 |
| UC-CERT | Sep 17-19, 2002 | HIVOL25 | | *38.9* | cfm | *41.9* | cfm | -7.2 |
| CARB | Jul 15-17, 2002 | HIVOL10V | | *40.9* | cfm | *41.3* | cfm | -1.0 |
| UC-CERT | Mar 06-07, 2002 | AN400 | Channel 1 | 15.41 | lpm | 15.96 | lpm | -3.4 |
| UC-CERT | | | 2 | 6.98 | lpm | 6.92 | lpm | 0.9 |
| UC-CERT | | | 4 | 7.34 | lpm | 7.29 | lpm | 0.7 |
| UC-CERT | | | 5 | 8.07 | lpm | 8.17 | lpm | -1.2 |
| UC-CERT | | | 6 | 7.88 | lpm | 7.68 | lpm | 2.6 |
| UC-CERT | Mar 06-07, 2002 | AN100 PM2.5 | S/N 79 | 16.64 | lpm | 16.58 | lpm | 0.4 |
| UC-CERT | Sep 17-19, 2002 | AN100 PM2.5 | S/N 79 | 16.62 | lpm | 16.82 | lpm | -1.2 |
| UC-CERT | Mar 06-07, 2002 | AN100 PM2.5 | S/N 83 | 16.75 | lpm | 16.83 | lpm | -0.5 |
| CARB | Jul 15-17, 2002 | AN100 PM2.5 | | 16.68 | lpm | 16.78 | lpm | -0.6 |
| UC-CERT | Sep 17-19, 2002 | AN100 PM2.5 | S/N 83 | 16.65 | lpm | 16.48 | lpm | 1.0 |
| UC-CERT | Mar 06-07, 2002 | BAM PM10 | | 17.3 | lpm | 16.49 | lpm | 4.9 |
| UC-CERT | Sep 17-19, 2002 | BAM PM10 | | 15.9 | lpm | 16.2 | lpm | -1.9 |
| UC-CERT | Mar 06-07, 2002 | BAM PM2.5 | | 16.6 | lpm | 15.9 | lpm | 4.4 |
| UC-CERT | Sep 17-19, 2002 | BAM PM2.5 | | 16.3 | lpm | 16.2 | lpm | 0.6 |
| UC-CERT | Mar 06-07, 2002 | GreenTek | | 5.2 | lpm | 4.7 | lpm | 10.6 |
| UC-CERT | Sep 17-19, 2002 | GreenTek | | 5.33 | lpm | 4.61 | lpm | 15.6 |
| UC-CERT | Sep 17-19, 2002 | Minivol | S/N 1315 | 5.013 | lpm | 5.033 | lpm | -0.4 |
| UC-CERT | Sep 17-19, 2002 | Minivol | S/N 1259 | 5.03 | lpm | 5.095 | lpm | -1.3 |
| UC-CERT | Sep 17-19, 2002 | Minivol | S/N 1325 | 5.1 | lpm | 5.161 | lpm | -1.2 |
| UC-CERT | Sep 17-19, 2002 | Minivol | S/N 1183 | 5.025 | lpm | 5.017 | lpm | 0.2 |
| UC-CERT | Sep 17-19, 2002 | Minivol | S/N 1177 | 5.205 | lpm | 5.281 | lpm | -1.4 |
| UC-CERT | Mar 06-07, 2002 | OPC* System | | 15.81 | lpm | 15.61 | lpm | 1.3 |
| UC-CERT | Sep 17-19, 2002 | OPC* System | | 16.4 | lpm | 15.7 | lpm | 4.5 |
| UC-CERT | Mar 06-07, 2002 | RP5400 | | 16 | lpm | 15.45 | lpm | 3.6 |
| UC-CERT | Sep 17-19, 2002 | RP5400 | | 15.2 | lpm | 15.55 | lpm | -2.3 |
| UC-CERT | Mar 06-07, 2002 | TEOM PM10 | Total | 16.65 | lpm | 16.26 | lpm | 2.4 |
| UC-CERT | Sep 17-19, 2002 | TEOM PM10 | Total | 16.66 | lpm | 16.69 | lpm | -0.2 |
| UC-CERT | Sep 17-19, 2002 | TEOM PM10 | Main | 2.99 | lpm | 2.94 | lpm | 1.7 |
| UC-CERT | Mar 06-07, 2002 | TEOM PM2.5 | Total | 16.64 | lpm | 16.96 | lpm | -1.9 |
| UC-CERT | Sep 17-19, 2002 | TEOM PM2.5 | Total | 16.6 | lpm | 17.21 | lpm | -3.5 |
| UC-CERT | Sep 17-19, 2002 | TEOM PM2.5 | Main | 3.1 | lpm | 2.99 | lpm | 3.7 |

* Optical Particle Counters

**Table 3-4. Continuous Gaseous Analyzer Accuracy.**

| Agency | Audit Date | Instrument | Observable | Concentration (ppm) Audit | Concentration (ppm) Station | %Difference | Regression Slope* |
|---|---|---|---|---|---|---|---|
| UC-CERT | March 7, 2002 | TEI 42C | NOx | 0.000 | 0.001 | --- | 1.038 |
| UC-CERT | March 7, 2002 | TEI 42C | NOx | 0.050 | 0.052 | 4.0 | |
| UC-CERT | March 7, 2002 | TEI 42C | NOx | 0.172 | 0.179 | 4.1 | |
| UC-CERT | March 7, 2002 | TEI 42C | NOx | 0.297 | 0.308 | 3.7 | |
| UC-CERT | March 7, 2002 | TEI 42C | NOx | 0.398 | 0.414 | 4.0 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOx | 0.000 | 0.000 | --- | 1.012 |
| UC-CERT | September 18, 2002 | TEI 42C | NOx | 0.061 | 0.064 | 4.9 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOx | 0.176 | 0.180 | 2.3 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOx | 0.283 | 0.289 | 2.1 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOx | 0.353 | 0.358 | 1.4 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOx | 0.441 | 0.447 | 1.4 | |
| UC-CERT | March 7, 2002 | TEI 42C | NO | 0.000 | 0.002 | --- | 1.006 |
| UC-CERT | March 7, 2002 | TEI 42C | NO | 0.050 | 0.049 | -2.0 | |
| UC-CERT | March 7, 2002 | TEI 42C | NO | 0.172 | 0.173 | 0.6 | |
| UC-CERT | March 7, 2002 | TEI 42C | NO | 0.297 | 0.299 | 0.7 | |
| UC-CERT | March 7, 2002 | TEI 42C | NO | 0.398 | 0.401 | 0.8 | |
| UC-CERT | September 18, 2002 | TEI 42C | NO | 0.000 | 0.000 | --- | 1.010 |
| UC-CERT | September 18, 2002 | TEI 42C | NO | 0.061 | 0.064 | 4.9 | |
| UC-CERT | September 18, 2002 | TEI 42C | NO | 0.176 | 0.180 | 2.3 | |
| UC-CERT | September 18, 2002 | TEI 42C | NO | 0.283 | 0.289 | 2.1 | |
| UC-CERT | September 18, 2002 | TEI 42C | NO | 0.353 | 0.356 | 0.8 | |
| UC-CERT | September 18, 2002 | TEI 42C | NO | 0.441 | 0.447 | 1.4 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NO | 0.000 | 0.000 | --- | 1.040 |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NO | 0.061 | 0.065 | 6.6 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NO | 0.176 | 0.186 | 5.7 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NO | 0.283 | 0.297 | 4.9 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NO | 0.353 | 0.363 | 2.8 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NO | 0.441 | 0.462 | 4.8 | |
| UC-CERT | March 7, 2002 | TEI 42C | $NO_2$ | 0.000 | 0.002 | --- | 1.032 |
| UC-CERT | March 7, 2002 | TEI 42C | $NO_2$ | 0.015 | 0.019 | 26.7 | |
| UC-CERT | March 7, 2002 | TEI 42C | $NO_2$ | 0.080 | 0.093 | 16.3 | |
| UC-CERT | March 7, 2002 | TEI 42C | $NO_2$ | 0.176 | 0.185 | 5.1 | |
| UC-CERT | March 7, 2002 | TEI 42C | $NO_2$ | 0.288 | 0.301 | 4.5 | |
| CARB | July 15-17, 2002 | TEI 42C | $NO_2$ | 0.063 | 0.065 | 3.2 | 0.997 |
| CARB | July 15-17, 2002 | TEI 42C | $NO_2$ | 0.180 | 0.181 | 0.6 | |
| CARB | July 15-17, 2002 | TEI 42C | $NO_2$ | 0.376 | 0.377 | 0.3 | |
| UC-CERT | September 18, 2002 | TEI 42C | $NO_2$ | 0.000 | 0.000 | --- | 1.010 |
| UC-CERT | September 18, 2002 | TEI 42C | $NO_2$ | 0.036 | 0.036 | 0.0 | |
| UC-CERT | September 18, 2002 | TEI 42C | $NO_2$ | 0.081 | 0.083 | 2.5 | |
| UC-CERT | September 18, 2002 | TEI 42C | $NO_2$ | 0.195 | 0.195 | 0.0 | |
| UC-CERT | September 18, 2002 | TEI 42C | $NO_2$ | 0.276 | 0.281 | 1.8 | |
| UC-CERT | September 18, 2002 | TEI 42C | $NO_2$ | 0.357 | 0.360 | 0.8 | |
| UC-CERT | March 7, 2002 | UCR | $NO_2$ | 0.000 | 0.000 | --- | **0.746** |
| UC-CERT | March 7, 2002 | UCR | $NO_2$ | 0.015 | 0.021 | 40.0 | |
| UC-CERT | March 7, 2002 | UCR | $NO_2$ | 0.080 | 0.094 | 17.7 | |
| UC-CERT | March 7, 2002 | UCR | $NO_2$ | 0.176 | 0.130 | -26.1 | |
| UC-CERT | March 7, 2002 | UCR | $NO_2$ | 0.288 | 0.227 | -21.2 | |
| UC-CERT | September 18, 2002 | UCR | $NO_2$ | 0.000 | 0.000 | --- | **0.643** |
| UC-CERT | September 18, 2002 | UCR | $NO_2$ | 0.036 | 0.032 | -11.1 | |
| UC-CERT | September 18, 2002 | UCR | $NO_2$ | 0.081 | 0.067 | -17.3 | |
| UC-CERT | September 18, 2002 | UCR | $NO_2$ | 0.195 | 0.143 | -26.7 | |
| UC-CERT | September 18, 2002 | UCR | $NO_2$ | 0.276 | 0.190 | -31.2 | |
| UC-CERT | September 18, 2002 | UCR | $NO_2$ | 0.357 | 0.230 | -35.6 | |

* Slope should be between 0.90 and 1.10 to meet the QAPP objective

**Table 3-4. Continuous Gaseous Analyzer Accuracy (Continued).**

| Agency | Audit Date | Instrument | Observable | Concentration (ppm) Audit | Station | %Difference | Regression Slope* |
|---|---|---|---|---|---|---|---|
| UC-CERT | March 7, 2002 | TEI 42C | NOy | 0.000 | 0.000 | --- | 1.008 |
| UC-CERT | March 7, 2002 | TEI 42C | NOy | 0.050 | 0.049 | -2.0 | |
| UC-CERT | March 7, 2002 | TEI 42C | NOy | 0.172 | 0.172 | 0.0 | |
| UC-CERT | March 7, 2002 | TEI 42C | NOy | 0.297 | 0.300 | 1.0 | |
| UC-CERT | March 7, 2002 | TEI 42C | NOy | 0.398 | 0.400 | 0.5 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOy | 0.000 | 0.001 | --- | 1.028 |
| UC-CERT | September 18, 2002 | TEI 42C | NOy | 0.061 | 0.065 | 6.6 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOy | 0.176 | 0.184 | 4.5 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOy | 0.283 | 0.297 | 4.9 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOy | 0.353 | 0.363 | 2.8 | |
| UC-CERT | September 18, 2002 | TEI 42C | NOy | 0.441 | 0.455 | 3.2 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NOy | 0.000 | 0.002 | --- | 1.050 |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NOy | 0.061 | 0.068 | 11.5 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NOy | 0.176 | 0.191 | 8.5 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NOy | 0.283 | 0.302 | 6.7 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NOy | 0.353 | 0.365 | 3.4 | |
| UC-CERT | September 18, 2002 | TEI 42C 2nd inst. | NOy | 0.441 | 0.471 | 6.8 | |
| UC-CERT | March 7, 2002 | TEI 42C | $HNO_3$ | 0.000 | 0.002 | --- | 1.009 |
| UC-CERT | March 7, 2002 | TEI 42C | $HNO_3$ | 0.050 | 0.050 | 0.0 | |
| UC-CERT | March 7, 2002 | TEI 42C | $HNO_3$ | 0.172 | 0.172 | 0.0 | |
| UC-CERT | March 7, 2002 | TEI 42C | $HNO_3$ | 0.297 | 0.300 | 1.0 | |
| UC-CERT | March 7, 2002 | TEI 42C | $HNO_3$ | 0.398 | 0.403 | 1.3 | |
| UC-CERT | September 18, 2002 | TEI 42C | $HNO_3$ | 0.000 | 0.000 | --- | 1.027 |
| UC-CERT | September 18, 2002 | TEI 42C | $HNO_3$ | 0.061 | 0.063 | 3.3 | |
| UC-CERT | September 18, 2002 | TEI 42C | $HNO_3$ | 0.176 | 0.181 | 2.8 | |
| UC-CERT | September 18, 2002 | TEI 42C | $HNO_3$ | 0.283 | 0.295 | 4.2 | |
| UC-CERT | September 18, 2002 | TEI 42C | $HNO_3$ | 0.353 | 0.361 | 2.3 | |
| UC-CERT | September 18, 2002 | TEI 42C | $HNO_3$ | 0.441 | 0.453 | 2.7 | |
| CARB | July 15-17, 2002 | API 400 | $O_3$ | 0.364 | 0.350 | -3.8 | 0.968 |
| CARB | July 15-17, 2002 | API 400 | $O_3$ | 0.158 | 0.150 | -5.1 | |
| CARB | July 15-17, 2002 | API 400 | $O_3$ | 0.062 | 0.058 | -6.5 | |
| UC-CERT | September 19, 2002 | API 400 | $O_3$ | 0.000 | 0.003 | --- | 1.004 |
| UC-CERT | September 19, 2002 | API 400 | $O_3$ | 0.081 | 0.084 | 3.7 | |
| UC-CERT | September 19, 2002 | API 400 | $O_3$ | 0.192 | 0.196 | 2.1 | |
| UC-CERT | September 19, 2002 | API 400 | $O_3$ | 0.281 | 0.280 | -0.4 | |
| UC-CERT | September 19, 2002 | API 400 | $O_3$ | 0.356 | 0.363 | 2.0 | |
| CARB | July 15-17, 2002 | TEI 55C | NMHC | 0.600 | 0.610 | 1.7 | 0.974 |
| CARB | July 15-17, 2002 | TEI 55C | NMHC | 1.170 | 1.160 | -0.9 | |
| CARB | July 15-17, 2002 | TEI 55C | NMHC | 1.770 | 1.750 | -1.1 | |
| CARB | July 15-17, 2002 | Dasibi 3008 | CO | 7.160 | 7.200 | 0.6 | 1.021 |
| CARB | July 15-17, 2002 | Dasibi 3008 | CO | 18.300 | 18.100 | -1.1 | |
| CARB | July 15-17, 2002 | Dasibi 3008 | CO | 37.300 | 37.900 | 1.7 | |
| CARB | July 15-17, 2002 | API 100A | $SO_2$ | 0.071 | 0.073 | 2.8 | 0.993 |
| CARB | July 15-17, 2002 | API 100A | $SO_2$ | 0.182 | 0.184 | 1.1 | |
| CARB | July 15-17, 2002 | API 100A | $SO_2$ | 0.370 | 0.370 | 0.0 | |

* Slope should be between 0.90 and 1.10 to meet the QAPP objective

**Table 3-5. Meteorological Measurement Accuracy.**

| Measurement | Audit Value | Station Response | Difference |
|---|---|---|---|
| Barometric Pressure | 750 mm Hg | 750 mm Hg | 0 mm Hg |
| Wind Direction | 090° | 091° | 1° |
| | 180° | 182° | 2° |
| | 270° | 272° | 2° |
| | 355° | 359° | 4° |
| Horizontal Wind Speed | 0.27 mph | 0.23 mph | -0.04 mph |
| | 5.60 mph | 5.58 mph | -0.36 mph |
| | 10.93 mph | 10.91 mph | -0.18 mph |
| | 16.26 mph | 16.23 mph | -0.18 mph |
| | 32.25 mph | 32.20 mph | -0.16 mph |
| Temperature | 44.1°C | 44.1°C | 0.0°C |
| | 26.5°C | 26.4°C | -0.1°C |
| | 0.4°C | 0.4°C | 0.0°C |
| Relative Humidity | 91.5% | 89.9% | -1.6% |
| | 62.4% | 65.0% | 2.6% |
| | 32.1% | 37.0% | 4.9% |

* Meteorological audit conducted by CARB, July 15-17, 2002

## 3.3 Detection Limits

Table 3-6 summarizes the instrument detection limits that were generally encountered. Table 3-7 through Table 3-9 summarize the minimum detection limits for the entire study period for integrated samples measured by the Desert Research Institute's Sequential Filter Samplers (SFS), the Andersen single channel FRM Sampler and the Andersen 6-Channel Reference Ambient Air Speciation Sampler (RAAS). All detection limits are in micrograms (µg) per filter. As mentioned earlier, these represent three times the standard deviation of concentrations measured on the field and laboratory blanks.

**Table 3-6. Instrument Detection Limits.**

| Species | Values in µg/filter | |
|---|---|---|
| | Analysis Method[a] | IDL[b] |
| Chloride ($Cl^-$) | IC | 1.50048 |
| Nitrite ($NO_2^-$) | IC | 1.50048 |
| Nonvolatilized Nitrate ($NO_3^-$) | IC | 1.50048 |
| Volatilized Nitrate (NO3-) | IC | 1.50048 |
| Phosphate ($PO_4^{3-}$) | IC | 1.50048 |
| Sulfate ($SO_4^=$) | IC | 1.50048 |
| Ammonium ($NH_4^+$) | AC | 1.50048 |
| Ammonia ($NH_3$) | AC | 1.50048 |
| Soluble Sodium ($Na^+$) | AAS | 0.23616 |
| Soluble Magnesium ($Mg^{2+}$) | AAS | 0.05472 |
| Soluble Potassium ($K^+$) | AAS | 0.14976 |
| Soluble Calcium ($Ca^{2+}$) | AAS | 0.09792 |
| Organic Carbon (OC) | TOR | 2.75904 |
| Elemental Carbon (EC) | TOR | 2.75904 |
| Sodium (Na) | XRF | 0.95328 |
| Magnesium (Mg) | XRF | 0.3456 |
| Aluminum (Al) | XRF | 0.13824 |
| Silicon (Si) | XRF | 0.0864 |
| Phosphorus (P) | XRF | 0.07776 |
| Sulfur (S) | XRF | 0.06912 |
| Chlorine (Cl) | XRF | 0.13824 |
| Patassium (K) | XRF | 0.08352 |
| Calcium (Ca) | XRF | 0.06336 |
| Titanium (Ti) | XRF | 0.04032 |
| Vanadium (V) | XRF | 0.03456 |
| Chromium (Cr) | XRF | 0.02592 |
| Manganese (Mn) | XRF | 0.02304 |
| Iron (Fe) | XRF | 0.02016 |
| Cobalt (Co) | XRF | 0.01152 |
| Nickel (Ni) | XRF | 0.01152 |
| Copper (Cu) | XRF | 0.0144 |
| Zinc (Zn) | XRF | 0.0144 |
| Gallium (Ga) | XRF | 0.02592 |
| Arsenic (As) | XRF | 0.02304 |
| Selenium (Se) | XRF | 0.01728 |
| Bromine (Br) | XRF | 0.0144 |
| Rubidium (Rb) | XRF | 0.0144 |
| Strontium (Sr) | XRF | 0.0144 |
| Yttrium (Y) | XRF | 0.01728 |
| Zerconium (Zr) | XRF | 0.02304 |
| Molybdenum (Mo) | XRF | 0.03744 |
| Palladium (Pd) | XRF | 0.15264 |
| Silver (Ag) | XRF | 0.16704 |
| Cadmium (Cd) | XRF | 0.16704 |
| Indium (In) | XRF | 0.17856 |
| Tin (Sn) | XRF | 0.23328 |
| Antimony (Sb) | XRF | 0.24768 |
| Barium (Ba) | XRF | 0.71712 |
| Lanthanum (La) | XRF | 0.85536 |
| Gold (Au) | XRF | 0.0432 |
| Mercury (Hg) | XRF | 0.03456 |
| Thallium (Tl) | XRF | 0.03456 |
| Lead (Pb) | XRF | 0.04032 |
| Uranium (U) | XRF | 0.03168 |

a IC=ion chromatography. AC=automated colorimetry. AAS=atomic absorption spectrophotometry. TOR=thermal/optical reflectance. XRF=x-ray fluorescence.

b Instrument detection limit (IDL) is the concentration at which instrument response equals three times the standard deviation of the response to a known concentration of zero.

**Table 3-7. Minimum Detection Limits (MDL) of Samples Collected Using Andersen Single Channel FRM Sampler for the Complete Study Period.**

| Species | Values in µg/filter | |
|---|---|---|
| | MDL | No. of blanks |
| Mass | 23.56 | 51 |
| Chloride ($Cl^-$) | 3.7976 | 48 |
| Non-Volatilized Nitrate ($NO_3^-$) | 4.5797 | 48 |
| Sulfate ($SO_4^=$) | 4.8114 | 48 |
| Ammonium ($NH_4^+$) | 1.7294 | 51 |
| Soluble Sodium ($Na^+$) | 1.1355 | 52 |
| Soluble Potassium ($K^+$) | 0.3719 | 52 |
| OC1* | 2.2337 | 34 |
| OC2* | 11.5692 | 34 |
| OC3* | 9.1794 | 34 |
| OC4* | 2.1659 | 34 |
| Pyrolized Organics | 0.3910 | 34 |
| Organic Carbon | 18.1885 | 51 |
| EC1* | 0.5160 | 34 |
| EC2* | 0.6027 | 34 |
| EC3* | 0.2058 | 34 |
| Elemental Carbon (EC) | 0.7920 | 51 |
| Total Carbon | 18.4730 | 51 |
| Sodium (Na) | 8.6650 | 52 |
| Magnesium (Mg) | 2.4607 | 52 |
| Aluminum (Al) | 0.7388 | 52 |
| Silicon (Si) | 0.9187 | 52 |
| Phosphorous (P) | 0.1764 | 52 |
| Sulfur (S) | 0.1557 | 52 |
| Chlorine (Cl) | 0.2352 | 52 |
| Potassium (K) | 0.1572 | 52 |
| Calcium (Ca) | 0.1567 | 52 |
| Titanium (Ti) | 0.3949 | 52 |
| Vanadium (V) | 0.2126 | 52 |
| Chromium (Cr) | 0.0609 | 52 |
| Manganese (Mn) | 0.0323 | 52 |
| Iron (Fe) | 0.4096 | 52 |
| Cobalt (Co) | 0.0173 | 52 |
| Nickel (Ni) | 0.0221 | 52 |
| Copper (Cu) | 0.0881 | 52 |
| Zinc (Zn) | 0.1651 | 52 |
| Gallium (Ga) | 0.0744 | 52 |
| Arsenic (As) | 0.0338 | 52 |
| Selenium (Se) | 0.0206 | 52 |
| Bromine (Br) | 0.0160 | 52 |
| Rubidium (Rb) | 0.0134 | 52 |
| Strontium (Sr) | 0.0206 | 52 |
| Yttrium (Y) | 0.0285 | 52 |
| Zirconium (Zr) | 0.0287 | 52 |
| Molybdenum (Mo) | 0.0774 | 52 |
| Palladium (Pd) | 0.1362 | 52 |
| Silver (Ag) | 0.1694 | 52 |
| Cadmium (Cd) | 0.1730 | 52 |
| Indium (In) | 0.1701 | 52 |
| Tin (Sn) | 0.2296 | 52 |
| Antimony (Sb) | 0.2090 | 52 |
| Barium (Ba) | 1.1214 | 52 |
| Lanthanum (La) | 1.2050 | 52 |
| Gold (Au) | 0.0847 | 52 |
| Mercury (Hg) | 0.0347 | 52 |
| Thallium (Tl) | 0.0321 | 52 |
| Lead (Pb) | 0.0932 | 52 |
| Uranium (U) | 0.0399 | 52 |

* OC1-OC4 and EC1-EC3 refer to the organic carbon and elemental carbon fractions, respectively, obtained by Thermal Optical Reflectance (TOR) method using IMPROVE protocol.

**Table 3-8. Minimum Detection Limits (MDL) of Samples Collected Using Sequential Filter Samplers (SFS) for the Complete Study Period.**

| Species | Values in µg/filter | |
|---|---|---|
| | MDL | No. of blanks |
| Mass | 24.40 | 55 |
| Chloride ($Cl^-$) | 1.6909 | 9 |
| Non-Volatilized Nitrate ($NO_3^-$) | 4.9553 | 9 |
| Volatilized Nitrate ($NO_3^-$) | 0.0000 | 7 |
| Sulfate ($SO_4^=$) | 4.0933 | 9 |
| Ammonium ($NH_4^+$) | 0.6698 | 9 |
| Soluble Potassium ($K^+$) | 0.0912 | 9 |
| Soluble Sodium ($Na^+$) | 0.3379 | 9 |
| OC1 | 6.6157 | 7 |
| OC2 | 2.5391 | 7 |
| OC3 | 5.2456 | 7 |
| OC4 | 2.7475 | 7 |
| Pyrolized Organics | 0.0000 | 7 |
| Organic Carbon | 13.6294 | 7 |
| EC 1 | 0.2495 | 7 |
| EC 2 | 1.1825 | 7 |
| EC 3 | 0.0000 | 7 |
| Elemental Carbon (EC) | 1.1013 | 7 |
| Total Carbon | 14.0645 | 7 |
| Sodium (Na) | 9.7579 | 7 |
| Magnesium (Mg) | 1.3531 | 7 |
| Aluminum (Al) | 0.6437 | 7 |
| Silicon (Si) | 0.1191 | 7 |
| Phosphorous (P) | 0.1267 | 7 |
| Sulfur (S) | 0.1699 | 7 |
| Chlorine (Cl) | 0.2226 | 7 |
| Potassium (K) | 0.1197 | 7 |
| Calcium (Ca) | 0.0718 | 7 |
| Titanium (Ti) | 0.3408 | 7 |
| Vanadium (V) | 0.2468 | 7 |
| Chromium (Cr) | 0.0770 | 7 |
| Manganese (Mn) | 0.0200 | 7 |
| Iron (Fe) | 0.1199 | 7 |
| Cobalt (Co) | 0.0136 | 7 |
| Nickel (Ni) | 0.0151 | 7 |
| Copper (Cu) | 0.0344 | 7 |
| Zinc (Zn) | 0.1872 | 7 |
| Gallium (Ga) | 0.0593 | 7 |
| Arsenic (As) | 0.0347 | 7 |
| Selenium (Se) | 0.0179 | 7 |
| Bromine (Br) | 0.0125 | 7 |
| Rubidium (Rb) | 0.0143 | 7 |
| Strontium (Sr) | 0.0268 | 7 |
| Yttrium (Y) | 0.0194 | 7 |
| Zirconium (Zr) | 0.0417 | 7 |
| Molybdenum (Mo) | 0.0539 | 7 |
| Palladium (Pd) | 0.0820 | 7 |
| Silver (Ag) | 0.1791 | 7 |
| Cadmium (Cd) | 0.2265 | 7 |
| Indium (In) | 0.0762 | 7 |
| Tin (Sn) | 0.2759 | 7 |
| Antimony (Sb) | 0.2865 | 7 |
| Barium (Ba) | 1.1247 | 7 |
| Lanthanum (La) | 2.3500 | 7 |
| Gold (Au) | 0.0600 | 7 |
| Mercury (Hg) | 0.0186 | 7 |
| Thallium (Tl) | 0.0311 | 7 |
| Lead (Pb) | 0.0654 | 7 |
| Uranium (U) | 0.0474 | 7 |
| Ammonia ($NH_3$) | 7.0608 | 6 |

* OC1-OC4 and EC1-EC3 refer to the organic carbon and elemental carbon fractions, respectively, obtained by Thermal Optical Reflectance (TOR) method using IMPROVE protocol.

**Table 3-9. Minimum Detection Limits (MDL) of Samples Collected Using Andersen RAAS 6-Channel Speciation Sampler for the Complete Study Period.**

| | Species* | Values in µg/filter | |
|---|---|---|---|
| | | MDL | No. of blanks |
| Un-Denuded Channel | Mass | 28.66 | 31 |
| | QBT OC1 | 4.9053 | 69 |
| | QBT OC2 | 4.8892 | 70 |
| | QBT OC3 | 6.5762 | 70 |
| | QBT OC4 | 2.3319 | 70 |
| | QBT Pyrolized Organics | 0.0464 | 70 |
| | QBT Organic Carbon (OC) | 15.51 | 85 |
| | QBT EC1 | 0.7416 | 70 |
| | QBT EC2 | 0.5846 | 70 |
| | QBT EC3 | 0.0000 | 70 |
| | QBT Elemental Carbon (EC) | 0.8641 | 85 |
| | QBT Total Carbon | 15.78 | 85 |
| | Chloride ($Cl^-$) | 4.5418 | 54 |
| | Non-Volatilized Nitrate ($NO_3^-$) | 0.8802 | 53 |
| | Sulfate ($SO_4^=$) | 1.0823 | 54 |
| | Ammonium ($NH_4^+$) | 2.4375 | 50 |
| | Soluble Potassium ($K^+$) | 0.3144 | 46 |
| | Soluble Sodium ($Na^+$) | 1.6948 | 46 |
| | OC1 | 3.0671 | 52 |
| | OC2 | 3.9572 | 52 |
| | OC3 | 7.5142 | 52 |
| | OC4 | 2.4418 | 52 |
| | Pyrolized Organics | 0.0000 | 52 |
| | Organic Carbon | 13.63 | 68 |
| | EC 1 | 0.7655 | 52 |
| | EC 2 | 0.6804 | 52 |
| | EC 3 | 0.0582 | 52 |
| | Elemental Carbon (EC) | 1.7362 | 69 |
| | Total Carbon | 14.46 | 69 |
| | QBQ OC1 | 4.8961 | 69 |
| | QBQ OC2 | 4.7279 | 69 |
| | QBQ OC3 | 6.5092 | 69 |
| | QBQ OC4 | 2.3160 | 69 |
| | QBQ Pyrolized Organics | 0.0467 | 69 |
| | QBQ Organic Carbon (OC) | 14.23 | 85 |
| | QBQ EC1 | 0.7468 | 69 |
| | QBQ EC2 | 0.5885 | 69 |
| | QBQ EC3 | 0.0000 | 69 |
| | QBQ Elemental Carbon (EC) | 1.4031 | 85 |
| | QBQ Total Carbon | 14.75 | 85 |
| Carbon Denuder Channel | Denuded OC1 | 3.2817 | 62 |
| | Denuded OC2 | 4.1522 | 62 |
| | Denuded OC3 | 7.4832 | 62 |
| | Denuded OC4 | 2.3413 | 62 |
| | Denuded Pyrolized Organics | 0.0000 | 62 |
| | Denuded Organic Carbon (OC) | 14.27 | 79 |
| | Denuded EC1 | 0.7012 | 62 |
| | Denuded EC2 | 0.6043 | 62 |
| | Denuded EC3 | 0.0533 | 62 |
| | Denuded Elemental Carbon (EC) | 1.1823 | 79 |
| | Denuded Total Carbon | 14.84 | 79 |
| | Denuded QBQ OC1 | 4.9281 | 69 |
| | Denuded QBQ OC2 | 4.8346 | 69 |
| | Denuded QBQ OC3 | 6.7425 | 69 |
| | Denuded QBQ OC4 | 2.3603 | 69 |
| | Denuded QBQ Pyrolized Organics | 0.0467 | 69 |
| | Denuded QBQ Organic Carbon (OC) | 13.77 | 86 |
| | Denuded QBQ EC1 | 0.7468 | 69 |
| | Denuded QBQ EC2 | 0.5885 | 69 |
| | Denuded QBQ EC3 | 0.0000 | 69 |
| | Denuded QBQ Elemental Carbon (EC) | 1.1862 | 86 |
| | Denuded QBQ Total Carbon | 14.02 | 86 |
| Nitric Acid ($HNO_3$) Denuder | Denuded $Cl^-$ | 10.89 | 75 |
| | Denuded $NO_3^-$ | 0.8559 | 76 |
| | Denuded $SO_4^=$ | 1.7457 | 76 |
| | Denuded Volatilized $NO_3^-$ | 1.6866 | 54 |
| NH3 Denuder | Denuded $NH_4^+$ | 4.8201 | 36 |
| | Denuded Ammonia ($NH_3^+$) | 5.5192 | 42 |

| | Species* | Values in µg/filter | |
|---|---|---|---|
| | | MDL | No. of blanks |
| Un-Denuded Channel | Sodium (Na) | 5.7876 | 12 |
| | Magnesium (Mg) | 1.3111 | 12 |
| | Aluminum (Al) | 0.5184 | 12 |
| | Silicon (Si) | 1.6779 | 11 |
| | Phosphorous (P) | 0.1076 | 12 |
| | Sulfur (S) | 0.0771 | 12 |
| | Chlorine (Cl) | 0.0997 | 12 |
| | Potassium (K) | 0.1179 | 12 |
| | Calcium (Ca) | 0.1537 | 12 |
| | Titanium (Ti) | 0.4380 | 12 |
| | Vanadium (V) | 0.3157 | 12 |
| | Chromium (Cr) | 0.0857 | 12 |
| | Manganese (Mn) | 0.0374 | 12 |
| | Iron (Fe) | 0.2556 | 12 |
| | Cobalt (Co) | 0.0195 | 12 |
| | Nickel (Ni) | 0.0268 | 12 |
| | Copper (Cu) | 0.0335 | 12 |
| | Zinc (Zn) | 0.0367 | 12 |
| | Gallium (Ga) | 0.0448 | 12 |
| | Arsenic (As) | 0.0263 | 12 |
| | Selenium (Se) | 0.0176 | 12 |
| | Bromine (Br) | 0.0166 | 12 |
| | Rubidium (Rb) | 0.0144 | 12 |
| | Strontium (Sr) | 0.0168 | 12 |
| | Yttrium (Y) | 0.0149 | 12 |
| | Zirconium (Zr) | 0.0268 | 12 |
| | Molybdenum (Mo) | 0.0661 | 12 |
| | Palladium (Pd) | 0.1320 | 12 |
| | Silver (Ag) | 0.1906 | 12 |
| | Cadmium (Cd) | 0.1671 | 12 |
| | Indium (In) | 0.2228 | 12 |
| | Tin (Sn) | 0.2512 | 12 |
| | Antimony (Sb) | 0.2857 | 12 |
| | Barium (Ba) | 1.4252 | 12 |
| | Lanthanum (La) | 2.5524 | 12 |
| | Gold (Au) | 0.0729 | 12 |
| | Mercury (Hg) | 0.0396 | 12 |
| | Thallium (Tl) | 0.0388 | 12 |
| | Lead (Pb) | 0.0742 | 12 |
| | Uranium (U) | 0.0290 | 12 |

* QBT refers to the Quartz filter behind the Teflon filter in a Teflon-Quartz filter pack. QBQ refers to the Quartz filter behind the Quartz filter in a Quartz-Quartz filter pack. If "QBT" or "QBQ" is not specified, or unless specified explicitly, it refers to the species on the front filter. Volatilized nitrate is obtained from nylon back-up filter on the Quartz-nylon flter pack channel. The type and presence of the denuder is indicated to the left.

OC1-OC4 and EC1-EC3 refer to the organic carbon and elemental carbon fractions respectively, obtained using TOR

### 3.4 Bias and Comparability

Various articles on the inter-comparability of the different samplers and measurements (Chow et al., 2005b,2005d,2005c,Park et al., 2005) have either been published, or are in the process of preparation. Table 3-10 through Table 3-12 list the different comparison metrics for mass, carbon, nitrate and sulfate measurements as discussed in the QAPP. The mass comparisons against the FRM sampler showed correlation coefficients (r), typically greater than 0.90, except for the TEOM. The TEOM sampler inlet was maintained at 50 $^{o}$C, resulting in the loss of semi-volatile components and hence under-estimating the mass concentrations significantly (Chow et al., 2005b). The BAM measurements were consistently biased higher than the FRM measurements possibly due to water absorption by hygroscopic species (Chow et al., 2005b). Table 3-11 shows that the organic carbon (OC), elemental carbon (EC) and total carbon (TC) measurements were, in general, comparable between the AN100 FRM, the AN400 RAAS and the SFS integrated samplers (Chow et al., 2005c,Watson and Chow, 2002b). The inter-comparison of the three integrated samplers showed high correlations ($r \geq 0.95$), indicating a highly predictable linear relationship. The R&P 5400 continuous ambient carbon analyzer was neither comparable to, nor predictable of, the integrated SFS sampler measurements (Chow et al., 2005c).

While the R&P 8400N continuous nitrate analyzer under-predicted nitrate concentrations in comparison to the integrated speciation sampler (AN400), they were, in general, highly correlated ($r > 0.84$) (Table 3-12). The comparison between the R&P 8400S continuous sulfate analyzer and the integrated samplers showed poorer correlations, possibly because of low ambient sulfate concentrations. The comparison between the FRM and the AN400 samplers showed excellent agreement for both nitrate and sulfate (Park et al., 2005a).

**Table 3-10. Mass Comparisons.**

| Samplers | | | Ordinary Least Squares Regression | | | | | Y-X | | Distribution of Y-X | | | | Y/X | | Begin | End |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Y | X | N | Slope ± | unc | int ± | unc. | r | avg ± | std dev | <1σ | 1σ-2σ | 2σ-3σ | >3σ | avg ± | std dev | Date | Date |
| | | | | | ($\mu g/m^3$) | | | ($\mu g/m^3$) | | | | | | | | | |
| AN300_2 | AN300_1 | 151 | 0.95 ± | 0.01 | 0.64 ± | 0.31 | 0.99 | -0.38 ± | 2.72 | | | | | 0.99 ± | 0.12 | 01/06/99 | 01/26/02 |
| RP2K_2 | RP2K_1 | 77 | 0.91 ± | 0.02 | 0.34 ± | 0.48 | 0.99 | -1.86 ± | 3.14 | | | | | 0.93 ± | 0.13 | 09/11/02 | 12/29/03 |
| AN300_1 | AN100 | 106 | 0.98 ± | 0.02 | 1.47 ± | 0.50 | 0.99 | 1.06 ± | 3.66 | 44 | 37 | 16 | 9 | 1.10 ± | 0.16 | 07/05/99 | 02/01/02 |
| AN300_2 | AN100 | 148 | 0.92 ± | 0.01 | 1.63 ± | 0.28 | 0.99 | 0.02 ± | 3.01 | 89 | 40 | 16 | 3 | 1.04 ± | 0.11 | 07/05/99 | 11/04/02 |
| RP2K_1 | AN100 | 103 | 0.91 ± | 0.01 | 1.11 ± | 0.29 | 0.99 | -0.50 ± | 2.45 | 69 | 28 | 3 | 3 | 1.00 ± | 0.14 | 02/07/02 | 12/29/03 |
| RP2K_2 | AN100 | 66 | 0.87 ± | 0.01 | 1.18 ± | 0.31 | 0.99 | -1.59 ± | 2.93 | 39 | 17 | 7 | 3 | 0.96 ± | 0.20 | 09/11/02 | 12/29/03 |
| | | | | | | | | | | | | | | | | | |
| SFS | AN100 | 60 | 0.85 ± | 0.02 | 1.02 ± | 0.65 | 0.99 | -3.04 ± | 6.27 | 18 | 16 | 12 | 14 | 0.97 ± | 0.31 | 12/02/99 | 01/31/01 |
| AN400 | AN100 | 239 | 0.96 ± | 0.01 | 0.89 ± | 0.19 | 0.99 | -0.07 ± | 2.44 | 155 | 63 | 13 | 8 | 1.03 ± | 0.19 | 07/05/99 | 12/29/03 |
| DICHOT $PM_{2.5}$ | AN100 | 114 | 0.81 ± | 0.02 | 2.71 ± | 0.87 | 0.95 | -1.75 ± | 9.10 | 75 | 33 | 4 | 2 | 0.97 ± | 0.10 | 07/05/99 | 10/28/01 |
| M1ST | AN100 | 185 | 0.98 ± | 0.01 | 1.25 ± | 0.31 | 0.99 | 0.87 ± | 3.19 | 96 | 37 | 21 | 31 | 1.11 ± | 0.25 | 04/06/00 | 12/29/03 |
| BAM $PM_{2.5}$ | AN100 | 206 | 0.95 ± | 0.01 | 4.40 ± | 0.46 | 0.98 | 3.34 ± | 5.07 | 42 | 36 | 26 | 102 | 1.30 ± | 0.33 | 12/20/99 | 09/24/03 |
| TEOM $PM_{2.5}$ | AN100 | 222 | 0.40 ± | 0.03 | 4.66 ± | 0.88 | 0.74 | -9.62 ± | 18.95 | 55 | 47 | 15 | 105 | 0.78 ± | 0.37 | 07/11/99 | 12/29/03 |
| DUSTTRAK | AN100 | 142 | 1.86 ± | 0.07 | 12.46 ± | 1.91 | 0.92 | 29.34 ± | 22.97 | 1 | 2 | 1 | 138 | 2.73 ± | 0.98 | 04/30/00 | 06/20/03 |
| GREENTEK | AN100 | 66 | 1.44 ± | 0.06 | -2.95 ± | 1.85 | 0.95 | 7.72 ± | 13.95 | 13 | 7 | 10 | 36 | 1.20 ± | 0.39 | 10/04/01 | 01/21/03 |
| | | | | | | | | | | | | | | | | | |
| BAM $PM_{10}$ | HIVOL10V | 105 | 1.05 ± | 0.03 | 4.76 ± | 1.32 | 0.97 | 7.02 ± | 8.48 | | | | | 1.18 ± | 0.23 | 12/08/99 | 08/29/01 |
| TEOM $PM_{10}$ | HIVOL10V | 111 | 0.67 ± | 0.05 | 2.17 ± | 2.45 | 0.81 | -11.51 ± | 17.66 | | | | | 0.72 ± | 0.23 | 07/11/99 | 06/24/01 |
| | | | | | | | | | | | | | | | | | |
| AN400 | SFS | 63 | 1.10 ± | 0.02 | 0.57 ± | 0.84 | 0.98 | 2.97 ± | 5.69 | 19 | 17 | 10 | 17 | 1.14 ± | 0.20 | 12/02/99 | 01/31/01 |
| MOUDI | SFS | 15 | 1.09 ± | 0.21 | 6.28 ± | 16.15 | 0.82 | 12.54 ± | 27.00 | 5 | 1 | 1 | 8 | 1.21 ± | 0.39 | 12/15/00 | 02/03/01 |
| DUSTTRAK | BAM $PM_{2.5}$ | 830 | 2.13 ± | 0.03 | 3.41 ± | 0.80 | 0.94 | 30.34 ± | 24.73 | | | | | 2.33 ± | 0.79 | 04/26/00 | 06/23/03 |
| GREENTEK | BAM $PM_{2.5}$ | 373 | 1.52 ± | 0.03 | -9.79 ± | 0.97 | 0.94 | 4.91 ± | 14.94 | | | | | 1.04 ± | 0.39 | 09/16/01 | 01/22/03 |
| | | | | | | | | | | | | | | | | | |
| RAD25 | AN100 | 115 | 4.07 ± | 0.13 | -9.52 ± | 4.97 | 0.95 | | | | | | | 3.34 | 1.02 | 11/20/00 | 08/25/03 |
| RAD | AN100 | 192 | 4.49 ± | 0.08 | -9.79 ± | 2.42 | 0.97 | | | | | | | 3.67 | 1.18 | 03/25/00 | 08/01/03 |
| RAD | SFS | 74 | 5.46 ± | 0.17 | 7.08 ± | 7.40 | 0.96 | | | | | | | 5.31 | 1.90 | 03/25/00 | 02/03/01 |

**Table 3-11. Carbon Measurement Comparisons.**

| Samplers | | | Ordinary Least Squares Regression | | | | | | | Y-X | | | Distribution of Y-X | | | | Y/X | | | Begin | End |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Y | X | N | Slope | ± | unc | int | ± | unc. | r | avg | ± | std dev | <1σ | 1σ-2σ | 2σ-3σ | >3σ | avg | ± | std dev | Date | Date |
| | | | | | | ($\mu g/m^3$) | | | | ($\mu g/m^3$) | | | | | | | | | | | |
| SFS OC | RP5400 OC | 19 | 0.59 | ± | 0.11 | 0.17 | ± | 0.97 | 0.79 | -3.35 | ± | 1.51 | 2 | 0 | 0 | 17 | 0.62 | ± | 0.20 | 01/19/00 | 02/03/01 |
| SFS EC | RP5400 EC | 19 | 0.55 | ± | 0.08 | 0.32 | ± | 0.16 | 0.86 | -0.49 | ± | 0.55 | 3 | 9 | 4 | 3 | 0.79 | ± | 0.27 | 01/19/00 | 02/03/01 |
| SFS TC | RP5400 TC | 19 | 0.60 | ± | 0.10 | 0.34 | ± | 1.05 | 0.83 | -3.84 | ± | 1.87 | 1 | 1 | 1 | 16 | 0.65 | ± | 0.20 | 01/19/00 | 02/03/01 |
| | | | | | | | | | | | | | | | | | | | | | |
| AN100 OC | SFS OC | 55 | 1.05 | ± | 0.02 | -0.38 | ± | 0.27 | 0.99 | 0.02 | ± | 1.34 | 40 | 13 | 1 | 1 | 0.99 | ± | 0.13 | 12/02/99 | 01/31/01 |
| AN400 OC | SFS OC | 55 | 1.08 | ± | 0.03 | -0.10 | ± | 0.31 | 0.98 | 0.55 | ± | 1.59 | 33 | 18 | 3 | 1 | 1.06 | ± | 0.18 | 12/02/99 | 01/31/01 |
| AN400 OC | AN100 OC | 56 | 1.02 | ± | 0.02 | 0.32 | ± | 0.25 | 0.99 | 0.51 | ± | 1.25 | 40 | 9 | 5 | 2 | 1.07 | ± | 0.17 | 12/02/99 | 01/31/01 |
| | | | | | | | | | | | | | | | | | | | | | |
| AN100 EC | SFS EC | 55 | 1.01 | ± | 0.03 | 0.12 | ± | 0.10 | 0.98 | 0.14 | ± | 0.50 | 42 | 10 | 2 | 1 | 1.11 | ± | 0.25 | 12/02/99 | 01/31/01 |
| AN400 EC | SFS EC | 55 | 1.04 | ± | 0.03 | -0.09 | ± | 0.08 | 0.98 | 0.01 | ± | 0.43 | 40 | 13 | 1 | 1 | 1.01 | ± | 0.3 | 12/02/99 | 01/31/01 |
| AN400 EC | AN100 EC | 56 | 0.99 | ± | 0.04 | -0.12 | ± | 0.11 | 0.97 | -0.14 | ± | 0.58 | 26 | 24 | 4 | 2 | 0.92 | ± | 0.24 | 12/02/99 | 01/31/01 |
| | | | | | | | | | | | | | | | | | | | | | |
| AN100 TC | SFS TC | 55 | 1.04 | ± | 0.02 | -0.32 | ± | 0.28 | 0.99 | 0.15 | ± | 1.40 | 39 | 14 | 1 | 1 | 1.01 | ± | 0.13 | 12/02/99 | 01/31/01 |
| AN400 TC | SFS TC | 55 | 1.08 | ± | 0.02 | -0.24 | ± | 0.33 | 0.99 | 0.59 | ± | 1.79 | 34 | 16 | 4 | 1 | 1.04 | ± | 0.17 | 12/02/99 | 01/31/01 |
| AN400 TC | AN100 TC | 56 | 1.03 | ± | 0.02 | 0.10 | ± | 0.27 | 0.99 | 0.40 | ± | 1.36 | 37 | 14 | 4 | 1 | 1.04 | ± | 0.16 | 12/02/99 | 01/31/01 |

**Table 3-12. Nitrate and Sulfate Measurement Comparisons.**

| Sampling period | Samplers Y | X* | N | Ordinary Least Squares Regression Slope | Intercept | r |
|---|---|---|---|---|---|---|
| ***Nirate ($NO_3^-$)*** | | | | | | |
| 2001 | R&P8400N | AN400 NV | 50 | 0.49 | 0.83 | 0.97 |
| | | AN400 Total | 50 | 0.38 | 0.71 | 0.94 |
| 2002 | R&P8400N | AN400 NV | 57 | 0.61 | 0.61 | 0.97 |
| | | AN400 Total | 57 | 0.64 | -0.10 | 0.97 |
| 2003 | R&P8400N | AN400 NV | 54 | 0.54 | 0.94 | 0.91 |
| | | AN400 Total | 54 | 0.61 | 0.03 | 0.96 |
| Winter 01-03[a] | R&P8400N | AN400 NV | 41 | 0.53 | 0.94 | 0.98 |
| | | AN400 Total | 41 | 0.38 | 2.22 | 0.91 |
| Summer 01-03[b] | R&P8400N | AN400 NV | 41 | 0.41 | 0.57 | 0.19 |
| | | AN400 Total | 42 | 0.60 | 0.01 | 0.87 |
| 2001 | R&P8400N | AN100 | 50 | 0.50 | 0.95 | 0.97 |
| 2002 | R&P8400N | AN100 | 59 | 0.65 | 0.86 | 0.97 |
| 2003 | R&P8400N | AN100 | 54 | 0.44 | 1.50 | 0.84 |
| Winter 01-03 | R&P8400N | AN100 | 40 | 0.52 | 1.27 | 0.96 |
| Summer 01-03 | R&P8400N | AN100 | 43 | 0.09 | 0.90 | 0.03 |
| 2001-2004 | R&P8400N | R&P8400N | 1064 | 0.86 | -0.08 | 0.93 |
| 2001-2003 | AN400 | AN100 | 168 | 1.02 | 0.43 | 0.99 |
| ***Sulfate ($SO_4^=$)*** | | | | | | |
| 2002 | R&P8400S | AN400 | 53 | 0.98 | 0.09 | 0.74 |
| 2003 | R&P8400S | AN400 | 44 | 0.46 | 0.74 | 0.57 |
| Winter 02-03[c] | R&P8400S | AN400 | 23 | 0.63 | 0.82 | 0.77 |
| Summer 02-03[d] | R&P8400S | AN400 | 28 | 0.40 | 0.71 | 0.52 |
| 2002 | R&P8400S | AN100 | 53 | 1.03 | 0.18 | 0.77 |
| 2003 | R&P8400S | AN100 | 43 | 0.49 | 0.66 | 0.54 |
| Winter 02-03 | R&P8400S | AN100 | 22 | 0.86 | 0.48 | 0.87 |
| Summer 02-03 | R&P8400S | AN100 | 28 | 0.19 | 1.09 | 0.29 |
| 2001-2003 | AN400 | AN100 | 166 | 1.01 | 0.05 | 0.97 |

* NV = Non-Volatilized nitrate

*Total = Total particulate nitrate = sum of volatilzed and non-volatilized nitrate

[a] Winter 01-03: Dec 2000, Jan-Feb 2001, Dec 2001-Feb 2002, Dec 2002-Feb 2003, Dec 2003

[b] Summer 01-03: Jun-Aug 2001, Jun-Aug 2002, Jun-Aug 2003

[c] Winter 02-03: Feb 2002, Dec 2002-Feb 2003, Dec 2003

[d] Summer 02-03: Jun-Aug 2002, Jun-Aug 2003

### 3.5 Data Completeness

Table 3-13 through Table 3-16 summarize the data completeness for the various instruments at the Fresno Supersite. As seen, the average data recovery was typically greater than 75% for most instruments. While certain instruments had data recovery less than 75% for specific years, the average data recovery exceeds the goal of 75%, except for the R&P 5400 carbon analyzer. This was mostly attributed to instrument malfunction and downtime for maintenance and repair. The R&P 5400 carbon analyzer malfunctioned frequently and presented numerous maintenance issues compared to other continuous instruments. The experience at the Fresno Supersite suggests that the R&P 5400 carbon analyzer was unreliable. The integrated sampler measurements showed more than 90% recovery for all parameters. The meteorological measurements also exhibited more than 95% data recovery.

**Table 3-13. Data Completeness of Continuous Instruments**

| Instrument | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|
| **Light Scattering Instruments** | | | | |
| Dusttrak | 2000 | 25-Apr-00 | 31-Dec-00 | 55.3% |
| Dusttrak | 2001 | 01-Jan-01 | 31-Dec-01 | 86.5% |
| Dusttrak | 2002 | 01-Jan-02 | 31-Dec-02 | 88.6% |
| Dusttrak | 2003 | 01-Jan-03 | 24-Jun-03 | 99.7% |
| *Average* | | | | *82.5%* |
| GreenTek, 1-hr | 2000 | 25-Apr-00 | 31-Dec-00 | 98.5% |
| GreenTek, 1-hr | 2001 | 01-Jan-01 | 31-Aug-01 | 97.8% |
| *Average* | | | | *98.2%* |
| GreenTek. 5 min | 2001 | 15-Sep-01 | 31-Dec-01 | 65.2% |
| GreenTek. 5 min | 2002 | 01-Jan-02 | 31-Dec-02 | 93.9% |
| *Average* | | | | *79.6%* |
| NGN_2 | 2000 | 01-Feb-00 | 31-Dec-00 | 83.6% |
| NGN_2 | 2001 | 01-Jan-01 | 31-Dec-01 | 83.3% |
| NGN_2 | 2002 | 01-Jan-02 | 31-Dec-02 | 78.7% |
| NGN_2 | 2003 | 01-Jan-03 | 21-Dec-03 | 88.1% |
| *Average* | | | | *83.4%* |
| RAD25, 5 min | 2000 | 08-Sep-00 | 31-Dec-00 | 99.2% |
| RAD25, 5 min | 2001 | 01-Jan-01 | 31-Dec-01 | 92.4% |
| RAD25, 5 min | 2002 | 01-Jan-02 | 31-Dec-02 | 98.5% |
| RAD25, 5 min | 2003 | 01-Jan-03 | 05-Aug-03 | 97.5% |
| *Average* | | | | *96.9%* |
| RAD25, 1-min | 2003 | 05-Aug-03 | 31-Dec-03 | 97.9% |
| RAD25, 1-min | 2004 | 01-Jan-04 | 31-Dec-04 | 83.0% |
| *Average* | | | | *90.5%* |
| RAD, 5 min | 2000 | 21-Mar-00 | 31-Dec-00 | 94.7% |
| RAD, 5 min | 2001 | 01-Jan-01 | 31-Dec-01 | 97.3% |
| RAD, 5 min | 2002 | 01-Jan-02 | 31-Dec-02 | 99.3% |
| RAD, 5 min | 2003 | 01-Jan-03 | 05-Aug-03 | 97.0% |
| *Average* | | | | *97.1%* |
| RAD, 1-min | 2003 | 05-Aug-03 | 31-Dec-03 | 96.9% |
| RAD, 1-min | 2004 | 01-Jan-04 | 31-Dec-04 | 83.0% |
| *Average* | | | | *89.9%* |
| **Light Absorption Instruments** | | | | |
| AE-1 | 1999 | 17-Dec-99 | 31-Dec-99 | 73.8% |
| AE-1 | 2000 | 01-Jan-00 | 31-Dec-00 | 88.8% |
| AE-1 | 2001 | 01-Jan-01 | 31-Dec-01 | 68.8% |
| AE-1 | 2002 | 01-Jan-02 | 31-Dec-02 | 72.0% |
| *Average* | | | | *75.8%* |
| AE-2 | 2003 | 25-Feb-03 | 31-Dec-03 | 89.9% |
| AE-2 | 2004 | 01-Jan-04 | 31-Dec-04 | 85.8% |
| *Average* | | | | *87.8%* |
| AE-7 | 1999 | 12-May-99 | 31-Dec-99 | 88.8% |
| AE-7 | 2000 | 01-Jan-00 | 31-Dec-00 | 79.0% |
| AE-7 | 2001 | 01-Jan-01 | 31-Dec-01 | 92.7% |
| AE-7 | 2002 | 01-Jan-02 | 31-Dec-02 | 93.7% |
| AE-7 | 2003 | 01-Jan-03 | 31-Dec-03 | 93.5% |
| AE-7 | 2004 | 01-Jan-04 | 31-Dec-04 | 94.5% |
| *Average* | | | | *90.4%* |

**Table 3-13. Data Completeness of Continuous Instruments (Continued).**

| Instrument | | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| **PM10 Mass** | | | | | |
| BAM | | 1999 | 04-Dec-99 | 31-Dec-99 | 96.9% |
| BAM | | 2000 | 01-Jan-00 | 31-Dec-00 | 98.3% |
| BAM | | 2001 | 01-Jan-01 | 31-Dec-01 | 97.4% |
| BAM | | 2002 | 01-Jan-02 | 31-Dec-02 | 99.3% |
| BAM | | 2003 | 01-Jan-03 | 31-Dec-03 | 97.1% |
| | *Average* | | | | *97.8%* |
| TEOM | | 1999 | 10-Jul-99 | 31-Dec-99 | 93.0% |
| TEOM | | 2000 | 01-Jan-00 | 31-Dec-00 | 97.0% |
| TEOM | | 2001 | 01-Jan-01 | 31-Dec-01 | 58.4% |
| TEOM | | 2002 | 01-Jan-02 | 31-Dec-02 | 98.6% |
| TEOM | | 2003 | 01-Jan-03 | 31-Dec-03 | 99.9% |
| TEOM | | 2004 | 01-Jan-04 | 31-Dec-04 | 72.4% |
| | *Average* | | | | *86.5%* |
| **PM2.5 Mass** | | | | | |
| BAM | | 1999 | 16-Dec-99 | 31-Dec-99 | 91.7% |
| BAM | | 2000 | 01-Jan-00 | 31-Dec-00 | 96.2% |
| BAM | | 2001 | 01-Jan-01 | 31-Dec-01 | 91.4% |
| | *Average* | | | | *93.1%* |
| TEOM | | 1999 | 10-Jul-99 | 31-Dec-99 | 89.6% |
| TEOM | | 2000 | 01-Jan-00 | 31-Dec-00 | 98.6% |
| TEOM | | 2001 | 01-Jan-01 | 31-Dec-01 | 64.0% |
| TEOM | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| TEOM | | 2003 | 01-Jan-03 | 31-Dec-03 | 99.9% |
| TEOM | | 2004 | 01-Jan-04 | 31-Dec-04 | 99.6% |
| | *Average* | | | | *91.9%* |
| **Nitrate** | | | | | |
| R&P8400N - 1 | | 2000 | 12-Oct-00 | 31-Dec-00 | 78.8% |
| R&P8400N - 1 | | 2001 | 01-Jan-01 | 31-Dec-01 | 79.6% |
| R&P8400N - 1 | | 2002 | 01-Jan-02 | 31-Dec-02 | 96.9% |
| R&P8400N - 1 | | 2003 | 01-Jan-03 | 31-Dec-03 | 86.7% |
| R&P8400N - 1 | | 2004 | 01-Jan-04 | 31-Dec-04 | 98.3% |
| | *Average* | | | | *88.0%* |
| R&P8400N - 2 | | 2000 | 16-Aug-00 | 31-Dec-00 | 88.5% |
| R&P8400N - 2 | | 2001 | 01-Jan-01 | 31-Dec-01 | 97.8% |
| R&P8400N - 2 | | 2002 | 01-Jan-02 | 31-Dec-02 | 85.6% |
| R&P8400N - 2 | | 2003 | 01-Jan-03 | 31-Dec-03 | 53.0% |
| R&P8400N - 2 | | 2004 | 01-Jan-04 | 31-Dec-04 | 98.4% |
| | *Average* | | | | *84.7%* |
| **Sulfate** | | | | | |
| R&P8400S | | 2002 | 29-Jan-02 | 31-Dec-02 | 91.1% |
| R&P8400S | | 2003 | 01-Jan-03 | 31-Dec-03 | 77.0% |
| R&P8400S | | 2004 | 01-Jan-04 | 31-Dec-04 | 82.9% |
| | *Average* | | | | *83.7%* |

**Table 3-13. Data Completeness of Continuous Instruments (Continued).**

| Instrument | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|
| **Carbon** | | | | |
| RP5400 | 2000 | 13-Jan-00 | 31-Dec-00 | 48.6% |
| RP5400 | 2001 | 01-Jan-01 | 31-Dec-01 | 70.0% |
| RP5400 | 2002 | 01-Jan-02 | 31-Dec-02 | 68.7% |
| RP5400 | 2003 | 01-Jan-03 | 31-Dec-03 | 43.3% |
| RP5400 | 2004 | 01-Jan-04 | 31-Dec-04 | 48.4% |
| *Average* | | | | *55.8%* |
| Sunset | 2003 | 23-Jul-03 | 31-Dec-03 | 89.0% |
| Sunset | 2004 | 01-Jan-04 | 31-Dec-04 | 89.9% |
| *Average* | | | | *89%* |
| PAH | 1999 | 30-Sep-99 | 31-Dec-99 | 99.4% |
| PAH | 2000 | 01-Jan-00 | 31-Dec-00 | 98.9% |
| PAH | 2001 | 01-Jan-01 | 31-Dec-01 | 100.0% |
| PAH | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| PAH | 2003 | 01-Jan-03 | 31-Dec-03 | 97.8% |
| PAH | 2004 | 01-Jan-04 | 31-Dec-04 | 91.0% |
| *Average* | | | | *97.8%* |
| **Particle Counters** | | | | |
| Lasair | 2000 | 06-Jan-00 | 31-Dec-00 | 92.4% |
| Lasair | 2001 | 01-Jan-01 | 31-Dec-01 | 89.0% |
| Lasair | 2002 | 01-Jan-02 | 31-Dec-02 | 94.1% |
| Lasair | 2003 | 01-Jan-03 | 31-Dec-03 | 98.0% |
| Lasair | 2004 | 01-Jan-04 | 31-Dec-04 | 99.2% |
| *Average* | | | | *94.5%* |
| Climet | 2000 | 06-Jan-00 | 31-Dec-00 | 97.8% |
| Climet | 2001 | 01-Jan-01 | 31-Dec-01 | 84.9% |
| Climet | 2002 | 01-Jan-02 | 31-Dec-02 | 89.3% |
| Climet | 2003 | 01-Jan-03 | 31-Dec-03 | 92.7% |
| Climet | 2004 | 01-Jan-04 | 31-Dec-04 | 98.1% |
| *Average* | | | | *92.6%* |
| SMPS_LONG | 2000 | 17-Mar-00 | 31-Dec-00 | 98.0% |
| SMPS_LONG | 2001 | 01-Jan-01 | 31-Dec-01 | 89.7% |
| SMPS_LONG | 2002 | 01-Jan-02 | 31-Dec-02 | 95.9% |
| SMPS_LONG | 2003 | 01-Jan-03 | 31-Dec-03 | 95.2% |
| SMPS_LONG | 2004 | 01-Jan-04 | 31-Dec-04 | 76.0% |
| *Average* | | | | *90.9%* |
| SMPS_Nano | 2002 | 25-Aug-02 | 31-Dec-02 | 99.3% |
| SMPS_Nano | 2003 | 01-Jan-03 | 31-Dec-03 | 60.4% |
| SMPS_Nano | 2004 | 01-Jan-04 | 31-Dec-04 | 87.7% |
| *Average* | | | | *82.4%* |
| **NO and NOy Measurements** | | | | |
| TEI 42C | 2000 | 13-Jan-00 | 31-Dec-00 | 86.7% |
| TEI 42C | 2001 | 01-Jan-01 | 31-Dec-01 | 89.3% |
| *Average* | | | | *88.0%* |

Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements.

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Mass | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Mass | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Mass | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Mass | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Mass | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Mass | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Mass | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Mass | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Mass | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Mass | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Chloride ($Cl^-$) | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Chloride ($Cl^-$) | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Chloride ($Cl^-$) | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Chloride ($Cl^-$) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Chloride ($Cl^-$) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | Chloride ($Cl^-$) | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Chloride ($Cl^-$) | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | Chloride ($Cl^-$) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Chloride ($Cl^-$) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Chloride ($Cl^-$) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |
| AN400 | Denuded $Cl^-$ | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded $Cl^-$ | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN100 | Non-Volatilized Nitrate ($NO_3^-$) | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Non-Volatilized Nitrate ($NO_3^-$) | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Non-Volatilized Nitrate ($NO_3^-$) | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Non-Volatilized Nitrate ($NO_3^-$) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Non-Volatilized Nitrate ($NO_3^-$) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | Non-Volatilized Nitrate ($NO_3^-$) | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Non-Volatilized Nitrate ($NO_3^-$) | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | Non-Volatilized Nitrate ($NO_3^-$) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Non-Volatilized Nitrate ($NO_3^-$) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Non-Volatilized Nitrate ($NO_3^-$) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |
| SFS | Volatilized Nitrate ($NO_3^-$) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Volatilized Nitrate ($NO_3^-$) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Volatilized Nitrate ($NO_3^-$) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |
| AN400 | Denuded $NO_3^-$ | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded $NO_3^-$ | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | Denuded Volatilized $NO_3^-$ | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded Volatilized $NO_3^-$ | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |

Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued).

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Sulfate ($SO_4^=$) | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Sulfate ($SO_4^=$) | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Sulfate ($SO_4^=$) | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Sulfate ($SO_4^=$) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Sulfate ($SO_4^=$) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | Sulfate ($SO_4^=$) | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Sulfate ($SO_4^=$) | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | Sulfate ($SO_4^=$) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Sulfate ($SO_4^=$) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Sulfate ($SO_4^=$) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |
| AN400 | Denuded $SO_4^=$ | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded $SO_4^=$ | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN100 | Ammonium ($NH_4^+$) | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Ammonium ($NH_4^+$) | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Ammonium ($NH_4^+$) | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Ammonium ($NH_4^+$) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Ammonium ($NH_4^+$) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | Ammonium ($NH_4^+$) | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Ammonium ($NH_4^+$) | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | Ammonium ($NH_4^+$) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Ammonium ($NH_4^+$) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Ammonium ($NH_4^+$) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |
| AN400 | Denuded $NH_4^+$ | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded $NH_4^+$ | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN100 | Soluble Potassium ($K^+$) | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Soluble Potassium ($K^+$) | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Soluble Potassium ($K^+$) | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Soluble Potassium ($K^+$) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Soluble Potassium ($K^+$) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | Soluble Potassium ($K^+$) | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Soluble Potassium ($K^+$) | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | Soluble Potassium ($K^+$) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Soluble Potassium ($K^+$) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Soluble Potassium ($K^+$) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |

Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued).

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Soluble Sodium ($Na^+$) | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Soluble Sodium ($Na^+$) | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Soluble Sodium ($Na^+$) | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Soluble Sodium ($Na^+$) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Soluble Sodium ($Na^+$) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | Soluble Sodium ($Na^+$) | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Soluble Sodium ($Na^+$) | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | Soluble Sodium ($Na^+$) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Soluble Sodium ($Na^+$) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Soluble Sodium ($Na^+$) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |
| AN100 | Sodium (Na) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Sodium (Na) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Sodium (Na) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Sodium (Na) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Sodium (Na) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Sodium (Na) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Sodium (Na) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Sodium (Na) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Sodium (Na) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Sodium (Na) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Magnesium (Mg) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Magnesium (Mg) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Magnesium (Mg) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Magnesium (Mg) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Magnesium (Mg) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Magnesium (Mg) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Magnesium (Mg) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Magnesium (Mg) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Magnesium (Mg) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Magnesium (Mg) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Aluminum (Al) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Aluminum (Al) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Aluminum (Al) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Aluminum (Al) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Aluminum (Al) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Aluminum (Al) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Aluminum (Al) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Aluminum (Al) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Aluminum (Al) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Aluminum (Al) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |

**Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued)**

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Silicon (Si) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Silicon (Si) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Silicon (Si) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Silicon (Si) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Silicon (Si) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Silicon (Si) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Silicon (Si) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Silicon (Si) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Silicon (Si) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Silicon (Si) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Phosphorous (P) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Phosphorous (P) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Phosphorous (P) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Phosphorous (P) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Phosphorous (P) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Phosphorous (P) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Phosphorous (P) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Phosphorous (P) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Phosphorous (P) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Phosphorous (P) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Sulfur (S) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Sulfur (S) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Sulfur (S) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Sulfur (S) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Sulfur (S) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Sulfur (S) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Sulfur (S) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Sulfur (S) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Sulfur (S) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Sulfur (S) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Chlorine (Cl) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Chlorine (Cl) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Chlorine (Cl) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Chlorine (Cl) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Chlorine (Cl) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Chlorine (Cl) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Chlorine (Cl) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Chlorine (Cl) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Chlorine (Cl) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Chlorine (Cl) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |

**Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements.(Continued).**

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Potassium (K) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Potassium (K) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Potassium (K) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Potassium (K) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Potassium (K) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Potassium (K) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Potassium (K) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Potassium (K) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Potassium (K) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Potassium (K) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Calcium (Ca) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Calcium (Ca) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Calcium (Ca) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Calcium (Ca) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Calcium (Ca) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Calcium (Ca) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Calcium (Ca) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Calcium (Ca) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Calcium (Ca) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Calcium (Ca) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Titanium (Ti) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Titanium (Ti) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Titanium (Ti) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Titanium (Ti) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Titanium (Ti) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Titanium (Ti) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Titanium (Ti) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Titanium (Ti) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Titanium (Ti) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Titanium (Ti) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Vanadium (V) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Vanadium (V) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Vanadium (V) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Vanadium (V) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Vanadium (V) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Vanadium (V) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Vanadium (V) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Vanadium (V) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Vanadium (V) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Vanadium (V) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |

Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements.(Continued).

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Chromium (Cr) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Chromium (Cr) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Chromium (Cr) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Chromium (Cr) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Chromium (Cr) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Chromium (Cr) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Chromium (Cr) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Chromium (Cr) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Chromium (Cr) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Chromium (Cr) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Manganese (Mn) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Manganese (Mn) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Manganese (Mn) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Manganese (Mn) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Manganese (Mn) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Manganese (Mn) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Manganese (Mn) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Manganese (Mn) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Manganese (Mn) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Manganese (Mn) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Iron (Fe) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Iron (Fe) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Iron (Fe) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Iron (Fe) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Iron (Fe) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Iron (Fe) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Iron (Fe) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Iron (Fe) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Iron (Fe) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Iron (Fe) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Cobalt (Co) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Cobalt (Co) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Cobalt (Co) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Cobalt (Co) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Cobalt (Co) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Cobalt (Co) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Cobalt (Co) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Cobalt (Co) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Cobalt (Co) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Cobalt (Co) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |

**Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued)**

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Nickel (Ni) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Nickel (Ni) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Nickel (Ni) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Nickel (Ni) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Nickel (Ni) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Nickel (Ni) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Nickel (Ni) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Nickel (Ni) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Nickel (Ni) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Nickel (Ni) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Copper (Cu) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Copper (Cu) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Copper (Cu) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Copper (Cu) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Copper (Cu) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Copper (Cu) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Copper (Cu) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Copper (Cu) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Copper (Cu) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Copper (Cu) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Zinc (Zn) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Zinc (Zn) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Zinc (Zn) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Zinc (Zn) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Zinc (Zn) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Zinc (Zn) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Zinc (Zn) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Zinc (Zn) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Zinc (Zn) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Zinc (Zn) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Gallium (Ga) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Gallium (Ga) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Gallium (Ga) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Gallium (Ga) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Gallium (Ga) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Gallium (Ga) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Gallium (Ga) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Gallium (Ga) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Gallium (Ga) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Gallium (Ga) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |

Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued)

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Arsenic (As) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Arsenic (As) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Arsenic (As) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Arsenic (As) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Arsenic (As) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Arsenic (As) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Arsenic (As) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Arsenic (As) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Arsenic (As) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Arsenic (As) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Selenium (Se) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Selenium (Se) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Selenium (Se) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Selenium (Se) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Selenium (Se) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Selenium (Se) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Selenium (Se) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Selenium (Se) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Selenium (Se) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Selenium (Se) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Bromine (Br) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Bromine (Br) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Bromine (Br) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Bromine (Br) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Bromine (Br) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Bromine (Br) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Bromine (Br) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Bromine (Br) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Bromine (Br) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Bromine (Br) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Rubidium (Rb) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Rubidium (Rb) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Rubidium (Rb) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Rubidium (Rb) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Rubidium (Rb) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Rubidium (Rb) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Rubidium (Rb) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Rubidium (Rb) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Rubidium (Rb) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Rubidium (Rb) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |

Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued).

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Strontium (Sr) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Strontium (Sr) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Strontium (Sr) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Strontium (Sr) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Strontium (Sr) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Strontium (Sr) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Strontium (Sr) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Strontium (Sr) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Strontium (Sr) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Strontium (Sr) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Yttrium (Y) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Yttrium (Y) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Yttrium (Y) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Yttrium (Y) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Yttrium (Y) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Yttrium (Y) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Yttrium (Y) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Yttrium (Y) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Yttrium (Y) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Yttrium (Y) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Zirconium (Zr) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Zirconium (Zr) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Zirconium (Zr) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Zirconium (Zr) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Zirconium (Zr) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Zirconium (Zr) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Zirconium (Zr) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Zirconium (Zr) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Zirconium (Zr) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Zirconium (Zr) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Molybdenum (Mo) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Molybdenum (Mo) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Molybdenum (Mo) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Molybdenum (Mo) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Molybdenum (Mo) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Molybdenum (Mo) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Molybdenum (Mo) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Molybdenum (Mo) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Molybdenum (Mo) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Molybdenum (Mo) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |

**Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued)**

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Palladium (Pd) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Palladium (Pd) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Palladium (Pd) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Palladium (Pd) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Palladium (Pd) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Palladium (Pd) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Palladium (Pd) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Palladium (Pd) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Palladium (Pd) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Palladium (Pd) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Silver (Ag) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Silver (Ag) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Silver (Ag) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Silver (Ag) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Silver (Ag) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Silver (Ag) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Silver (Ag) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Silver (Ag) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Silver (Ag) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Silver (Ag) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Cadmium (Cd) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Cadmium (Cd) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Cadmium (Cd) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Cadmium (Cd) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Cadmium (Cd) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Cadmium (Cd) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Cadmium (Cd) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Cadmium (Cd) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Cadmium (Cd) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Cadmium (Cd) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Indium (In) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Indium (In) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Indium (In) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Indium (In) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Indium (In) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Indium (In) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Indium (In) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Indium (In) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Indium (In) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Indium (In) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |

**Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued).**

| Instrument | Parameter | | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|---|
| AN100 | Tin (Sn) | | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Tin (Sn) | | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Tin (Sn) | | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Tin (Sn) | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Tin (Sn) | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *97.4%* |
| AN400 | Tin (Sn) | | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Tin (Sn) | | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | | *Average* | | | | *90.8%* |
| SFS | Tin (Sn) | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Tin (Sn) | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Tin (Sn) | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.9%* |
| AN100 | Antimony (Sb) | | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Antimony (Sb) | | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Antimony (Sb) | | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Antimony (Sb) | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Antimony (Sb) | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *97.4%* |
| AN400 | Antimony (Sb) | | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Antimony (Sb) | | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | | *Average* | | | | *90.8%* |
| SFS | Antimony (Sb) | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Antimony (Sb) | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Antimony (Sb) | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.9%* |
| AN100 | Barium (Ba) | | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Barium (Ba) | | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Barium (Ba) | | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Barium (Ba) | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Barium (Ba) | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *97.4%* |
| AN400 | Barium (Ba) | | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Barium (Ba) | | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | | *Average* | | | | *90.8%* |
| SFS | Barium (Ba) | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Barium (Ba) | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Barium (Ba) | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.9%* |
| AN100 | Lanthanum (La) | | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Lanthanum (La) | | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Lanthanum (La) | | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Lanthanum (La) | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Lanthanum (La) | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *97.4%* |
| AN400 | Lanthanum (La) | | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Lanthanum (La) | | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | | *Average* | | | | *90.8%* |
| SFS | Lanthanum (La) | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Lanthanum (La) | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Lanthanum (La) | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.9%* |

**Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued)**

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Gold (Au) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Gold (Au) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Gold (Au) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Gold (Au) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Gold (Au) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Gold (Au) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Gold (Au) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Gold (Au) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Gold (Au) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Gold (Au) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Mercury (Hg) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Mercury (Hg) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Mercury (Hg) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Mercury (Hg) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Mercury (Hg) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Mercury (Hg) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Mercury (Hg) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Mercury (Hg) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Mercury (Hg) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Mercury (Hg) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Thallium (Tl) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Thallium (Tl) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Thallium (Tl) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Thallium (Tl) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Thallium (Tl) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Thallium (Tl) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Thallium (Tl) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Thallium (Tl) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Thallium (Tl) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Thallium (Tl) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN100 | Lead (Pb) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Lead (Pb) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Lead (Pb) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Lead (Pb) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Lead (Pb) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Lead (Pb) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Lead (Pb) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Lead (Pb) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Lead (Pb) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Lead (Pb) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |

**Table 3-14. Data Completeness of Integrated Samplers: Mass, Ions, Metals and Elements. (Continued)**

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN100 | Uranium (U) | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | Uranium (U) | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | Uranium (U) | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | Uranium (U) | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Uranium (U) | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | Uranium (U) | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | Uranium (U) | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| SFS | Uranium (U) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Uranium (U) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Uranium (U) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| SFS | Ammonia ($NH_3$) | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Ammonia ($NH_3$) | 2000 | 01-Jan-00 | 14-Dec-00 | 96.8% |
| SFS | Ammonia ($NH_3$) | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.9%* |
| AN400 | Denuded Ammonia ($NH_3^+$) | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded Ammonia ($NH_3^+$) | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN100 | $b_{abs}$ | 1999 | 05-Jul-99 | 31-Dec-99 | 96.7% |
| AN100 | $b_{abs}$ | 2000 | 01-Jan-00 | 31-Dec-00 | 95.1% |
| AN100 | $b_{abs}$ | 2001 | 01-Jan-01 | 31-Dec-01 | 95.1% |
| AN100 | $b_{abs}$ | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | $b_{abs}$ | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *97.4%* |
| AN400 | $b_{abs}$ | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | $b_{abs}$ | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |

**Table 3-15. Data Completeness of Integrated Samplers: Carbon**

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN400 | QBT OC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT OC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT OC2 | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT OC2 | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT OC3 | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT OC3 | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT OC4 | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT OC4 | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT Pyrolized Organics | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT Pyrolized Organics | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT Organic Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT Organic Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT EC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT EC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT EC2 | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT EC2 | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT EC3 | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT EC3 | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT Elemental Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT Elemental Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN400 | QBT Total Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 90.0% |
| AN400 | QBT Total Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 91.5% |
| | *Average* | | | | *90.8%* |
| AN100 | OC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | OC1 | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | OC1 | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | OC1 | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | OC1 | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | OC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | OC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | OC1 | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | OC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | OC1 | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |

Table 3-15. Data Completeness of Integrated Samplers: Carbon (Continued)

| Instrument | Parameter | | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|---|
| AN100 | OC2 | | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | OC2 | | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | OC2 | | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | OC2 | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | OC2 | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *96.4%* |
| AN400 | OC2 | | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | OC2 | | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | | *Average* | | | | *97.5%* |
| SFS | OC2 | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | OC2 | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | OC2 | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.7%* |
| AN100 | OC3 | | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | OC3 | | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | OC3 | | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | OC3 | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | OC3 | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *96.4%* |
| AN400 | OC3 | | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | OC3 | | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | | *Average* | | | | *97.5%* |
| SFS | OC3 | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | OC3 | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | OC3 | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.7%* |
| AN100 | OC4 | | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | OC4 | | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | OC4 | | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | OC4 | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | OC4 | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *96.4%* |
| AN400 | OC4 | | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | OC4 | | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | | *Average* | | | | *97.5%* |
| SFS | OC4 | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | OC4 | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | OC4 | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.7%* |
| AN100 | Pyrolized Organics | | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Pyrolized Organics | | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Pyrolized Organics | | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Pyrolized Organics | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Pyrolized Organics | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *96.4%* |
| AN400 | Pyrolized Organics | | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Pyrolized Organics | | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | | *Average* | | | | *97.5%* |

Table 3-15. Data Completeness of Integrated Samplers: Carbon (Continued)

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| SFS | Pyrolized Organics | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Pyrolized Organics | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Pyrolized Organics | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |
| AN100 | Organic Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Organic Carbon | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Organic Carbon | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Organic Carbon | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Organic Carbon | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | Organic Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Organic Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | Organic Carbon | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Organic Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Organic Carbon | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |
| AN100 | EC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | EC1 | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | EC1 | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | EC1 | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | EC1 | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | EC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | EC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | EC1 | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | EC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | EC1 | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |
| AN100 | EC2 | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | EC2 | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | EC2 | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | EC2 | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | EC2 | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | *Average* | | | | *96.4%* |
| AN400 | EC2 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | EC2 | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| SFS | EC2 | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | EC2 | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | EC2 | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | *Average* | | | | *97.7%* |

Table 3-15. Data Completeness of Integrated Samplers: Carbon (Continued)

| Instrument | Parameter | | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|---|
| AN100 | EC3 | | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | EC3 | | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | EC3 | | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | EC3 | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | EC3 | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *96.4%* |
| AN400 | EC3 | | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | EC3 | | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | | *Average* | | | | *97.5%* |
| SFS | EC3 | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | EC3 | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | EC3 | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.7%* |
| AN100 | Elemental Carbon | | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Elemental Carbon | | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Elemental Carbon | | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Elemental Carbon | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Elemental Carbon | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *96.4%* |
| AN400 | Elemental Carbon | | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Elemental Carbon | | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | | *Average* | | | | *97.5%* |
| SFS | Elemental Carbon | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Elemental Carbon | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Elemental Carbon | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.7%* |
| AN100 | Total Carbon | | 1999 | 05-Jul-99 | 31-Dec-99 | 93.3% |
| AN100 | Total Carbon | | 2000 | 01-Jan-00 | 31-Dec-00 | 91.8% |
| AN100 | Total Carbon | | 2001 | 01-Jan-01 | 31-Dec-01 | 96.7% |
| AN100 | Total Carbon | | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| AN100 | Total Carbon | | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| | | *Average* | | | | *96.4%* |
| AN400 | Total Carbon | | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Total Carbon | | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | | *Average* | | | | *97.5%* |
| SFS | Total Carbon | | 1999 | 01-Dec-99 | 31-Dec-99 | 96.8% |
| SFS | Total Carbon | | 2000 | 01-Jan-00 | 14-Dec-00 | 96.3% |
| SFS | Total Carbon | | 2001 | 18-Jan-01 | 30-Jan-01 | 100.0% |
| | | *Average* | | | | *97.7%* |
| AN400 | QBQ OC1 | | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ OC1 | | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | | *Average* | | | | *97.5%* |
| AN400 | QBQ OC2 | | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ OC2 | | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | | *Average* | | | | *97.5%* |

**Table 3-15. Data Completeness of Integrated Samplers: Carbon (Continued)**

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN400 | QBQ OC3 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ OC3 | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | QBQ OC4 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ OC4 | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | QBQ Pyrolized Organics | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ Pyrolized Organics | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | QBQ Organic Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ Organic Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | QBQ EC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ EC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | QBQ EC2 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ EC2 | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | QBQ EC3 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ EC3 | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | QBQ Elemental Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ Elemental Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | QBQ Total Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | QBQ Total Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 94.9% |
| | *Average* | | | | *97.5%* |
| AN400 | Denuded OC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded OC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded OC2 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded OC2 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded OC3 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded OC3 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded OC4 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded OC4 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded Pyrolized Organics | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded Pyrolized Organics | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded Organic Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded Organic Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded EC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded EC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |

Table 3-15. Data Completeness of Integrated Samplers: Carbon (Continued)

| Instrument | Parameter | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|---|
| AN400 | Denuded EC2 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded EC2 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded EC3 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded EC3 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded Elemental Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded Elemental Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded Total Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded Total Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ OC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ OC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ OC2 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ OC2 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ OC3 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ OC3 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ OC4 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ OC4 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ Pyrolized Organics | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ Pyrolized Organics | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ Organic Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ Organic Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ EC1 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ EC1 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ EC2 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ EC2 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ EC3 | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ EC3 | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ Elemental Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ Elemental Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |
| AN400 | Denuded QBQ Total Carbon | 1999 | 05-Jul-99 | 31-Dec-99 | 100.0% |
| AN400 | Denuded QBQ Total Carbon | 2000 | 01-Jan-00 | 14-Dec-00 | 93.2% |
| | *Average* | | | | *96.6%* |

**Table 3-16. Data Completeness of Meteorological Measurements**

| Instrument | Year | Start Date | End Date | % Recovery |
|---|---|---|---|---|
| **Meteorological Measurements** | | | | |
| Met One 060A-2 Ambient Temperature | 1999 | 10-Jul-99 | 31-Dec-99 | 97.6% |
| Met One 060A-2 Ambient Temperature | 2000 | 01-Jan-00 | 31-Dec-00 | 99.5% |
| Met One 060A-2 Ambient Temperature | 2001 | 01-Jan-01 | 31-Dec-01 | 98.2% |
| Met One 060A-2 Ambient Temperature | 2002 | 01-Jan-02 | 31-Dec-02 | 99.8% |
| Met One 060A-2 Ambient Temperature | 2003 | 01-Jan-03 | 31-Dec-03 | 99.1% |
| Met One 060A-2 Ambient Temperature | 2004 | 01-Jan-04 | 31-Dec-04 | 99.9% |
| *Average* | | | | *99.0%* |
| Met One 083V Relative Humidity | 1999 | 10-Jul-99 | 31-Dec-99 | 99.7% |
| Met One 083V Relative Humidity | 2000 | 01-Jan-00 | 31-Dec-00 | 99.6% |
| Met One 083V Relative Humidity | 2001 | 01-Jan-01 | 31-Dec-01 | 100.0% |
| Met One 083V Relative Humidity | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| Met One 083V Relative Humidity | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| Met One 083V Relative Humidity | 2004 | 01-Jan-04 | 31-Dec-04 | 100.0% |
| *Average* | | | | *99.9%* |
| Met One 010-SC Wind Speed | 1999 | 10-Jul-99 | 31-Dec-99 | 99.7% |
| Met One 010-SC Wind Speed | 2000 | 01-Jan-00 | 31-Dec-00 | 99.5% |
| Met One 010-SC Wind Speed | 2001 | 01-Jan-01 | 31-Dec-01 | 100.0% |
| Met One 010-SC Wind Speed | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| Met One 010-SC Wind Speed | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| Met One 010-SC Wind Speed | 2004 | 01-Jan-04 | 31-Dec-04 | 100.0% |
| *Average* | | | | *99.9%* |
| Met One 025-5C Wind Direction | 1999 | 10-Jul-99 | 31-Dec-99 | 99.5% |
| Met One 025-5C Wind Direction | 2000 | 01-Jan-00 | 31-Dec-00 | 99.6% |
| Met One 025-5C Wind Direction | 2001 | 01-Jan-01 | 31-Dec-01 | 100.0% |
| Met One 025-5C Wind Direction | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| Met One 025-5C Wind Direction | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| Met One 025-5C Wind Direction | 2004 | 01-Jan-04 | 31-Dec-04 | 100.0% |
| *Average* | | | | *99.8%* |
| Met One 090D Barometric Pressure | 2000 | 24-May-00 | 31-Dec-00 | 100.0% |
| Met One 090D Barometric Pressure | 2001 | 01-Jan-01 | 31-Dec-01 | 100.0% |
| Met One 090D Barometric Pressure | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| Met One 090D Barometric Pressure | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| Met One 090D Barometric Pressure | 2004 | 01-Jan-04 | 31-Dec-04 | 100.0% |
| *Average* | | | | *100.0%* |
| LI-COR LI-200SA Solar Radiation | 1999 | 30-Sep-99 | 31-Dec-99 | 99.3% |
| LI-COR LI-200SA Solar Radiation | 2000 | 01-Jan-00 | 31-Dec-00 | 99.6% |
| LI-COR LI-200SA Solar Radiation | 2001 | 01-Jan-01 | 31-Dec-01 | 100.0% |
| LI-COR LI-200SA Solar Radiation | 2002 | 01-Jan-02 | 31-Dec-02 | 100.0% |
| LI-COR LI-200SA Solar Radiation | 2003 | 01-Jan-03 | 31-Dec-03 | 100.0% |
| LI-COR LI-200SA Solar Radiation | 2004 | 01-Jan-04 | 31-Dec-04 | 99.2% |
| *Average* | | | | *99.7%* |

# 4 CONCLUSIONS

The intention of the U.S. Environmental Protection Agency's Supersite Program was to operate research-grade air monitoring stations to improve understanding of measurement technologies, source contributions and control strategies, and effects of suspended particles on health. This report summarized the quality assurance activities carried out for the Fresno Supersite project and their findings. It also supplements the Fresno Supersite Final Report (Watson et al., 2005a). Pursuant to the laboratory systems audit, the Standard Operating Procedures are now reviewed continually and updated as, and when, necessary. An inter-laboratory comparison showed good analytical agreement between the DRI and EPA analyses. DRI laboratory performance met or exceeded the compliance standards, and no deficiencies were found. The field audits showed the flow accuracy to be within the respective instrument objective stated in the QAPP, except for the GreenTek photometer. Various articles have been published on the inter-comparability of the samplers, suggesting in general that, except for the TEOM, the mass measurements were highly correlated. The R&P 5400 continuous carbon analyzer was neither comparable to, nor predictable of, the integrated filter carbon measurements. The R&P 8400N continuous nitrate monitor, while being well-correlated with filter measurements, was consistently low biased. On average, all the continuous and integrated samplers showed data recoveries greater than 75%, except for the R&P 5400 carbon analyzer. The experience at the Fresno Supersite indicated that the R&P 5400 carbon analyzer was unreliable. All the meteorological measurements had data recoveries greater than 75%.

# 5 REFERENCES

Bevington, P.R. (1969). *Data Reduction and Error Analysis for the Physical Sciences*. McGraw Hill, New York, NY.

California Air Resources Board (2003). Aethalometer intercomparison field study. Prepared by California Air Resources Board, Sacramento, CA.

Chow, J.C.; Watson, J.G.; Chen, L.W.A.; Paredes-Miranda, G.; Chang, M.C.; Trimble, D.; Fung, K.K.; Zhang, J.; and Yu, J.Z. (2005a). Refining temperature measures in thermal/optical carbon analysis. *Atmos. Chem. Physics Discussion*, **5**:4477-4505.

Chow, J.C.; Watson, J.G.; Chen, L.-W.A.; Arnott, W.P.; Moosmüller, H.; and Fung, K.K. (2004). Equivalence of elemental carbon by Thermal/Optical Reflectance and Transmittance with different temperature protocols. *Environ. Sci. Technol.*, **38**(16):4414-4422.

Chow, J.C.; Watson, J.G.; Chen, L.-W.A.; Chang, M.C.; and Paredes-Miranda, G. (2005). Comparison of the DRI/OGC and Model 2001 Thermal/Optical carbon analyzers. Prepared for IMPROVE Steering Committee, Fort Collins, CO, by Desert Research Institute, Reno, NV.

Chow, J.C.; Watson, J.G.; Lowenthal, D.H.; Chen, L.W.A.; Tropp, R.J.; Park, K.; and Magliano, K. (2005b). PM2.5 and PM10 mass measurements in California's San Joaquin Valley. *Aerosol Sci. Technol.*, submitted.

Chow, J.C.; Watson, J.G.; Lowenthal, D.H.; Chen, L.-W.A.; and Magliano, K. (2005c). Particulate carbon measurements in California's San Joaquin Valley. *Chemosphere*, in press.

Chow, J.C.; Watson, J.G.; Park, K.; Lowenthal, D.H.; Chen, L.W.A.; Robinson, N.F.; and Magliano, K. (2005d). Comparison of particle light scattering and PM2.5 mass in central California. *J. Environ. Toxicol.*, submitted.

Chu, S.H.; Paisie, J.W.; and Jang, B.W.L. (2004). PM data analysis - a comparison of two urban areas: Fresno and Atlanta. *Atmos. Environ.*, **38**(20):3155-3164. ISI:000221838500005.

Engelbrecht, J.P. (2002). Laboratory Measurement Systems Audit - California Regional $PM_{10}/PM_{2.5}$ Air Quality Study. Prepared by Desert Research Institute, Reno, NV.

Evans, G.F.; Highsmith, R.V.; Sheldon, L.S.; Suggs, J.C.; Williams, R.W.; Zweidinger, R.B.; Creason, J.P.; Walsh, D.; Rodes, C.E.; and Lawless, P.A. (2000). The 1999 Fresno Particulate Matter Exposure Studies: Comparison of community, outdoor, and residential PM mass measurements. *JAWMA*, **50**(11):1887-1896.

Gemmill, D. (2002a). Quality Assurance Audit Report - Fresno Supersite. Prepared by University of California, College of Engineering–Center for Environmental Research and Technology, Riverside, CA.

Gemmill, D.B. (2002b). Draft Quality Assurance Audit Report - Fresno Supersite. Prepared by University of California, College of Engineering–Center for Environmental Research and Technology, Riverside, CA.

Held, T.; Ying, Q.; Kaduwela, A.; and Kleeman, M. (2004). Modeling particulate matter in the San Joaquin Valley with a source-oriented externally mixed three-dimensional photochemical grid model. *Atmos. Environ.*, **38**(22):3689-3711. ISI:000222214900013.

Howard-Reed, C.; Rea, A.W.; Zufall, M.J.; Burke, J.M.; Williams, R.W.; Suggs, J.C.; Sheldon, L.S.; Walsh, D.; and Kwok, R. (2000). Use of a continuous nephelometer to measure personal exposure to particles during the U.S. Environmental Protection Agency Baltimore and Fresno panel studies. *JAWMA*, **50**(7):1125-1132.

Lawless, P.A.; Rodes, C.E.; Evans, G.; Sheldon, L.; and Creason, J. (2001). Aerosol concentrations during the 1999 Fresno Exposure Studies as functions of size, season, and meteorology. *Aerosol Sci. Technol.*, **34**(1):66-74.

Park, K.; Chow, J.C.; Watson, J.G.; Arnott, W.P.; Trimble, D.; Bowers, K.; Bode, R.; Petzold, A.; and Hansen, A.D.A. (2005). Comparison of continuous and filter-based carbon measurements at the Fresno Supersite. *JAWMA*, accepted.

Park, K. et al. (2005a). Semi-continuous and filter-based measurements of nitrate and sulfate at the Fresno Supersite . *JAWMA*, In Preparation.

Poore, M.W. (2000). Oxalic acid in $PM_{2.5}$ in California. *JAWMA*, **50**(11):1874-1875.

Poore, M.W. (2002). Levoglucosan in $PM_{2.5}$ at the Fresno supersite. *JAWMA*, **52**(1):3-4.

Schauer, J.J.; and Cass, G.R. (2000). Source apportionment of wintertime gas-phase and particle-phase air pollutants using organic compounds as tracers. *Environ. Sci. Technol.*, **34**(9):1821-1832.

Taylor, S.; and Boswell, E. (2005). Performance Evaluation of DRI Laboratory- Technical Memorandum. Prepared by the U.S. Environmental Protection Agency. http://www.epa.gov/ttn/amtic/files/ambient/pm25/spec/driaudit.pdf.

Watson, J.G.; and Chow, J.C. (2002a). A wintertime $PM_{2.5}$ episode at the Fresno, CA, supersite. *Atmos. Environ.*, **36**(3):465-475.

Watson, J.G.; and Chow, J.C. (2002b). Comparison and evaluation of in-situ and filter carbon measurements at the Fresno Supersite. *J. Geophys. Res.*, **107**(D21):ICC 3-1-ICC 3-15. doi: 10.1029/2001JD000573.

Watson, J.G.; Chow, J.C.; Bowen, J.L.; Lowenthal, D.H.; Hering, S.; Ouchida, P.; and Oslund, W. (2000). Air quality measurements from the Fresno Supersite. *JAWMA*, **50**(8):1321-1334. ISI:000089085700005.

Watson, J.G.; Chow, J.C.; Chen, L.W.A.; Lowenthal, D.H.; Trimble, D.L.; and Park, K. (2005a). Fresno supersite final report. Prepared for US Environmental Protection Agency OAQPS, by Desert Research Institute, Reno, NV.

Watson, J.G.; Chow, J.C.; DuBois, D.W.; Green, M.C.; Frank, N.H.; and Pitchford, M.L. (1997). Guidance for network design and optimal site exposure for $PM_{2.5}$ and $PM_{10}$. Report No. EPA-454/R-99-022. Prepared by U.S. Environmental Protection Agency, Research Triangle Park, NC. http://www.epa.gov/ttn/amtic/pmstg.html.

Watson, J.G.; Chow, J.C.; Fitz, D.; and Ouchida, P. (2001a). Quality Assurance Project Plan, Fresno Supersite - Phase II (Revision 1). Prepared for the U.S. Environmental Protection Agency by Desert Research Institute, Reno, NV.

Watson, J.G.; Chow, J.C.; Hering, S.V.; and Fitz, D.R. (2002). Final report for Phase I of Fresno supersite measurements. Prepared for Cooperative Institute for Atmospheric Sciences and Terrestrial Applications, Las Vegas, NV, by Desert Research Institute, Reno, NV.

Watson, J.G.; Chow, J.C.; Lowenthal, D.H.; Kreisberg, N.; Hering, S.V.; and Stolzenburg, M.R. (2005b). Variations of nanoparticle concentrations at the Fresno supersite. *Sci. Total Environ.*, in press.

Watson, J.G.; Chow, J.C.; Lowenthal, D.H.; Stolzenburg, M.R.; Kreisberg, N.M.; and Hering, S.V. (2002). Particle size relationships at the Fresno supersite. *JAWMA*, **52**(7):822-827.

Watson, J.G.; Chow, J.C.; Park, K.; and Lowenthal, D.H. (2005c). Nanoparticle and ultrafine particle events at the Fresno Supersite. *JAWMA*, **55**:submitted.

Watson, J.G.; Lioy, P.J.; and Mueller, P.K. (1995). The measurement process: Precision, accuracy, and validity. In *Air Sampling Instruments for Evaluation of Atmospheric Contaminants,* 8th ed., B.S. Cohen and S.V. Hering, Eds. American Conference of Governmental Industrial Hygienists, Cincinnati, OH, pp. 187-194.

Watson, J.G.; Turpin, B.J.; and Chow, J.C. (2001b). The measurement process: Precision, accuracy, and validity. In *Air Sampling Instruments for Evaluation of Atmospheric Contaminants, Ninth Edition,* 9th ed., B.S. Cohen and C.S.J. McCammon, Eds. American Conference of Governmental Industrial Hygienists, Cincinnati, OH, pp. 201-216.

# APPENDICES

**DRAFT**

# QUALITY ASSURANCE AUDIT REPORT

## FRESNO SUPERSITE

**OPERATED BY:**

**California Air Resources Board**
**Monitoring and Laboratory Division, Air Quality Surveillance Branch**
**1927 13th Street**
**Sacramento, CA 95812**

**Desert Research Institute**
**2215 Raggio Parkway**
**Reno, NV 89512**

**Audit Date: March 6-7, 2002**

**Prepared by:**

**David Gemmill**
**Quality Assurance Officer**
**College of Engineering**
**Center for Environmental Research and Technology**
**University of California at Riverside**
**Riverside, CA 92507**

August 28, 2002

## SUMMARY OF AUDIT RESULTS

1. **Continuous Analyzers:** The audit results were satisfactory, with the exception of the UCR $NO_2$ analyzer. The slope value for this instrument was outside the ±20% objective, and its correlation coefficient was 0.987, indicating poor linearity. The appropriate troubleshooting of this analyzer should be initiated. It should also be noted that a study is being performed that compares the data from this analyzer to the data from the TEI analyzer. The results of this study will be issued in a separate report.

2. **Particulate Samplers:** All audit results were satisfactory with the exception of the GT 640A. The operator reported that the flow control system for this sampler does not work as well as it does for the other samplers. All samplers were in good condition and operating properly.

3. **System Evaluation:** The general system condition, operations, and maintenance were evaluated. No significant unsatisfactory audit results were encountered. The procedures followed in the execution of this project were consistent with those described in the QAPP. Overall, the monitoring equipment was in satisfactory operational condition. All instrument calibrations were done in a proper manner and all documentation was complete, concise, and up to date.

## CONTENTS



## TABLES

# 1.0 INTRODUCTION

This report contains the results of a quality assurance audit of selected components of the Fresno Supersite, an ambient air monitoring station operated jointly by the Desert Research Institute (DRI) and the California Air Resources Board (ARB). The station is operated per the *Quality Assurance Project Plan for the Fresno Supersite – Phase II*, Revision 1, dated April 2001 (QAPP). The main purpose of this Supersite is to operate research-grade air monitoring equipment to improve understanding of measurement technologies, source contributions and control strategies, with a special emphasis on the effects of suspended particulates on health. Detailed goals and objectives of the Supersite are presented in the QAPP. The Fresno Supersite is one of seven such facilities within the continental United States, all funded by the U.S. Environmental Protection Agency (EPA). The Supersite research instruments are installed at the same monitoring location as the equipment for a compliance monitoring station operated by the ARB.

Mr. David Gemmill of the University of California at Riverside College of Engineering Center for Environmental Research and Technology (CE-CERT) performed the audit during the period of March 6-7, 2002. Performance audits were conducted in the following areas:

1. Continuous analyzers for monitoring oxides of nitrogen ($NO_x$), nitric oxide (NO), nitric acid ($HNO_3$), total reactive nitrogen compounds ($NO_y$), and nitrogen dioxide ($NO_2$).

2. Flow rates of filter-based and continuous particulate and light scattering samplers for the monitoring of $PM_{2.5}$ (mass and chemical species), $PM_{10}$, particle counts (within specific aerodynamic size ranges), elemental carbon and organic carbon.

3. General system evaluation.

It should be noted that ARB QA personnel perform routine performance audits of this station's meteorological instruments and criteria pollutant measurements. Therefore, these measurements were not covered within this audit.

Present for the audit was Mr. Scott Scheller of ARB, principal operator of the Fresno Supersite, and Mr. Matt Gonzi, principal field representative of DRI. Their cooperation and assistance are gratefully acknowledged.

# 2.0 DESCRIPTION OF MONITORING EQUIPMENT

## 2.1 Continuous Analyzers

The Supersite contains the continuous analyzers listed in Table 1-1 of the QAPP. The continuous analyzers audited are those listed in Table 1. The TEI 42C NO/$NO_x$ analyzer is an EPA reference method for the monitoring of $NO_2$, according to the criteria specified in *40CFR53*.

The UCR $NO_2$/PAN GC is a research instrument that operates as follows: The analyzer draws ambient air through a sample loop. Once per cycle (one minute cycle time) a valve switches and the sample is pushed into a capillary column using air carrier gas. $NO_2$ and PAN are separated from each other in this column. The separated constituents elute from the column onto a fabric wick wetted with Luminol solution. $NO_2$ and PAN react with Luminol, emitting photons of light proportional to their concentration. The central portion of the wick is viewed by a photomultiplier, the signal of which is proportional to the mixing ratio of $NO_2$ in the air. A particular objective of this audit was to evaluate the performance of this analyzer with respect to the TEI analyzer.

**Table 1 Continuous Analyzers Audited**

| Pollutants | Analyzer Make and Model | Range, ppm |
|---|---|---|
| NO, $NO_x$, $NO_2$ | TEI 42C | 0-0.500 |
| $NO_y$, $HNO_3$ | TEI 42C | 0-0.500 |
| $NO_2$, PAN | UCR $NO_2$/PAN GC | 0-0.500 |

## 2.2 Sampling Technique

Ambient air is drawn into a borosilicate glass sample manifold by means of a blower, located downstream of the manifold. Excess manifold flow is vented through an exit in the bottom of the shelter. The inlet of this manifold is approximately 15 meters above ground level, and one meter above the shelter roof, which satisfies all appropriate EPA probe siting criteria described in *40CFR58, Appendix E*. Each analyzer draws its own sample from the manifold through its own Teflon sample line and pump. Each sample line contains a particulate filter in order to keep the internal analyzer pneumatics clean.

## 2.3 Calibration Equipment for Continuous Analyzers

The calibration system for the analyzers audited consists of an Environics 9100 calibrator (dilutor), which is used to perform zero, span, and multipoint calibrations of the continuous analyzers. The calibrator is equipped with mass flow controllers and an ozone generator. Appropriate span concentrations for calibrations are generated by using the calibrator to dilute a multiblend standard gas cylinder. The cylinder certifications were performed by the supplier in accordance with the procedures in the *EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (September 1997)*. The calibrations of the $O_3$ analyzer are performed using a certified ozone transfer standard.

## 2.4 Data Acquisition Systems

The analyzers under audit are interfaced to a computer configured with LabView® data acquisition software, which updates the signal from each device at the preset averaging periods listed in Table 1-1 of the QAPP. The averaging period for most continuous analyzers is five minutes. The data are telemetered at least daily to the DRI data processing center in Reno.

### 2.5 Particulate and Light Scattering Samplers

The Supersite contains the samplers listed in Table 1-1 of the QAPP. Nearly all of these samplers received audits of their indicated flow rates and integrity checks.

## 3.0 CALIBRATION PROCEDURES

The calibration procedures for the Fresno Supersite instrumentation are generally described in Section 2.7 and Table 2-6 of the QAPP. Detailed calibration procedures are described in the Standard Operating Procedures (SOPs) for each individual instrument.

The calibration gases for the analyzers audited are generated by dilution of standard gas cylinders using the Environics 9100 calibrator. The dilution air and span gas mass flow controllers in the system's calibrator are periodically calibrated using an authoritative flow rate reference device.

Span concentrations for the UCR $NO_2$ analyzer are generated using the calibration system to perform gas phase titration of NO with $O_3$ while the TEI 42C concurrently samples the same test atmosphere. This procedure consists of first performing a multipoint calibration of the TEI NO and $NO_x$ channels using NO only. The calibrator is then set to generate an NO concentration of about 80% of full scale to the TEI 42C analyzer, and the ozone generator is turned on to convert a portion of the NO to $NO_2$. The resulting drop in the NO channel is corrected to true NO concentration and (according to the GPT method) is equal to the input $NO_2$ concentration. Several different ozone lamp settings are used to achieve the desired $NO_2$ concentrations.

During all calibrations the calibrator flow rate and ozone lamp settings are recorded, along with the resulting analyzer responses.

## 4.0 AUDIT PROCEDURES, EQUIPMENT AND STANDARDS

### 4.1 Continuous Analyzers

The procedures used for the NO/$NO_x$, $NO_2$, $NO_y$ and $HNO_3$ analyzer audits met or exceeded the guidelines and requirements in the *Quality Assurance Handbook for Air Pollution Measurement Systems (EPA-600-R-94/038b), Section 2.0.12; and 40CFR58, Appendix A.* The audit consists of delivering to each analyzer five different concentrations of pollutant, including zero ppm, using a portable audit calibration system. The audit system consists of a standard cylinder, a zero air cylinder, and a calibrator (diluter).

The NO audit concentrations are generated by dilution of a standard cylinder using the audit calibrator, and the $NO_2$ concentrations are generated using the gas phase titration procedure. The audit gas concentrations enter each analyzer through the same sample line and in-line particulate filters normally encountered by ambient air. After the analyzer response has equilibrated, the analyzer output is read from the data logger and, if necessary, is corrected to reported concentrations. The audit is thus a multipoint comparison between the audit concentrations and the corresponding corrected system analyzer responses. The audit concentrations are generated within the ranges required in the references cited above, with special emphasis on expected ambient concentrations.

### 4.1.1 Evaluation of Audit Results

The percent difference at each concentration is calculated using the following equation:

$$\%Dif. = [(C_2 - C_1)/C_1] \text{ H } 100$$

In this equation and the equation to follow, $C_1$ is the audit concentration and $C_2$ is the corresponding reported (corrected) analyzer concentration. The multipoint comparison data for each channel audited is used to generate a linear regression equation in the following form:

$$C_2 = \text{Slope}\ (C_1) + \text{Intercept}$$

The slope, intercept, and correlation coefficient (r) are used to evaluate the audit results. The following evaluation guidelines are from the *Quality Assurance Handbook for Air Pollution Measurement Systems (EPA-600-R-94/038b), Section 2.0.12*: The audit results are satisfactory if the slope is within a 0.850 to 1.150 range, the intercept is within ±3% of the analyzer range, and the correlation coefficient is ∃ 0.9950. The criterion specified in Table 2-6 the QAPP is ±10% for the measurements made with the TEI 42C analyzers, and ±20% for the measurements performed with the UCR $NO_2$/PAN GC.

### 4.1.2 Audit Equipment for Continuous Analyzers

The calibrator used for the audit is a CSI Model 1700. The calibrator contains two mass flow controllers, which provide known flow rates of dilution air from a zero air cylinder and span gas from a standard gas cylinder. Therefore the calibrator is capable of delivering the desired gas concentrations by adjusting each mass flow controller to provide previously determined flow rates. The span gas flow controller has a nominal range of 10-100 standard cubic centimeters per minute (sccm), and the dilution air flow controller has a nominal range of 1000-10,000 sccm. Repeated checks of these mass flow controllers have shown that the calibrations are usually accurate to within ∀1%, and nearly always accurate to within ∀2%. These mass flow controllers were calibrated using a Bios meter on 03/3/02.

The calibrator contains an ozone generator, which is used to conduct $O_3$ and $NO_2$ audits. The ozone stream can be directed into the dilution air stream, enabling an $O_3$ audit. The ozone stream may also be directed into a NO span gas stream, enabling $NO_2$ audits by means of the gas phase titration (GPT) procedure. The calibrator has a reaction chamber and a mixing chamber of appropriate dimensions, which when taken together with the flow rates used, comply with the EPA requirements for the dynamic reaction parameter specifications for $NO_2$ generation by means of the gas phase titration procedure, as described in the *EPA Technical Assistance Document for the Chemiluminescence Measurement of $NO_2$ (EPA-600/4-75-003)*, December 1975.

As required by EPA, high concentration span gases come in contact with only stainless steel, Teflon, and glass. Diluted gases come in contact with only glass or Teflon, and are sampled from the calibrator at ambient pressure.

**4.1.3 Audit NO Standard**

A NIST-traceable gas cylinder containing a nominal concentration 50 ppm NO was used to audit the TEI 42C and UCR Luminol analyzers. Analysis of this cylinder was performed in accordance with the procedures in the *EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (Revised September 1997)*. Documentation of NIST traceability of the standard used for this audit is presented in Table 3 of this report.

**4.1.4 Audit $NO_2$ Standard and $NO_2$ Converter Efficiency**

The audit $NO_2$ concentrations are generated using the gas phase titration (GPT) procedure, which consists of adding $O_3$ to excess NO. Each $NO_2$ concentration is determined using the calibrated NO channel to measure the decrease in the NO concentration after $O_3$ is added to the known NO concentration. All $NO_2$ concentrations are generated in such a way that the remaining NO concentration is within the required 0.080 to 0.120 ppm range. This procedure is described in detail in the *Quality Assurance Handbook for Air Pollution Measurement Systems, (EPA-600-R-94/038b), Sections 2.3.2, and Section 2.0.12.*

The audit of the TEI 42C NO/$NO_x$ analyzer calibrated each audit calibrator span gas flow rate and ozone lamp setting with respect to a known $NO_2$ concentration. These same calibrator settings were then used to perform the audit of the $NO_2$ component of the UCR $NO_2$/PAN GC.

The $NO_2$ converter efficiency of the TEI 42C NO/$NO_x$ analyzer was tested during the gas phase titration procedure. The converter efficiency (CE) is calculated by the equation below:

$$CE = 100 \times [1 - (\Delta NO_x / \Delta NO)]$$

In this equation $\Delta NO_x$ and $\Delta NO$ are the decreases in the $NO_x$ and NO concentrations as indicated by the respective analyzer channels when changing from the NO-only test atmosphere to those containing NO and $NO_2$. The CE values for each upscale $NO_2$ concentration are averaged, and the resulting value must be 96% or higher for the converter to pass the test.

## 4.2 Particulate and Light Scattering Samplers

The samplers are audited using the procedures described in the *Quality Assurance Handbook for Air Pollution Measurement Systems (EPA-600-R-94/038b),* Sections 2.10.7, and 2.12.10.2. Generally, the audit consists of a test of the accuracy of the sampler's indicated flow rate and a comparison of the sampler's measured flow rates to its design flow rate. In addition, the sampler is inspected for proper operation, leaks, cleanliness, and structural integrity. All gaskets and fittings are inspected, and the sample filter holders are inspected for integrity.

The standard used to provide the audit flow rates is a Model HC-1 HC Bios Meter, S/N H810. The Bios Meter is an authoritative volume standard which meets all applicable NIST specifications.

The sampler is turned on and allowed to warm up for at least five minutes. Next, the sampler's inlet head is removed, and an adaptor is attached to the downtube to which the audit flow rate measurement standard is connected. The following are then recorded:

1. Ambient temperature in EK, and barometric pressure in mm Hg.

2. The flow rates as read by the sampler’s measurement/recording system.

3. The flow rate as read by the audit standard in actual liters per minute (ALM).

If the sampler flow rates differ significantly from the target set points, all audit data are recorded without adjustments being made to the sampler flow rates. At that time, with the permission of the operator, the sampler flow rate is adjusted to the correct set point, and the audit is then repeated. If this adjustment to the sampler flow rate is necessary, both sets of audit results (before and after adjustment) are presented in the audit report.

If necessary, the indicated sampler flow rates are corrected to ALM, using the latest calibration equations and the ambient temperature and pressure. These corrections to the sampler flow rates are done in the same manner as a routine sample. The corrected sampler flow rate is compared to the corresponding audit flow rate in percent difference, using the following equation:

$$\%\text{Dif.} = [(S-A)/A] \times 100$$

In this equation, S is the indicated sampler flow rate in actual ALM, and A is the measured audit flow rate in ALM. The ranges for satisfactory results for this test depend on the device under audit, and are presented in Table 2-6 of the QAPP. Generally, however the satisfactory criterion is ±5%.

## 4.3 System Evaluation

The system evaluation consists of an inspection and evaluation of critical on-site air monitoring equipment components. This includes a review of the fabrication, assembly and operation of the test systems in their operational mode. The major items reviewed are general system condition, documentation and operations, and the sample intake systems. During this evaluation the auditor looked for anything that could have an adverse effect on the air monitoring system's ability to produce accurate, precise, and reliable data.

## 5.0 AUDIT RESULTS

### 5.1 Continuous Analyzers

The continuous analyzer audit results presented in Table 2 contain the following information:

1. Each audit concentration ($C_1$) and its resulting reported analyzer concentration ($C_2$) as read by the data logger for each channel audited. Also shown is the percent difference between each audit and analyzer concentration, which is calculated using the following equation:

$$\%Dif. = [(C_2-C_1)/C_1] \text{ H } 100$$

2. Slope, intercept, and correlation coefficient, r, based on a linear regression between $C_1$ and $C_2$ for each channel audited. These constants are calculated by comparing the audit concentrations ($C_1$) to the corresponding analyzer concentrations ($C_2$) according to the following equation:

$$C_2 = \text{slope } (C_1) + \text{intercept}$$

$C_2$ is the concentration as would be routinely reported as valid data.

It should be noted that the audit standards for all three analyzers were NO or $NO_2$ only. The audit results indicate that with regard to slope, the results for both TEI 42C analyzers are well within the ±10% objective.

The 0.747 slope value for the UCR $NO_2$ analyzer is outside the ±20% objective. In addition, the correlation coefficient was 0.987, indicating poor linearity. A comparison of the $NO_2$ data from this analyzer versus the data from the chemiluminescence analyzer is being performed, and will be issued in a separate report.

Table 3 presents documentation of the audit NO standard.

### 5.2 Particulate and Light Scattering Samplers

The results of the audits of the particulate samplers are presented in Table 4. All audit results were in the satisfactory ±5% range with the exception of the GT 640A. The operator indicated that the flow rate regulation system on this sampler is relatively unreliable with respect to the other devices. The reported flow rate for this device is based on the results of the monthly flow rate check, and is not based on the indicated flow rate. All samplers were in good condition and were operating properly.

### 5.3 System Evaluation

A cursory evaluation of the operation indicated that no significant unsatisfactory audit results were encountered. The following summarizes the results of this evaluation.

- All samplers and sample intake systems are properly sited.
- All monitoring equipment was in satisfactory operational condition and was properly operated.
- The time synchronization for all the various systems agreed to within ±2 minutes.
- The sample custody documentation for the integrated samples was complete, concise, and thorough.
- All continuous analyzer calibrations are performed in a proper manner and are well documented.
- A calibration of the particle sizing instruments using PSL beads in five different sizes was observed. The calibration methodology was sound and its documentation was complete.

**Table 2 Continuous Analyzer Audit Results**

STATION: Fresno Supersite | ANALYZER: TEI 42C | DATE: 03/07/02
CHANNEL: **$NO_x$** | RANGE: 0-0.500 ppm | BEGIN: 0811
S/N: 42CY-64629-345 | END: 1148

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.001 | --- | Slope: | 1.038 |
| 0.050 | 0.052 | 4.0 | Inter.: | 0.001 |
| 0.172 | 0.179 | 4.1 | r: | 0.999995 |
| 0.297 | 0.308 | 3.7 | | |
| 0.398 | 0.414 | 4.0 | | |

STATION: Fresno Supersite | ANALYZER: TEI 42C | DATE: 03/07/02
CHANNEL: **NO** | RANGE: 0-0.500 ppm | BEGIN: 0811
S/N: 42CY-64629-345 | END: 1148

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.002 | --- | Slope: | 1.006 |
| 0.050 | 0.049 | -2.0 | Inter.: | 0.000 |
| 0.172 | 0.173 | 0.6 | r: | 0.99997 |
| 0.297 | 0.299 | 0.7 | | |
| 0.398 | 0.401 | 0.8 | | |

STATION: Fresno Supersite | ANALYZER: TEI 42C | DATE: 03/07/02
CHANNEL: **$NO_2$** | RANGE: 0-0.500 ppm | BEGIN: 0811
S/N: 42CY-64629-345 | END: 1148

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.002 | --- | Slope: | 1.030 |
| 0.015 | 0.019 | 4.4 | Inter: | 0.005 |
| 0.080 | 0.093 | 5.1 | r: | 0.9995 |
| 0.176 | 0.185 | 16.9 | | |
| 0.288 | 0.301 | 27.4 | $NO_2$ Converter Efficiency = 99.4% | |

**Table 2 Continuous Analyzer Audit Results**

STATION: Fresno Supersite | ANALYZER: UCR PAN/$NO_2$ GC | DATE: 03/07/02
CHANNEL: **$NO_2$** | RANGE: 0-0.500 ppm | BEGIN: 1352
S/N: Unknown | END: 1600

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.000 | --- | Slope: | 0.747 |
| 0.015 | 0.021 | 38.4 | Inter: | 0.011 |
| 0.080 | 0.094 | 17.7 | r: | 0.987 |
| 0.176 | 0.130 | -25.9 | | |
| 0.288 | 0.227 | -21.2 | | |

STATION: Fresno Supersite | ANALYZER: TEI 42C | DATE: 03/07/02
CHANNEL: **$NO_y$** | RANGE: 0-0.500 ppm | BEGIN: 0811
S/N: 42CY-66906-354 | END: 1148

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.000 | --- | Slope: | 1.008 |
| 0.050 | 0.049 | -2.0 | Inter.: | -0.001 |
| 0.172 | 0.172 | 0.0 | r: | 0.99998 |
| 0.297 | 0.300 | 1.0 | | |
| 0.398 | 0.400 | 0.5 | | |

STATION: Fresno Supersite | ANALYZER: TEI 42 | DATE: 03/07/02
CHANNEL: **$HNO_3$** | RANGE: 0-0.500 ppm | BEGIN: 0811
S/N: 42CY-66906-354 | END: 1148

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.002 | --- | Slope: | 1.009 |
| 0.050 | 0.050 | 0.0 | Inter.: | 0.000 |
| 0.172 | 0.172 | 0.0 | r: | 0.99996 |
| 0.297 | 0.300 | 1.0 | | |
| 0.398 | 0.403 | 1.3 | | |

**Table 3 Audit Gas Standard**

| Cylinder S/N | Certified Concentration | Certification Date |
|---|---|---|
| CC 40132 | 49.3 ppm NO | 02/15/01 |

**Table 4 Particulate Sampler Audit Results**

| Sampler | Channel | Indicated, ALM | Audit, ALM | Δ% |
|---|---|---|---|---|
| Andersen RAAS 100 $PM_{2.5}$; S/N: 79 | | 16.64 | 16.58 | 0.4 |
| Andersen RAAS 100 $PM_{2.5}$; S/N: 83 | | 16.75 | 16.83 | -0.5 |
| Andersen 400 $PM_{2.5}$ Speciation Sampler | 1 | 15.41 | 15.96 | -3.4 |
| | 2 | 6.98 | 6.92 | 0.9 |
| | 4 | 7.34 | 7.29 | 0.7 |
| | 5 | 8.07 | 8.17 | -1.2 |
| | 6 | 7.88 | 7.68 | 2.6 |
| Green Tech GT 640A | | 5.2 | 4.7 | 10.6 |
| Aethelometer - $PM_{2.5}$ | Single-wavelength | 7.0 | 6.77 | 3.4 |
| Aethelometer - $PM_{2.5}$ | 7-wavelength | 7.0 | 7.13 | -1.8 |
| R&P Carbon 5400 | | 16.00 | 15.45 | 3.6 |
| OPC System | | 15.81 | 15.61 | 1.3 |
| TEOM $PM_{2.5}$ | | 16.64 | 16.96 | -1.9 |
| TEOM $PM_{10}$ | | 16.65 | 16.26 | 2.4 |
| BAMS $PM_{10}$ | | 17.3 | 16.49 | 4.9 |
| BAMS $PM_{2.5}$ | | 16.6 | 15.9 | 4.4 |

# QUALITY ASSURANCE AUDIT REPORT

# FRESNO SUPERSITE

**OPERATED BY:**

**California Air Resources Board**
**Monitoring and Laboratory Division, Air Quality Surveillance Branch**
**1927 13th Street**
**Sacramento, CA 95812**

**Desert Research Institute**
**2215 Raggio Parkway**
**Reno, NV 89512**

**Audit Dates: September 17-19, 2002**

**Prepared by:**

**David Gemmill**
**Quality Assurance Officer**
**College of Engineering**
**Center for Environmental Research and Technology**
**University of California at Riverside**
**Riverside, CA 92507**

November 7, 2002

## SUMMARY OF AUDIT RESULTS

1. **Continuous Analyzers:** All audit results were satisfactory. However, the UCR $NO_2$ analyzer indicated a slope of 0.642, but the analyzer response data were taken directly from the data logger and no calibration correction was applied. It should also be noted that this analyzer was repaired the day before the audit. In addition, a study is being performed that compares the data from this analyzer to the data from the TEI 42 analyzer. The results of this study will be issued in a separate report.

2. **Particle Count Devices:** The Supersite particle counting devices were collocated with a UCR SEMS. The SEMS provides particle counts within numerous bins within the 0.03 to 0.73 micron range in 75-second increments. The collocation included ambient sampling and a calibration of both systems at zero and 0.27 microns using PSL beads. The results of this collocation will be presented in a separate report.

3. **Particulate Samplers:** All audit results were satisfactory with the exceptions of the Green Tech 640A and the new $PM_{2.5}$ High-Volume sampler. The operator reported that the flow control system for the Green Tech sampler does not work as well as it does for the other samplers. Re-calibration of the hi-vol is recommended, since the ±7% limit was exceeded. However, it is recognized that the experimental errors inherent in this vintage of technology will make it difficult to maintain the flow rates within this range. All samplers were in good condition and were operating properly.

4. **System Evaluation:** The general system condition, operations, maintenance, and documentation were evaluated. No significant unsatisfactory audit results were encountered. The procedures followed in the execution of this project are consistent with those described in the QAPP. Overall, the monitoring equipment was in satisfactory operational condition. All instrument calibrations are performed in a proper manner and all documentation is complete, concise, and up to date.

## CONTENTS



## TABLES

# 1.0 INTRODUCTION

This report contains the results of a quality assurance audit of selected components of the Fresno Supersite, a research ambient air monitoring station operated jointly by the Desert Research Institute (DRI) and the California Air Resources Board (ARB). The station is operated per the *Quality Assurance Project Plan for the Fresno Supersite – Phase II*, Revision 1, dated April 2001 (QAPP). The main purpose of the Supersite is to operate research-grade air monitoring instruments to improve understanding of measurement technologies, source contributions and control strategies, with a special emphasis on the effects of suspended particulates on health. Detailed goals and objectives of the Supersite are presented in the QAPP. The Fresno Supersite is one of seven such facilities within the continental United States, all funded by the U.S. Environmental Protection Agency (EPA). The Supersite research instruments are installed at the same monitoring location as the equipment for a compliance monitoring station operated by the ARB.

Mr. David Gemmill of the University of California at Riverside College of Engineering Center for Environmental Research and Technology (CE-CERT) performed the audit during the period of September 17-19, 2002. Performance audits were conducted in the following areas:

1. Continuous analyzers for monitoring oxides of nitrogen ($NO_x$), nitric oxide (NO), nitric acid ($HNO_3$), total reactive nitrogen compounds ($NO_y$), and nitrogen dioxide ($NO_2$).

2. The fine particle count system was audited by collocation with a UCR SEMS. The results of this collocation will be presented in a separate report.

3. Flow rates of filter-based and continuous particulate and light scattering samplers for the monitoring of $PM_{2.5}$ (mass and chemical species), $PM_{10}$, particle counts (within specific aerodynamic size ranges), elemental carbon and organic carbon.

4. General system evaluation.

ARB QA personnel conduct routine performance audits of the station's meteorological instruments and criteria pollutant measurements. The latest such audit was performed on July 15 and 17, 2002. The results from this audit were all satisfactory and are summarized in this report.

Present for the audit was Mr. Scott Scheller of ARB, principal operator of the Fresno Supersite, and Mr. Pat Seames, principal operator of the Fresno SLAMS site. Their cooperation and assistance are gratefully acknowledged.

# 2.0 DESCRIPTION OF MONITORING EQUIPMENT

## 2.1 Continuous Analyzers

At the time of the audit the Supersite contained the continuous analyzers listed in Table 1 below. Where applicable, the analyzers are reference or equivalent methods for the monitoring of their respective pollutants according to the criteria specified in *40CFR53*.

**Table 1. Supersite Continuous Analyzers**

| Make and Model | Serial Number | Pollutant(s) |
|---|---|---|
| TEI 42 | | $NO$-$NO_2$-$NO_x$ |
| TEI 42C | 42CY 64629-345 | $NO$-$NO_z$-$NO_y$ |
| TEI 42C | 42CY 66906-354 | $NO$-$HNO_3$ |
| TEI 55C | | $CH_4$-NMHC |
| API 400 | 180 | $O_3$ |
| API 100A | 461 | $SO_2$ |
| UC Riverside GC | | $NO_2$/PAN |
| Xontec 910A | | NMOC |
| Xontec 925 | | Carbonyl |
| Dasibi 3008 | | CO |

## 2.2 Sampling Technique

Ambient air is drawn by means of a separate sample line for each analyzer. The inlet of each sample line is set up to preclude rain from entering the sampling system. Each inlet is approximately 11 meters above ground level, and one meter above the shelter roof, which satisfies the appropriate EPA probe siting criteria described in *40CFR58, Appendix E*. Each analyzer draws its own sample through its own Teflon sample line and pump. Each sample line contains a particulate filter in order to keep the internal analyzer pneumatics clean.

## 2.3 Calibration Equipment for Continuous Analyzers

The calibration system consists of an Environics 9100 calibrator (dilutor), a zero air generation system, standard gas cylinders, and a certified ozone transfer standard. The calibrator is equipped with mass flow controllers and an ozone generator, and is configured with the zero air system and cylinders in order to perform zero, span, and multipoint calibrations of the continuous analyzers. Where applicable, the cylinder certifications are performed by the supplier in accordance with the procedures in the *EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (September 1997).* The calibrations of the $O_3$ analyzer are performed using the certified ozone transfer standard, which is maintained according to EPA's Technical Assistance Documents: *Transfer Standards for the Calibration of Air Monitoring Analyzers for Ozone (EPA-600/4-79-056), September 1979, and Technical Assistance Document for the Calibration of Ambient Ozone Monitors (EPA-600/4-79-057), September 1979.*

## 2.4 Data Acquisition Systems

 

The analyzers are interfaced to a computer configured with LabView® data acquisition software, which updates the signal from each device at the preset averaging periods listed in Table 1-1 of the QAPP. The averaging period for most continuous gas analyzers and particulate samplers is five minutes. The data are telemetered at least daily to the DRI data processing center in Reno.

### 2.5 Particulate and Light Scattering Samplers

The Supersite contains the samplers listed in Table 1-1 of the QAPP. Nearly all of these samplers received audits of their indicated flow rates and integrity checks.

## 3.0 CALIBRATION PROCEDURES

The calibration procedures for the Fresno Supersite instrumentation are generally described in Section 2.7 and Table 2-6 of the QAPP. Detailed calibration procedures are described in the Standard Operating Procedures (SOPs) for each individual instrument.

The calibration gases for the continuous gas analyzers are generated by dilution of standard gas cylinders using the Environics 9100 calibrator. The dilution air and span gas mass flow controllers in the system's calibrator are periodically calibrated using an authoritative flow rate reference device.

Span concentrations for the UCR $NO_2$ analyzer are generated using the calibration system to perform gas phase titration of NO with $O_3$ while the TEI 42C concurrently samples the same test atmosphere. This procedure consists of first performing a multipoint calibration of the TEI NO and $NO_x$ channels using NO only. The calibrator is then set to generate an NO concentration of about 80% of full scale to the TEI 42C analyzer, and the ozone generator is turned on to convert a portion of the NO to $NO_2$. The resulting drop in the NO channel is corrected to true NO concentration and (according to the GPT method) is equal to the input $NO_2$ concentration. Several different ozone lamp settings are used to achieve the desired $NO_2$ concentrations.

During all calibrations the calibrator flow rate and ozone lamp settings are recorded, along with the resulting analyzer responses.

Converter efficiency checks of the $NO_y$ analyzer are performed daily using an n-propyl nitrate (NPN) cylinder.

## 4.0 AUDIT PROCEDURES, EQUIPMENT AND STANDARDS

### 4.1 Continuous Analyzers

The procedures used for the NO/$NO_x$, $NO_2$, $NO_y$, $HNO_3$, and $O_3$ analyzer audits met or exceeded the guidelines and requirements in the *Quality Assurance Handbook for Air Pollution Measurement Systems (EPA-600-R-94/038b), Section 2.0.12; and 40CFR58, Appendix A.* The audit consists of delivering to each analyzer at least five different concentrations of pollutant, including zero ppm, using a portable audit calibration system. The audit system consists of a standard NO cylinder, a zero air cylinder, a calibrator (diluter), and a certified ozone transfer standard.

The NO audit concentrations are generated by dilution of a standard cylinder using the audit calibrator, and the $NO_2$ concentrations are generated using the gas phase titration procedure. The audit gas concentrations enter each analyzer through the same sample line and in-line particulate filters normally encountered by ambient air. After the analyzer response has equilibrated, the analyzer output is read from the data logger and, if necessary, is corrected to reported concentrations. The audit is thus a multipoint comparison between the audit concentrations and the corresponding corrected system analyzer responses. The audit concentrations are generated within the ranges required in the references cited above, with special emphasis on expected ambient concentrations.

### 4.1.1 Evaluation of Audit Results

The percent difference at each concentration is calculated using the following equation:

$$\%Dif. = [(C_2 - C_1)/C_1] \text{ H } 100$$

In this equation and the equation to follow, $C_1$ is the audit concentration and $C_2$ is the corresponding reported (corrected) analyzer concentration. The multipoint comparison data for each channel audited is used to generate a linear regression equation in the following form:

$$C_2 = \text{Slope } (C_1) + \text{Intercept}$$

The slope, intercept, and correlation coefficient (r) are used to evaluate the audit results. The following evaluation guidelines are from the *Quality Assurance Handbook for Air Pollution Measurement Systems (EPA-600-R-94/038b), Section 2.0.12*: The audit results are satisfactory if the slope is within a 0.850 to 1.150 range, the intercept is within ±3% of the analyzer range, and the correlation coefficient is ∃ 0.9950. The criterion specified in Table 2-6 the QAPP is ±10% for the measurements made with the oxides of nitrogen and ozone analyzers, and ±20% for the measurements performed with the UCR $NO_2$/PAN GC.

### 4.1.2 Audit Equipment for Continuous Analyzers

The calibrator used for the audit is a CSI Model 1700. The calibrator contains two mass flow controllers, which provide known flow rates of dilution air from a zero air cylinder and span gas from a standard gas cylinder. Therefore the calibrator is capable of delivering the desired gas concentrations by adjusting each mass flow controller to provide previously determined flow rates. The span gas flow controller has a nominal range of 10-100 standard cubic centimeters per minute (sccm), and the dilution air flow controller has a nominal range of 1000-10,000 sccm. Repeated checks of these mass flow controllers have shown that the calibrations are usually accurate to within ∀1%, and nearly always accurate to within ∀2%. These mass flow controllers were calibrated using a Bios meter on 09/15/02.

The calibrator contains an ozone generator, which is used to conduct $O_3$ and $NO_2$ audits. The ozone stream can be directed into the dilution air stream, enabling an $O_3$ audit. The ozone stream may also be directed into a NO span gas stream, enabling $NO_2$ audits by means of the gas phase titration (GPT) procedure. The calibrator has a reaction chamber and a mixing chamber of appropriate dimensions, which when taken together with the flow rates used, comply with the EPA requirements for the dynamic reaction parameter specifications for $NO_2$ generation by means of the gas phase titration procedure, as described in the *EPA Technical Assistance Document for the Chemiluminescence Measurement of $NO_2$ (EPA-600/4-75-003)*, December 1975.

As required by EPA, high concentration span gases come in contact with only stainless steel, Teflon, and glass. Diluted gases come in contact with only glass or Teflon, and are sampled from the calibrator at ambient pressure.

#### 4.1.3 Audit NO Standard

A NIST-traceable gas cylinder containing a nominal concentration 50 ppm NO was used to audit the TEI 42C and UCR Luminol analyzers. Analysis of this cylinder was performed in accordance with the procedures in the *EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (Revised September 1997)*. Documentation of NIST traceability of the standard used for this audit is presented in Table 3 of this report.

#### 4.1.4 Audit $NO_2$ Standard and $NO_2$ Converter Efficiency

The audit $NO_2$ concentrations are generated using the gas phase titration (GPT) procedure, which consists of adding $O_3$ to excess NO. Each $NO_2$ concentration is determined using the calibrated NO channel to measure the decrease in the NO concentration after $O_3$ is added to the known NO concentration. All $NO_2$ concentrations are generated in such a way that the remaining NO concentration is within the required 0.080 to 0.120 ppm range. This procedure is described in detail in the *Quality Assurance Handbook for Air Pollution Measurement Systems, (EPA-600-R-94/038b), Sections 2.3.2, and Section 2.0.12.*

The audit of the TEI 42C NO/$NO_x$ analyzer effectively calibrated each audit calibrator span gas flow rate and ozone lamp setting with respect to a known $NO_2$ concentration. These same calibrator settings were then used to perform the audit of the $NO_2$ component of the UCR $NO_2$/PAN GC.

The $NO_2$ converter efficiency of the TEI 42C NO/$NO_x$ analyzer was tested during the gas phase titration procedure. The converter efficiency (CE) is calculated by the equation below:

$$CE = 100 \times [1 - (\Delta NO_x / \Delta NO)]$$

In this equation $\Delta NO_x$ and $\Delta NO$ are the decreases in the $NO_x$ and NO concentrations as indicated by the respective analyzer channels when changing from the NO-only test atmosphere to those containing NO and $NO_2$. The CE values for each upscale $NO_2$ concentration are averaged, and the resulting value must be 96% or higher for the converter to pass the test.

### 4.2 Particulate and Light Scattering Samplers

The samplers are audited using the procedures described in the *Quality Assurance Handbook for Air Pollution Measurement Systems (EPA-600-R-94/038b),* Sections 2.10.7, 2.11.7, and 2.12.10.2. Generally, the audit consists of a test of the accuracy of the sampler's indicated flow rate and a comparison of the sampler's measured flow rates to its design flow rate. In addition, the sampler is inspected for proper operation, leaks, cleanliness, and structural integrity. All gaskets and fittings are inspected, and the sample filter holders are inspected for integrity.

#### 4.2.1 Medium and Low-Volume Samplers

The standard used to provide the audit flow rates is a Bios DC-Lite Primary Flow Meter, S/N 5828. The Bios Meter is an authoritative volume standard which meets all applicable NIST specifications.

The sampler is turned on and allowed to warm up for at least five minutes. Next, the sampler's inlet head is removed, and an adaptor is attached to the downtube to which the audit flow rate measurement standard is connected. The following are then recorded:

1. Ambient temperature in EK, and barometric pressure in mm Hg.
2. The flow rates as read by the sampler's measurement/recording system.
3. The flow rate as read by the audit standard in actual liters per minute (ALM).

If the sampler flow rates differ significantly from the target set points, all audit data are recorded without adjustments being made to the sampler flow rates. At that time, with the permission of the operator, the sampler flow rate is adjusted to the correct set point, and the audit is then repeated. If this adjustment to the sampler flow rate is necessary, both sets of audit results (before and after adjustment) are presented in the audit report.

If necessary, the indicated sampler flow rates are corrected to ALM, using the latest calibration equations and the ambient temperature and pressure. These corrections to the sampler flow rates are done in the same manner as a routine sample. The corrected sampler flow rate is compared to the corresponding audit flow rate in percent difference, using the following equation:

$$\%Dif. = [(S-A)/A] \times 100$$

In this equation, S is the indicated sampler flow rate in actual ALM, and A is the measured audit flow rate in ALM. The ranges for satisfactory results for this test depend on the device under audit, and are presented in Table 2-6 of the QAPP. Generally, however, the satisfactory criterion is ±5%.

### 4.2.2 High-Volume Sampler

The $PM_{10}$ sampler is audited using the procedures described in the *Quality Assurance Handbook for Air Pollution Measurement Systems (EPA-600/4-44-027a)*, Section 2.2.8.1 (January 1983), Section 2.0.12.11 (June 1984), and Section 2.11.7 (January 1990). The audit consists of two parts: (A) A test of the accuracy of the sampler's indicated flow rate, and (B) A test of the sampler's flow rate to its design flow of 40 actual cubic feet per minute (ACFM). The sampler is also inspected for proper operation, cleanliness and structural integrity. All gaskets are inspected, and the sample filter holders are inspected for integrity.

An audit orifice plate is placed on the sampler inlet with a sample filter in place. The sampler is then turned on and allowed to warm up for at least five minutes, when the following data are recorded:

1. Audit orifice pressure drop in inches of water.
2. Ambient temperature in degrees K and barometric pressure in mm Hg.
3. Indicated sampler flow rate with the audit orifice attached.
4. Indicated sampler flow rate with the audit orifice removed.

The audit orifice plate, manufactured by General Metal Works, was certified on 8/21/02 using a Dresser Roots Meter, S/N 7659995, according to the method described in the *Quality Assurance Handbook for Air Pollution Measurement Systems (EPA-600/4-44-027a)*, Section 2.11.2 (January 1990). The certification information for the orifice plate used for the audit is documented in the audit report. The Roots meter is an "authoritative volume" standard, which meets all applicable NIST specifications.

#### 4.2.1.1 Accuracy Test

The audit flow rate is calculated in actual conditions, and is compared to the corresponding indicated sampler flow rate in percent difference, according to the following equation:

$$\%\text{Dif.} = [(S_w - A)/A] \times 100$$

In this equation, $S_w$ is the indicated sampler flow rate in ACFM with the audit orifice attached, and A is the measured audit flow rate in ACFM. The range for satisfactory results for this test is a difference of ±7% or less.

#### 4.2.1.2 Design Flow Rate Test

The indicated sampler flow rate without the audit orifice is corrected to true flow rate, using the result of the accuracy test described above. This true flow rate is then compared to 40.0 ACFM, which is the flow at which the sampler was designed to operate. This is done using the following equation:

$$\%Dif. = \{\{[1-(\%Dif./100)][S_{w/o}] - 40.0\}/40.0\} \times 100$$

In this equation, %Dif. is obtained from the equation in Section 4.3.1, and $S_{w/o}$ is the indicated sampler flow rate without the audit orifice plate attached. The range for satisfactory results for the design flow test is a difference of ±10% or less.

### 4.3 System Evaluation

The system evaluation consists of an inspection and evaluation of critical on-site air monitoring equipment components. This includes a review of the fabrication, assembly and operation of the test systems in their operational mode. The major items reviewed are general system condition, documentation and operations, and the sample intake systems. During this evaluation the auditor looked for anything that could have an adverse effect on the air monitoring system's ability to produce accurate, precise, and reliable data.

## 5.0 AUDIT RESULTS

### 5.1 Continuous Analyzers

The continuous analyzer audit results presented in Table 2 contain the following information:

1. Each audit concentration ($C_1$) and its resulting reported analyzer concentration ($C_2$) as read by the data logger for each channel audited. Also shown is the percent difference between each audit and analyzer concentration, which is calculated using the following equation:

$$\%Dif. = [(C_2-C_1)/C_1] \text{ H } 100$$

2. Slope, intercept, and correlation coefficient, r, based on a linear regression between $C_1$ and $C_2$ for each channel audited. These constants are calculated by comparing the audit concentrations ($C_1$) to the corresponding analyzer concentrations ($C_2$) according to the following equation:

$$C_2 = \text{slope } (C_1) + \text{intercept}$$

$C_2$ is the concentration as would be routinely reported as validated data.

It should be noted that the audit standards for all three TEI analyzers and UCR analyzer were NO or $NO_2$ only. The audit results indicate that with regard to slope, the results for all three TEI analyzers and the $O_3$ analyzer are well within the ±10% objective.

The 0.642 slope value for the UCR $NO_2$ analyzer is outside its ±20% objective, but the analyzer response data were taken directly from the data logger and no calibration correction was applied. A comparison of the $NO_2$ data from this analyzer versus the data from the chemiluminescence analyzer is being performed, and will be issued in a separate report.

Table 3 presents documentation of the audit NO standard.

### 5.2 Particulate and Light Scattering Samplers

The results of the audits of the particulate samplers are presented in Table 4. All medium and low-volume sampler audit results were in the satisfactory ±5% range with the exception of the Green Tech 640A. In addition, the ±7% satisfactory range for the $PM_{2.5}$ Hi-vol was slightly exceeded. However, although not shown in Table 4, the percent difference in the sampler's 40 ACFM design flow rate and its flow rate with the audit orifice removed was 4.5%, well within the ±10% satisfactory range. All samplers were in good condition and were operating properly.

The flow rate regulation system on the Green Tech sampler is relatively unreliable with respect to the other devices. The reported flow rate for this device is based on the results of the monthly flow rate check, and is not based on the indicated flow rate.

The BAM and OPC flow rate systems are very sensitive to pressure drop. The audit flow rates for these systems were corrected per the pressure drop caused by the Bios Meter.

Re-calibration of the Andersen $PM_{2.5}$ Hi-vol is recommended, since the ±7% limit was exceeded. However, it is recognized that the experimental errors inherent in this vintage of technology will make it difficult to maintain the flow rates within this range.

### 5.3 System Evaluation

A cursory evaluation of the operation indicated that no significant unsatisfactory audit results were encountered. The following summarizes the results of this evaluation.

- All sample intake systems for the gas analyzers and particulate samplers are properly sited.
- All monitoring equipment is in satisfactory operational condition and is properly calibrated and operated.
- The time synchronization for all systems agreed to within ±1 minute.
- The sample custody documentation for the integrated samples is complete, concise, and thorough.
- All continuous analyzer and particulate sampler calibrations are performed in a proper manner and are well documented.

- A calibration of the particle sizing instruments using PSL beads in five different sizes was observed. The calibration methodology is sound and its documentation is concise and complete.

### 5.4 ARB Audit Results

Table 5 presents a summary of the results of an audit of the Fresno Supersite performed by ARB QA personnel on July 15 and 17, 2002. As indicated in the table, all audit results were satisfactory.

## Table 2 Continuous Analyzer Audit Results

STATION: Fresno Supersite | ANALYZER: TEI 42C | DATE: 09/18/02
CHANNEL: $NO_x$ | RANGE: 0-0.500 ppm | BEGIN: 0904
S/N: Unknown | END: 1608

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.000 | --- | Slope: | 1.012 |
| 0.061 | 0.064 | 4.9 | Inter.: | 0.001 |
| 0.176 | 0.180 | 2.3 | r: | 0.99998 |
| 0.283 | 0.289 | 2.1 | | |
| 0.353 | 0.358 | 1.4 | | |
| 0.441 | 0.447 | 1.4 | | |

STATION: Fresno Supersite | ANALYZER: TEI 42C | DATE: 09/18/02
CHANNEL: **NO** | RANGE: 0-0.500 ppm | BEGIN: 0904
S/N: Unknown | END: 1608

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.000 | --- | Slope: | 1.010 |
| 0.061 | 0.064 | 4.9 | Inter.: | 0.001 |
| 0.176 | 0.180 | 2.3 | r: | 0.99996 |
| 0.283 | 0.289 | 2.1 | | |
| 0.353 | 0.356 | 0.8 | | |
| 0.441 | 0.447 | 1.4 | | |

STATION: Fresno Supersite | ANALYZER: TEI 42C | DATE: 09/18/02
CHANNEL: $NO_2$ | RANGE: 0-0.500 ppm | BEGIN: 0904
S/N: Unknown | END: 1608

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.000 | --- | Slope: | 1.009 |
| 0.036 | 0.036 | 1.0 | Inter: | 0.000 |
| 0.081 | 0.083 | 2.2 | r: | 0.99994 |
| 0.195 | 0.195 | 0.0 | | |
| 0.276 | 0.281 | 1.7 | $NO_2$ Converter Efficiency = 99.7% | |
| 0.357 | 0.360 | 0.7 | | |

## Table 2 Continuous Analyzer Audit Results

STATION: Fresno Supersite | ANALYZER: UCR PAN/$NO_2$ GC | DATE: 09/18/02
CHANNEL: **$NO_2$** | RANGE: 0-0.500 ppm | BEGIN: 0904
S/N: Unknown | END: 1608

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.000 | --- | Slope: | 0.642 |
| 0.036 | 0.032 | -10.2 | Inter: | 0.009 |
| 0.081 | 0.067 | -17.5 | r: | 0.99668 |
| 0.195 | 0.143 | -26.7 | | |
| 0.276 | 0.190 | -31.2 | | |
| 0.357 | 0.230 | -35.6 | | |

STATION: Fresno Supersite | ANALYZER: TEI 42C | DATE: 09/18/02
CHANNEL: **$NO_y$** | RANGE: 0-0.500 ppm | BEGIN: 0904
S/N: 42CY-66906-354 | END: 1608

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.001 | --- | Slope: | 1.028 |
| 0.061 | 0.065 | 6.6 | Inter.: | 0.002 |
| 0.176 | 0.184 | 4.5 | r: | 0.99993 |
| 0.283 | 0.297 | 4.9 | | |
| 0.353 | 0.363 | 2.8 | Converter Efficiency: 98.5% | |
| 0.441 | 0.455 | 3.2 | | |

STATION: Fresno Supersite | ANALYZER: TEI 42 | DATE: 09/18/02
CHANNEL: H**$NO_3$** | RANGE: 0-0.500 ppm | BEGIN: 0904
S/N: 42CY-66906-354 | END: 1608

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.000 | --- | Slope: | 1.027 |
| 0.061 | 0.063 | 2.7 | Inter.: | 0.001 |
| 0.176 | 0.181 | 2.3 | r: | 0.99994 |
| 0.283 | 0.295 | 4.2 | | |
| 0.353 | 0.361 | 2.3 | Converter Efficiency: 98.7% | |
| 0.441 | 0.453 | 2.7 | | |

## Table 2 Continuous Analyzer Audit Results

STATION: Fresno Supersite | ANALYZER: TEI 42C | DATE: 09/18/02
CHANNEL: **$NO_y$** | RANGE: 0-0.500 ppm | BEGIN: 0904
S/N: 42CY-64629-345 | END: 1608

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.002 | --- | Slope: | 1.050 |
| 0.061 | 0.068 | 11.5 | Inter.: | 0.003 |
| 0.176 | 0.191 | 8.5 | r: | 0.9996 |
| 0.283 | 0.302 | 6.7 | | |
| 0.353 | 0.365 | 3.4 | Converter Efficiency: 99.4% | |
| 0.441 | 0.471 | 6.8 | | |

STATION: Fresno Supersite | ANALYZER: TEI 42 | DATE: 09/18/02
CHANNEL: **NO** | RANGE: 0-0.500 ppm | BEGIN: 0904
S/N: 42CY-64629-345 | END: 1608

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.000 | --- | Slope: | 1.040 |
| 0.061 | 0.065 | 6.6 | Inter.: | 0.001 |
| 0.176 | 0.186 | 5.7 | r: | 0.9998 |
| 0.283 | 0.297 | 4.9 | | |
| 0.353 | 0.363 | 2.8 | | |
| 0.441 | 0.462 | 4.8 | | |

STATION: Fresno Supersite | ANALYZER: API 400 | DATE: 09/19/02
CHANNEL: **$O_3$** | RANGE: 0-0.500 ppm | BEGIN: 0717
S/N: 180 | END: 0849

| Audit ppm | Station ppm | %Dif. | | |
|---|---|---|---|---|
| 0.000 | 0.003 | --- | Slope: | 1.003 |
| 0.081 | 0.084 | 3.7 | Inter: | 0.003 |
| 0.192 | 0.196 | 2.1 | r: | 0.9998 |
| 0.281 | 0.280 | -0.5 | | |
| 0.356 | 0.363 | 2.0 | | |

**Table 3 Audit Gas Standard**

| Cylinder S/N | Certified Concentration | Certification Date |
|---|---|---|
| CC 40132 | 49.3 ppm NO | 02/15/01 |

**Table 4 Particulate Sampler Audit Results**

| Sampler | Channel or S/N | Indicated, ALM | Audit, ALM | % Dif |
|---|---|---|---|---|
| R&P 5400 Carbon | | 15.20 | 15.55 | -2.3 |
| BAM $PM_{2.5}$ | | 16.3 | 16.2 | 0.6 |
| BAM $PM_{10}$ | | 15.9 | 16.2 | -1.8 |
| TEOM $PM_{10}$ | Total | 16.66 | 16.69 | -0.2 |
| TEOM $PM_{2.5}$ | Total | 16.60 | 17.21 | -3.5 |
| TEOM $PM_{10}$ | Main | 2.99 | 2.94 | 1.7 |
| TEOM $PM_{2.5}$ | Main | 3.10 | 2.99 | 3.7 |
| Andersen RAAS 100 $PM_{2.5}$ | 00079 | 16.62 | 16.82 | -1.2 |
| Andersen RAAS 100 $PM_{2.5}$ | 00083 | 16.65 | 16.48 | 1.0 |
| Minivol | 1315 | 5.013 | 5.033 | -0.4 |
| Minivol | 1259 | 5.030 | 5.095 | -1.3 |
| Minivol | 1325 | 5.100 | 5.161 | -1.2 |
| Minivol | 1183 | 5.025 | 5.017 | -0.2 |
| Minivol | 1177 | 5.205 | 5.281 | -1.4 |
| Green Tech GT-640A | | 5.33 | 4.61 | 15.6 |
| OPC System | | 16.4 | 15.7 | 4.5 |
| Aethelometer | Single wave | 6.9 | 7.1 | -2.8 |
| Aethelometer | Seven wave | 7.0 | 6.9 | 1.4 |
| Andersen 321A Hi-vol with $PM_{2.5}$ inlet | | 38.9 CFM | 41.9 CFM | -7.2 |

Standards used for audits:

a. Bios DC-Lite Primary Flow Meter, S/N 58282.
b. Graseby Hi-Vol Orifice Plate, certified 9/1/02 using a Roots Meter

## Table 5 ARB Audit Results

| Gas Analyzers | | | |
|---|---|---|---|
| **Measurement** | **Audit Value, ppm** | **Station Response, ppm** | **% Dif.** |
| $O_3$ | 0.364 | 0.350 | -3.8 |
| | 0.158 | 0.150 | -5.1 |
| | 0.062 | 0.058 | -6.5 |
| NMHC | 0.600 | 0.610 | 1.7 |
| | 1.17 | 1.16 | -0.9 |
| | 1.77 | 1.75 | -1.1 |
| CO | 7.16 | 7.20 | 0.6 |
| | 18.3 | 18.1 | -1.0 |
| | 37.3 | 37.9 | 1.7 |
| $SO_2$ | 0.071 | 0.073 | 2.8 |
| | 0.182 | 0.184 | 1.1 |
| | 0.370 | 0.370 | 0.0 |
| $NO_2$ | 0.063 | 0.065 | 3.2 |
| | 0.180 | 0.181 | 0.6 |
| | 0.376 | 0.377 | 0.3 |
| **Particulate Samplers** | | | |
| **Measurement** | **Audit Value** | **Station Response** | **%Dif.** |
| $PM_{10}$ | 41.3 ACFM | 40.9 ACFM | -1.0 |
| BAM | 17.20 L/M | 16.7 L/M | -2.9 |
| $PM_{2.5}$ | 16.78 L/M | 16.68 L/M | -0.6 |
| **Meteorological Instruments** | | | |
| **Measurement** | **Audit Value** | **Station Response** | **Dif.** |
| Barometric Pressure | 750 mm Hg | 750 mm Hg | 0 mm Hg |
| Wind Direction | 090° | 091° | 1° |
| | 180° | 182° | 2° |
| | 270° | 272° | 2° |
| | 355° | 359° | 4° |
| Horizontal Wind Speed | 0.27 mph | 0.23 mph | -0.04 mph |
| | 5.60 mph | 5.58 mph | -0.36 mph |
| | 10.93 mph | 10.91 mph | -0.18 mph |
| | 16.26 mph | 16.23 mph | -0.18 mph |
| | 32.25 mph | 32.20 mph | -0.16 mph |
| Temperature | 44.1°C | 44.1°C | 0.0°C |
| | 26.5°C | 26.4°C | -0.1°C |
| | 0.4°C | 0.4°C | 0.0°C |
| Relative Humidity | 91.5% | 89.9% | -1.6% |
| | 62.4% | 65.0% | 2.6% |
| | 32.1% | 37.0% | 4.9% |