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**QUALITY ASSURANCE PROJECT PLAN (QAPP)  
for the  
CLEAN AIR STANDARDS AND TRENDS NETWORK  
(CASTNET)  
AUDIT PROGRAM**

**Prepared for:  
U. S. Environmental Protection Agency  
Washington, DC 20460**

**Prepared by:**



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**EPA Contract No.: 68W02058  
Subcontract No.: 02058-28**

**July 2007**

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## **GROUP A: PROJECT MANAGEMENT**

### **A1 Approval Sheet**

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**List of Acronyms and Abbreviations**

ARS	Air Resource Specialist
ASTM	American Society for Testing and Materials
CASTNET	Clean Air Status and Trends Network
COR	Contraction Officer's Representative
DAS	data acquisition systems
EDD	Electronic Data Delivery
EEMS	Environmental Engineering and Measurement Services, Inc.
EPA	U.S. Environmental Protection Agency
FSAD	Field Site Audit Database
MACTEC	MACTEC Engineering and Consulting, Inc.
MFC	mass flow controller
NIST	National Institute of Standards and Technology
NPS	National Park Service
ppm	parts per million
QA	quality assurance
QAPP	quality assurance project plan
QMP	quality management plan
RH	relative humidity
ROM	read only memory
SOP	standard operating procedure
USNO	U.S. Naval Observatory
WRR	World Radiation Reference
$\Delta T$	temperature difference
$^{\circ}C$	degree Celsius

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### A3 Distribution List

The following individuals receive reports as specified in the report description and distribution table. Copies of this QAPP, and any subsequent revisions, are distributed to the first three persons listed:

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## 1.0 GROUP A: Project Management Elements

This Quality Assurance Project Plan (QAPP) has been prepared to meet the requirement of the Environmental Protection Agency (EPA) Contract Number 68W02058, Subcontract Number 02058-28 for the Clean Air Standards and Trends Network (CASNET) Audit Program. This QAPP describes the objectives of the auditing activities to be performed at CASTNET sites, data quality requirements and assessments, project management, organization and responsibilities of Environmental Engineering & Measurement Services, Inc. (EEMS) staff and consultants, and a schedule of activities and deliverables. This QAPP has been prepared compliant with EPA Order 5360.0 A2, *Policy and Program Requirements for the Mandatory Agency-wide Quality Systems* and with the EPA QAPP format as presented in the *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R5 (EPA 2001).

### 1.1 Section A1 – Title and Approval Sheet

Title and Approval Sheet provided in preliminary section of this document.

### 1.2 Section A2 – Table of Contents

Table of Contents provided in preliminary section of this document.

### 1.3 Section A3 – Distribution List

Distribution List provided in preliminary section of this document.

### 1.4 Section A4 – Project/Task Organization

The audit of CASTNET sites is fundamentally a quality assurance role to ensure the reliability of data collected at these sites. The purpose of the CASTNET Audit Program is to qualitatively appraise the total measurement system. This includes a thorough, on-site evaluation of facilities, equipment, personnel, training, procedures, documentation and reporting aspects of the field operations systems. Field systems audit results are used to ensure that good quality assurance/quality control (QA/QC) practices are being applied as defined in the CASTNET QAPP. The contractors responsible for operating the stations are MACTEC E&C for EPA sites and Air Resource Specialist, Inc. (ARS) for NPS sites.

EEMS is the organization that has been tasked to perform these audits. The responsibilities of EEMS personnel are as follows:

The project manager responsible for:

- Coordinate with the auditor regarding audit schedules, audit procedures, audit standards and constants, and required supplies.

- 
- Review all audit results.
  - Distribute the audit results to designated personnel in a timely fashion.
  - Review and approve any changes to the audit procedures.

The auditor is responsible for:

- Coordinate with the project manager regarding audit schedules, audit procedures, accuracy goals, required materials, and audit standards.
- Perform all required audits in accordance with approved audit protocols as described in the specific Standard Operating Procedure (SOP).
- Maintain all audit standards.
- Meet with observe and/or interview the site operator as needed during audits.
- Document the audit results using the appropriate form(s) and database.
- Prepare and forward audit reports to the project manager(s).

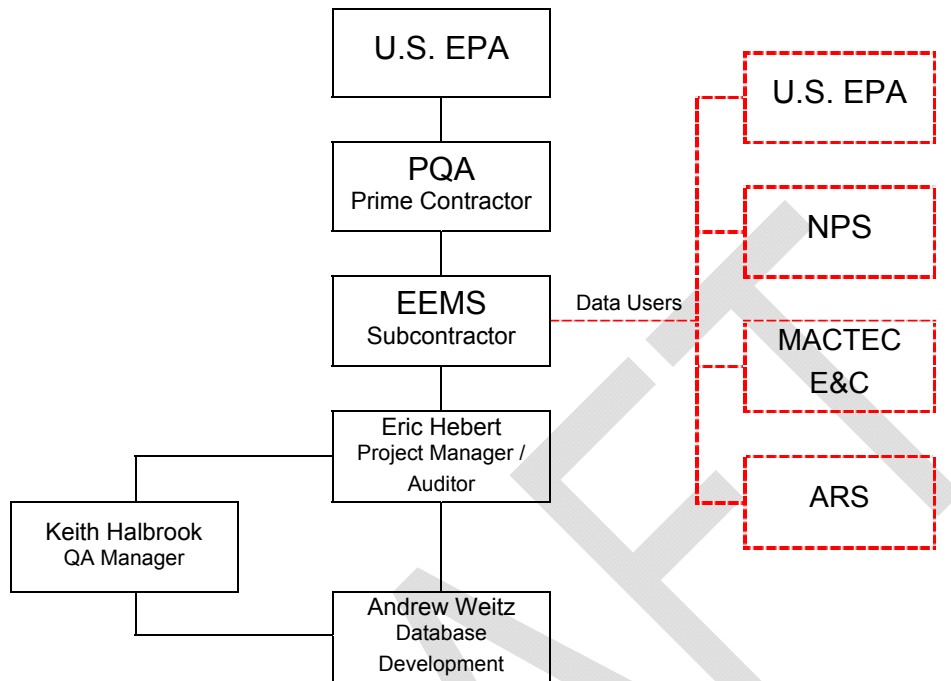
The QA manager is responsible for:

- Review of QAPP.
- Document control.
- Maintenance of NIST traceable records and audit standards.

Figure 1 shows the organizational chart together with the users of the data generated by this audit program.

Data generated by means of these audits is to be used by the EPA, by the NPS, and by the contractors responsible for operating the stations (MACTEC E&C and ARS) to establish whether QA/QC practices are being applied as defined in the CASTNET QAPP.



**Figure 1. Organizational Chart and Data Users**

### 1.5 Section A5 – Problem Definition/Background

CASTNET is a national program developed under mandate of the 1990 Clean Air Act Amendments to measure gaseous and aerosol species of atmospheric pollution using a continuous collection three-stage filter aggregated over a one week period, and hourly averages of surface ozone concentrations and various meteorological variables. The program objective is to determine relationships between emissions, air quality, deposition, and ecological effects. In conjunction with other national monitoring networks, CASTNET data are used to determine the effectiveness of national emission control programs and to assess temporal trends in atmospheric pollutants and special deposition patterns. Data are also used for long-range transport model evaluations and effects research. The network is cooperatively operated by the EPA and the National Park Service (NPS), and, as of January 2005, is comprised of 87 active rural sampling sites across the United States (see Table 1 and Figure 2 for site locations, and Table 2 for the audit program schedule).

**Table 1. CASTNET Site Location**

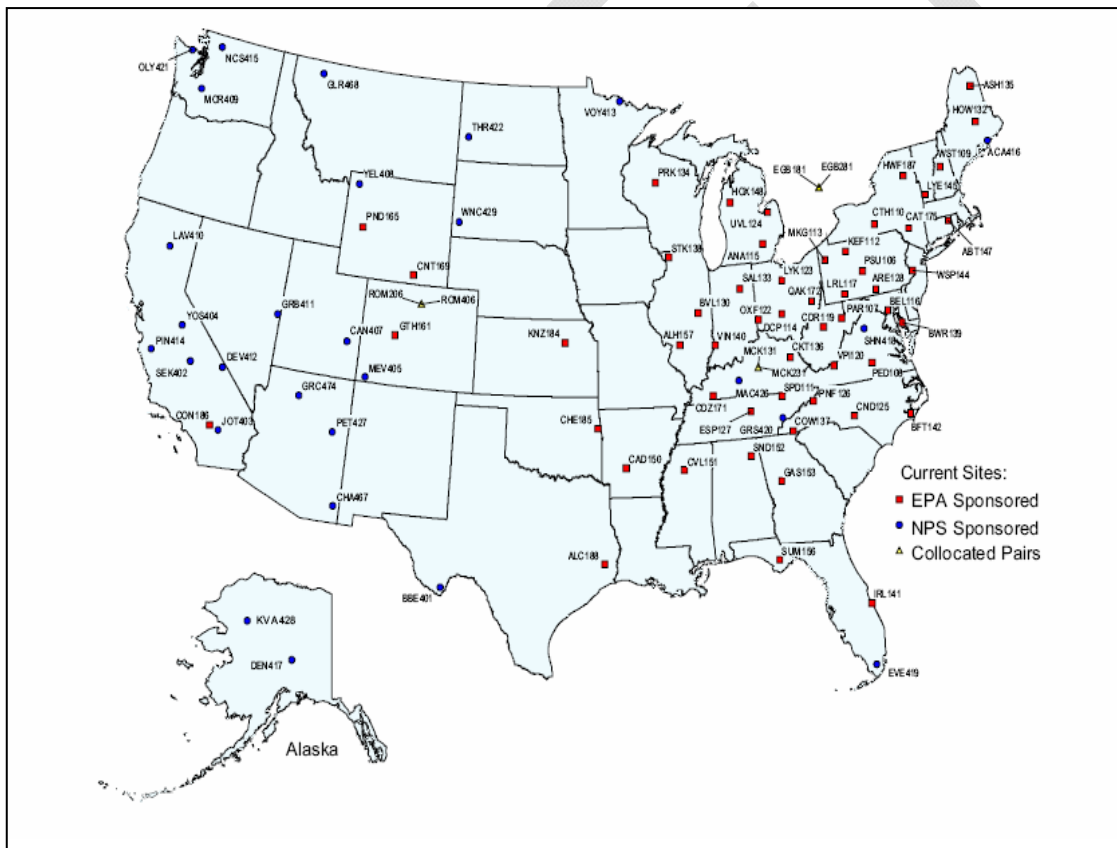
<b>State/Province</b>	<b>Site ID</b>	<b>Location</b>	<b>Sponsored by</b>
Alabama	SND152	Sand Mountain	EPA
Alaska	DEN417	Denali National Park	NPS
	KVA428	Kobuk Valley National Park	NPS
Arizona	CHA467	Chiricahua National Monument	NPS
	GRC474	Grand Canyon National Park	NPS
	PET427	Petrified Forest National Park	NPS
Arkansas	CAD150	Caddo Valley	EPA
California	CON186	Converse Station	EPA
	DEV412	Death Valley National Monument	NPS
	JOT403	Joshua Tree National Monument	NPS
	LAV410	Lassen Volcanic National Park	NPS
	PIN414	Pinnacles National Monument	NPS
	SEK402	Sequoia National Park	NPS
	YOS404	Yosemite National Park	NPS
Colorado	GTH161	Gothic	EPA
	MEV405	Mesa Verde National Park	NPS
	ROM206	Rocky Mountain National Park	EPA
	ROM406	Rocky Mountain National Park	NPS
Connecticut	ABT147	Abington	EPA
Florida	EVE419	Everglades National Park	NPS
	IRL141	Indian River Lagoon	EPA/SJRWMD
	SUM156	Sumatra	EPA
Georgia	GAS153	Georgia Station	EPA
Illinois	ALH157	Alhambra	EPA
	BVL130	Bondville	EPA
	STK138	Stockton	EPA

<b>State/Province</b>	<b>Site ID</b>	<b>Location</b>	<b>Sponsored by</b>
Indiana	SAL133	Salamonie Reservoir	EPA
	VIN140	Vincennes	EPA
Kansas	KNZ184	Konza Prairie	EPA
Kentucky	CDZ171	Cadiz	EPA
	CKT136	Crockett	EPA
	MAC426	Mammoth Cave National Park	NPS
	MCK131	Mackville	EPA
Maine	ACA416	Acadia National Park	NPS
	ASH135	Ashland	EPA
	HOW132	Howland	EPA
Maryland	BEL116	Beltsville	EPA
	BWR139	Blackwater National Wildlife Refuge	EPA
Michigan	ANA115	Ann Arbor	EPA
	HOX148	Hoxeyville	EPA
	UVL124	Unionville	EPA
Minnesota	VOY413	Voyageurs National Park	NPS
Mississippi	CVL151	Coffeerville	EPA
Montana	GLR468	Glacier National Park	NPS
Nebraska	SAN189	Santee	EPA
Nevada	GRB411	Great Basin National Park	NPS
New Hampshire	WST109	Woodstock	EPA
New Jersey	WSP144	Washington's Crossing	EPA
New York	CAT175	Claryville	EPA
	CTH110	Connecticut Hill	EPA
	HWF187	Huntington Wildlife Forest	EPA
North Carolina	BFT142	Beaufort	EPA
	CND125	Candor	EPA

<b>State/Province</b>	<b>Site ID</b>	<b>Location</b>	<b>Sponsored by</b>
	COW137	Coweeta	EPA
	PNF126	Cranberry	EPA
North Dakota	THR422	Theodore Roosevelt National Park	NPS
Ohio	DCP114	Deer Creek State Park	EPA
	LYK123	Lykens	EPA
	OXF122	Oxford	EPA
	QAK172	Quaker City	EPA
Oklahoma	CHE185	Cherokee Nation	EPA
Ontario	EGB181	Egbert, Ontario	EPA
Pennsylvania	ARE128	Arendtsville	EPA
	KEF112	Kane Experimental Forest	EPA
	LRL117	Laurel Hill State Park	EPA
	MKG113	M.K. Goddard State Park	EPA
	PSU106	Penn. State University	EPA
South Dakota	WNC429	Wind Caves National Park	NPS
Tennessee	ESP127	Edgar Evins State Park	EPA
	GRS420	Great Smoky Mountains National Park	NPS
	SPD111	Speedwell	EPA
Texas	ALC188	Alabama-Coushatta	EPA
	BBE401	Big Bend National Park	NPS
Utah	CAN407	Canyonlands National Park	NPS
Vermont	LYE145	Lye Brook	EPA
Virginia	PED108	Prince Edward	EPA
	SHN418	Shenandoah National Park	NPS
	VPI120	Horton Station	EPA
Washington	MOR409	Mount Rainier National Park	NPS
	NCS415	North Cascades National Park	NPS

State/Province	Site ID	Location	Sponsored by
West Virginia	CDR119	Cedar Creek State Park	EPA
	PAR107	Parsons	EPA
Wisconsin	PRK134	Perkinstown	EPA
Wyoming	CNT169	Centennial	EPA
	PND165	Pinedale	EPA
	YEL408	Yellowstone National Park	NPS

Figure 2. Map of CASTNET Site Locations



**Table 2. CASTNET Field Audit Schedule**

	FIRST QUARTER			SECOND QUARTER		
ODD YEAR	January	February	March	April	May	June
		CAD150 CHE185 ALC188 BBE401	CVL151 CDZ171 MAC426 MCK131 MCK231	PIN414 SEK402 DEV412 YOS404 LAV410	CKT136 DCP114 OXF122 QAK172	GTH161 ROM206 ROM406 CNT169 PND165 YEL408
	THIRD QUARTER			FOURTH QUARTER		
	July	August	September	October	November	December
	KNZ184 ALH157 VIN140 BVL130 STK138 SAN189	WNC429 PRK134 VOY413 THR422 GLR468	GRS420 VPI120 PED108	CND125 BFT142 BWR139 WSP144	SHN418 PAR107 CDR119 LRL117	
	FIRST QUARTER			SECOND QUARTER		
EVEN YEAR	January	February	March	April	May	June
		IRL141 EVE419 SUM156 GAS153 SND152	ESP127 SPD111 PNF126 COW137	CHA467 GRC474 PET427 MEV405 CAN407	SAL133 LYK123 ANA115 UVL124 HOX148	DEN417 KVA428 MOR409 NCS415
	THIRD QUARTER			FOURTH QUARTER		
	July	August	September	October	November	December
	CON186 JOT403 GRB411	ABT147 ACA416 HOW132 ASH135	WST109 LYE145 CAT175 HWF187	MKG113 KEF112 CTH110 EGB181	BEL116 ARE128 PSU106	

- EPA Sponsored Sites
- NPS Sponsored Sites

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## **1.6 Section A6 – Project/Task Description**

### **1.6.1 A6.1 Purpose**

The purpose of this project is to establish an independent and unbiased program of performance and systems audits for all CASTNET sampling sites and to assess and document the results. This program verifies that all evaluated parameters are consistent with CASTNET and EPA accuracy goals.

### **1.6.2 A6.2 Work Plan**

A Work Plan has been prepared in accordance with the terms and conditions of the contract clauses. This Work Plan can be found in Appendix A of this document.

### **1.6.3 A6.3 Work to be Performed**

EEMS prepared standard operation procedures (SOPs) for all aspects of the work. The SOPs include comprehensive audit forms to record both numeric audit results and field notes. The SOPs were submitted to the EPA for comment and approval before work began. EEMS will revise existing quality assurance documents (QAPP, quality management plan (QMP), etc.) as necessary to include the program described in the work assignment or prepare new documents to be compliant with EPA Order 5360.1 A2, *Policy and Program Requirements for the Mandatory Agency-wide Quality Systems*.

All measured variables at each site are challenged with standards which are NIST (or other authoritative source) traceable. All performance audit results are recorded using hard-copy forms and then entered into the relational database. Each site operator is observed and/or interviewed regarding site operation procedures and functions. All observations and assessments are recorded on systems audit hard-copy forms and then entered into the relational audit database.

EEMS developed comprehensive audit forms to record numeric audit results into a relational database for the entire audit program. The database accommodates detailed field notes, site sketches, photographs, and any other pertinent material needed to document the audit findings. The database also contains all traceability certifications and calibrations of standards used for the field site audits. Audit findings in the database are confirmed and verified and used to generate comprehensive audit reports for the individual sites. The reports include the field accuracy criteria given the stated configurations, and any other pertinent material. If a location has been previously audited, EEMS uses the audit report(s) from those audits as a basis for comparison to complete the current audit. Findings from the previous report(s) are reviewed to determine if corrective actions have been implemented.

EEMS developed an abbreviated or “spot” report form for preliminary numeric audit results and written findings that can be printed on-site and sent electronically the same day as the audit. Fields for performance and system audit findings that could result in data invalidation or required immediate attention are conspicuous on the spot report.

#### **1.6.4 A6.4 Field Site Audits**

EEMS is thoroughly familiar with all aspects of CASTNET field operations and with the CASTNET QAPP. EEMS field audit teams are familiar with all CASTNET site equipment and duties and are able to speak authoritatively on both topics.

##### **1.6.4.1 A6.4.1 Audit Schedule, Site Selection, Initial Communications**

EEMS developed a field auditing schedule so that all operating CASTNET sites are visited a minimum of once every two (2) years with the most efficient use of travel and other resources.

At least one (1) month prior to the anticipated date of a site audit, EEMS notifies the Work Assignment Contracting Officer’s Representative (COR) (or his alternate) by electronic mail and the EPA CASTNET contractor contact of the site survey. If the site is operated by the NPS, EEMS also notifies the NPS contact with the same information. At least two (2) weeks prior to the planned visit, EEMS contacts the site operator and coordinates the date and time of the audit and presents a brief agenda of anticipated activities.

##### **1.6.4.2 A6.4.2 Field Systems Audits**

EEMS conducts systems audits to provide a qualitative appraisal of the total measurements system at each CASTNET monitoring site. Site planning, organization, and operations are evaluated to ensure that good quality assurance/quality control practices are being applied. Among the audit issues, EEMS addresses the following:

- Site locations and configurations match those provided in the CASTNET QAPP.
- Meteorological instruments are in good physical and operational condition and are sited to meet EPA ambient monitoring guidelines (EPA – 600/4-82-060).
- Sites are accessible, orderly and, if applicable, compliant with OSHA safety standards.
- Sampling lines are free of leaks, kinks, visible contamination, weathering, and moisture.
- Site shelters provide adequate temperature control
- All ambient air quality instruments are functional being operated in the appropriate range, and the zero air supply desiccant is unsaturated.
- All instruments are in current calibration.



- Site documentation (maintenance schedules, on-site SOPs, etc.) is current and log book records are complete.
- Site operators demonstrate an adequate knowledge and ability to perform required site activities, including documentation.

### **1.6.4.3 A6.4.3 Field Performance Audits**

EEMS conducts a complete performance audit on all CASTNET instruments at each site. Specific methods used are summarized below. All standards used in the audits are traceable to the (National Institute of Standards and Technology) NIST or another authoritative standards organization and are certified as current. Accuracy criteria for the instruments are obtained from the current CASTNET QAPP.

#### **A6.4.3.1 Ozone Analyzer**

Ozone analyzers are audited in accordance with EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II – Ambient Air Specific Methods*. EEMS is thoroughly familiar with the different ozone sampling configurations employed in the CASTNET program. Audits are conducted by introducing a reference zero gas and no fewer than three (3) test atmospheres in the analyzer through the entire system by introducing the samples through the particle filter on the 10m tower. Audit challenge ranges include 0.03-0.08, 0.15-0.2, and 0.36-0.45 ppm. All secondary ozone standards are certified against a primary ozone standard each calendar quarter.

#### **A6.4.3.2 Ambient Air Sampling System**

Flow rate audits are conducted with an audit flow device connected to the filter pack mount on the CASTNET sample tower. Audits are conducted using either a mass flow meter calibrated against a primary flow standard or a portable primary flow standard. The flow systems are checked for leakage by capping off the sampling line at the audit device and verifying that the flow readings are negligible for both the audit device and the system mass flow meter.

#### **A6.4.3.3 Data Acquisition Systems (DAS)**

The voltage accuracy of the primary and back-up dataloggers at each site is verified by challenging two (2) datalogger channels (the first from channels 1-8 and the second from channels 9-16) with no fewer than six (6) reference voltages. Voltages in the range of 0-1.0 volts are generated by a digital voltage reference and verified on-site with a certified audit digital voltmeter. Other voltage-based DAS equipment such as strip chart recorders are similarly audited if used at specific sites.

#### **A6.4.3.4 Meteorological Measurement Systems**

Meteorological Measurement Systems are audited in accordance with the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV – Meteorological Measurements*.

##### **a. Wind Speed Sensors**

Dynamic tests of the horizontal wind speed sensors are performed using a wind speed calibrator. Sensor is tested at the shaft revolution speed range of 0-90% of full scale with no fewer than four (4) test points. The equivalent wind speeds as derived from the sensor manufacturer's specified values for shaft rpm vs. wind velocity are compared to readings obtained from the on-site dataloggers. Bearing integrity checks are also performed to verify the starting threshold of the sensor.

##### **b. Wind Direction Sensors**

Wind direction sensors are tested for orientation accuracy by verification of the datalogger reading while the vane is manually aligned towards two (2) or more reference landmarks of known true orientation from the site and separated approximately 90°. If local terrain or weather conditions prevent siting to established landmarks, the sensor orientation reference on the meteorological tower is used. Verification of landmarks and orientation reference are obtained by comparison to a NIST certified magnetic compass corrected for declination. Potentiometer linearity is verified by use of a rose dial. Eight (8) observed wind direction values separated by 45° are recorded. Sensor bearing integrity is also tested.

##### **c. Temperature and Temperature Difference Sensors**

Accuracy and linearity of temperature sensors are tested by immersion in no fewer than three (3) temperature baths, which include temperatures of 0 °C, ambient (approximately 20 °C), and as near to full scale as possible. Temperature difference ( $\Delta T$ ) systems are assessed by simultaneously immersing both sensors in each of the baths and noting the measured temperature differences.

##### **d. Relative Humidity (RH) Sensors**

RH sensor testing is conducted by collocating a reference sensor in a humidity chamber. At least three (3) readings spanning the range of 35-90% RH are taken and compared for evaluation. Adequate stabilization time for the sensors is allowed before readings are taken.

##### **e. Precipitation Sensors**

Tipping bucket precipitation gauges are tested with a volumetric precipitation gauge calibrator. Known quantities of water are transferred through the gauge orifice at a rate

equivalent to 2-inches per hour of precipitation. Tip response of the on-site datalogger is verified and the observed values compared to the actual introduced volumes. In addition to volume challenges, the gauges are manually advanced 10 counts, and the observed datalogger values verified.

#### **f. Solar Radiation Sensors**

Solar radiation sensors are tested by comparing measured values with those of a collocated reference radiation sensor during no fewer than three (3) one-hour data collection periods. Readings from the audit standard and on-site sensors are arithmetically averaged, converted to proper engineering units, and evaluated to establish system accuracy.

#### **g. Wetness Sensors**

Wetness sensors are tested by drying the sensing grid (if initially in “wet” mode) or by wetting it with distilled water (if initially in “dry” mode) and recording the corresponding DAS values to verify that the appropriate changes have occurred.

#### **1.6.4.4 A6.4.4 Archive Data**

All audit information is archived on optical ROM media.

### **1.7 Section A7 – Quality Objectives and Criteria**

The intent of the CASTNET Audit Program is to provide an unbiased evaluation for all CASTNET sampling sites and to assess and document the results to verify that all evaluated parameters are consistent with CASTNET and EPA accuracy goals. The quality objectives of this audit program are to evaluate the parameters in a precise manner and to accurately report the findings.

#### **1.7.1 A7.1 Field System Audits**

Technical field systems audits are qualitative and therefore acceptance criteria are not established. Methods used are in accordance with the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume I: A Field Guide To Environmental Quality Assurance*, and *Volume II: Part 1 Ambient Air Quality Monitoring Program Quality System Development*.

#### **1.7.2 A7.2 Field Performance Audits**

All challenge results are acquired and recorded from all on-site data-logging device(s). The results obtained from the primary DAS at each site are used to verify the instrument or sensor

accuracy. Prior to performing any instrument or system test, the recording channel(s) of the DAS(s) is flagged to indicate the parameter is being tested and not recording actual data. Following the audit tests and after sufficient time for the measurement system(s) to equilibrate to ambient conditions, the variable channel(s) is enabled for routine data recording. Detailed technical guidance and instructions are provided in the individual SOPs and referenced materials.

Meteorological measurement systems are audited in accordance with the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV - Meteorological Measurements*. Ambient gas analyzers and flow rate regulation systems are audited in accordance with the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II - Ambient Air Specific Methods*.

EEMS uses NIST or American Society for Testing and Materials (ASTM) traceable test equipment for flow rate and all meteorological variables except solar radiation. Solar radiation transfer standards are traceable to the World Radiation Reference (WRR) standard. Gas analyzer audit standards are traceable to EPA primary photometers.

Accuracy goals for all parameters are obtained from the project-specific QAPP. The specific audit acceptance criterion for the type of system being audited is summarized in **Table 3** and provided in the individual SOP.

**Table 3. Specific Audit Acceptance Criteria**

Sensor	Parameter	Audit Challenge	Acceptance Criteria
Precipitation	Response	10 manual tips	1 DAS count per tip
Precipitation	Accuracy	2 introductions of known amounts of water	$\leq \pm 10.0\%$ of input amount
Relative Humidity	Accuracy	Compared to reference instrument or standard solution	$\leq \pm 5.0\%$ above 85.0% RH; $\leq \pm 20.0\%$ at or below 85.0% RH
Solar Radiation	Accuracy	Compared to WRR traceable standard	$\leq \pm 10.0\%$ of daytime average
Surface Wetness	Response	Distilled water spray mist	Positive response

Sensor	Parameter	Audit Challenge	Acceptance Criteria
Surface Wetness	Sensitivity	1% decade resistance	N/A
Temperature	Accuracy	Comparison to 3 NIST measured baths (~ 0° C, ambient, ~ full-scale)	$\leq \pm 0.5^\circ \text{ C}$
Delta Temperature	Accuracy	Comparison to station temperature sensor	$\leq \pm 0.50^\circ \text{ C}$
Wind Direction	Orientation Accuracy	Parallel to alignment rod/crossarm, or sighted to distant point	$\leq \pm 5^\circ$ from degrees true
Wind Direction	Linearity	Eight cardinal points on test fixture	$\leq \pm 5^\circ$ mean absolute error
Wind Direction	Response Threshold	Starting torque tested with torque gauge	< 10 g-cm Climatronics; < 20 g-cm R. M. Young
Wind Speed	Accuracy	Shaft rotational speed generated and measured with certified synchronous motor	$\leq \pm 0.5$ mps below 5.0 mps input; $\leq \pm 5.0\%$ of input at or above 5.0 mps
Wind Speed	Starting Threshold	Starting torque tested with torque gauge	< 0.5 g-cm
Mass Flow Controller	Flow Rate	Comparison with Primary Standard	$\leq \pm 5.0\%$ of designated rate
Ozone	Slope	Linear regression of multi-point test gas concentration as measured with a certified transfer standard	$0.9000 \leq m \leq 1.1000$
	Intercept		$-5.0 \text{ ppb} \leq b \leq 5.0 \text{ ppb}$
	Correlation Coefficient		$0.9950 \leq r$
	Percent Difference	Comparison with Standard Concentration	$\leq \pm 10.0\%$ of test gas concentration

Sensor	Parameter	Audit Challenge	Acceptance Criteria
DAS	Accuracy	Comparison with certified standard	$\leq \pm 0.003$ VDC
DAS	Date and time	Comparison with local standard time USNO	$\leq \pm 5$ min

### 1.7.3 A7.3 Ozone Analyzer Audits

Ambient ozone gas analyzers are audited in accordance with the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II - Ambient Air Specific Methods*. EEMS uses ozone gas transfer standard photometers which are traceable to EPA primary photometers for field audits. EPA primary photometers are NIST certified.

### 1.7.4 A7.4 Ambient Air Sampling System

Flow rate regulation systems are audited in accordance with the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II - Ambient Air Specific Methods*. EEMS uses NIST or ASTM traceable test equipment for flow rate audits.

### 1.7.5 A7.5 Data Acquisition System

Specific acceptance criteria for DAS are defined as the difference between the measured input voltage from the NIST traceable DVM and the measured response obtained from the DAS.

The local standard time of day of the DAS will be checked using the reference time standard from the USNO.

### 1.7.6 A7.6 Meteorological Measurement Systems

Meteorological measurement systems are audited in accordance with the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV - Meteorological Measurements*, (March 1995).

EEMS uses test equipment traceable to NIST, World Radiation Reference (WRR), or the ASTM standard for all meteorological sensor accuracy audits.

## 1.8 Section A8 – Special Training/Certification

With over 15 years of specific CASTNET field operation experience, and nearly 20 years of air quality monitoring experience, EEMS is thoroughly familiar with all aspects of CASTNET field operations and with the CASTNET QAPP. EEMS field audit teams are familiar with all CASTNET site equipment and duties and are able to speak authoritatively on both topics.

## 1.9 Section A9 – Documents and Records

The EEMS QA Manager is responsible for review of and maintaining the current version of the SOPs and QAPP. The EEMS QA Manager is responsible for the distribution of the QAPP and SOPs.

Table 4 includes the different types of reports, generated for the CASTNET Audit Program and includes the recipient of each report and the level of detail.

**Table 4. Reports Generated for the CASTNET Audit Program**

Report Name	Recipients <sup>(1)</sup>	Purpose and Description	Records Included
Exit Report	Site Operator and EPA, and ARS/NPS or MACTEC	This is a project management report. Includes any variables not audited and may report any hazardous conditions encountered at the site.	N/A
Spot Report	EPA and MACTEC QA Manager or NPS and ARS QA Manager	This is a summary of the results and observations without technical details. Includes statistical results for each variable, comparison to acceptance criteria, and pass/fail designation.	N/A
Monthly Report	EPA and PQA	This is a project management report which summarizes the activities performed during the reporting period, and lists the activities anticipated for next reporting period.	N/A
Quarterly Report	EPA, NPS, and MACTEC E&C	Summarizes the sites audited during the quarter and the dates of the	Hard-copy only

Report Name	Recipients <sup>(1)</sup>	Purpose and Description	Records Included
	and ARS QA Mangers	audits. Provides detailed site audit report of findings for each variable including the raw challenge values, the corrected challenge values, and the recorded output values. Includes systems audit details, site maps with comparison to coordinates provided in CASTNET QAPP, and photographs of observed deficiencies.	
Annual Report	EPA, NPS, MACTEC E&C QA Manager, ARS QA Mangers	Report includes the same information as the Quarterly Reports with the addition of the fourth quarter, and a statistical summary of the audit results. An assessment of the network with recommendations for operational improvement is provided.	Hard-copy only
Database Report Submitted with Quarterly and Annual Report	EPA	Electronic Data Delivery (EDD) of relational database tables including all recorded results of site audits. All corrected input challenges and site recorded output values are included. Text memo fields of site systems observations are also included. Electronic images of site maps and photographs are provided.	Electronic Microsoft Access Database file (MDB) and JPG or MOV image files

<sup>(1)</sup> If the CASTNET site is sponsored by the EPA, the EPA and MACTEC are the recipients of the reports. For those CASTNET sites sponsored by the NPS, EPA, NPS and ARS are the recipients of the reports.



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## **2.0 GROUP B: Data Generation and Acquisition**

The data generated and acquired during site audits is comprised of a qualitative appraisal of the total measurements system obtained while performing the field systems audit, and quantitative data obtained when conducting the performance audit of the instruments. No samples are generated during these procedures. All procedures are performed according to those described in EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II - Ambient Air Specific Methods*. Meteorological measurement systems are audited in accordance with the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV - Meteorological Measurements*, (March 1995). These procedures are also referenced in the SOPs found in Appendix B of this document.

### **2.1 Section B1 – Sampling Process Design (Experimental Design)**

This section does not apply to this project.

### **2.2 Section B2 – Sampling Methods**

This section does not apply to this project

### **2.3 Section B3 – Sample Handling and Custody**

This section does not apply to this project

### **2.4 Section B4 – Analytical Methods**

This section does not apply to this project

### **2.5 Section B5 – Quality Control**

#### **2.5.1 B5.1 Ozone**

Quality control for audit methods includes routine maintenance and the quarterly certification of ozone transfer standards. Certification is provided by one or more of the US EPA regional laboratories which operate NIST traceable Standard Reference Photometers (SRP). Certification reports include NIST QC results of each transfer analyzer challenge which provide statistical analysis of analyzer deviations and uncertainties. See the sample certification report provided in Appendix C of this document.

#### **2.5.2 B5.2 Ambient Air Sampling and Meteorological Variables**

Quality control activities for flow rate audit devices and meteorological variable standards include the routine maintenance of each instrument as described in the manufactures

specifications. At least annually each standard is returned to the manufacturer, or a third party certification facility, for service and maintenance and to certify traceability NIST or other accepted authoritative standard. Each instrument is returned to EEMS with a certification report. See example included in Appendix C or this document.

All correction factors provided in certification reports are included and incorporated in the audit results and reports.

### **2.5.3 B5.3 System Audits**

Quality control of methods used for systems audits includes the regular update of mapping software files. These are necessary to verify the location and magnetic declination of each site location.

Review of the CASTNET QAPP annual revisions is also conducted to ensure current operational changes and acceptance criteria are incorporated in the audit procedures.

## **2.6 Section B6 – Instrument/Equipment Testing, Inspection, and Maintenance**

The procedures described in **2.5 Section B5 – Quality Control** are supervised and reviewed by the EEMS QA manager to ensure adherence. A certification schedule is maintained by the QA manager to ensure that all standards and instruments are certified at least annually (or quarterly in the case of ozone). Any standards or instruments that are out of certification are not used for audits until recertified.

All certification results are reviewed by the QA manager to ensure standard or instrument stability and acceptance. If any malfunction, certification discrepancy, or indication of maintenance required is identified, the QA manager takes action to resolve the issue. The action can include the return of the standard or instrument to the manufacturer for repair, maintenance, and recertification.

All standard certification results and records are maintained in the relational audit database.

## **2.7 Section B7 – Instrument/Equipment Calibration and Frequency**

Together with the SOPs developed for the CASTNET Audit Program, the following subsections identify the instruments and materials that are utilized during performance of the audits, as well as the criteria followed regarding calibration and standards.

The individual SOPs listed here are required for conducting performance audits at EPA and NPS designated CASTNET monitoring stations. They are intended to be used by qualified technicians that understand general instrument operation and audit techniques. The following SOPs provide technical guidance and detailed information regarding specific CASTNET auditing procedures:

- SOP-02058-1101 - *Audit Procedures, Ozone Analyzer, TEI 49 (CASTNET Installations).*
- SOP-02058-1200 - *Audit Procedures, Meteorological Sensors (CASTNET Installations).*
- SOP-02058-1300 - *Audit Procedures, Data Acquisition Systems, (CASTNET Installations).*
- SOP-02058-1400 - *Audit Procedures, Mass Flow Controlled- Dry Deposition Sample (CASTNET Installations).*
- SOP-02058-1500 - *Audit Procedures, Field Systems (CASTNET Installations).*

In addition to the specific instruments and equipment listed in the individual SOPs, the following materials are required to audit CASTNET ambient air quality monitoring stations.

- CASTNET QAPP.
- Station Log.
- Laptop computer with approved Field Site Audit Database (FSAD) and audit data forms (forms provided with parameter specific SOP).
- Global Positioning System (GPS).
- Miscellaneous supplies.
- Manufacturer's instruction manuals.

Instrument calibration and frequency of calibration are referred to in Section B5 and Section B6. All procedures are performed according to those described in EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II - Ambient Air Specific Methods*. Meteorological measurement systems are audited in accordance with the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV - Meteorological Measurements*, (March 1995).

#### **2.7.1 B7.1 Ozone Analyzer**

The following instruments and materials are required for conducting performance audits of ozone analyzers at EPA and NPS designated CASTNET monitoring stations. They are intended to be used by qualified technicians that understand general instrument operation and audit techniques:

- SOP-02058-1000 - *Field Site Performance Audits (CASTNET Installations)*.
- SOP-02058-1500 - *Audit Procedures, Field Systems (CASTNET Installations)*.
- CASTNET QAPP.
- Station Log.
- Laptop computer with approved FSAD and audit data forms (F-02058-1100-O3-rev001).
- Miscellaneous supplies and tools.
- Manufacturer's instruction manuals.

### **2.7.2 B7.2 Ambient Air Sampling Systems**

The following instruments and materials are required for conducting mass flow controller (MFC) performance audits at EPA and NPS designated CASTNET monitoring stations. They are intended to be used by qualified technicians that understand general instrument operation and audit techniques.

- SOP-02058-1500 - *Audit Procedures, Field Systems (CASTNET Installations)*.
- SOP-02058-1000 - *Field Site Performance Audits (CASTNET Installations)*.
- CASTNET QAPP.
- Station Log.
- Laptop computer with approved FSAD and audit data forms (F-02058-1400-MFC-rev001).
- Portable primary flow measurement device certified to NIST standards such as a BIOS model DC system or equivalent.
- Tubing and connections capable of connecting the flow standard to the CASTNET sampling head.
- Miscellaneous supplies.
- Manufacturer's instruction manuals.

### **2.7.3 B7.3 Data Acquisition System**

The following instruments and materials are required for conducting performance audits of DAS(s) at EPA and NPS designated CASTNET monitoring stations. They are intended to be used by qualified technicians that understand general instrument operation and audit techniques.

- CASTNET QAPP.
- SOP-02058-1500 - *Audit Procedures, Field Systems (CASTNET Installations)*.
- SOP-02058-1000 - *Field Site Performance Audits (CASTNET Installations)*.

- Station Log.
- Laptop computer with approved FSAD and audit data forms (F-02058-1300-DAS-rev001).
- Reference voltage source capable of generating test voltages between zero and 10 volts DC with one millivolt (mv) resolution.
- Digital voltmeter (DVM) certified to NIST standards capable of measuring voltages between zero and 10 volts DC to one tenth mv resolution.
- Various test leads and banana-plug connections.
- Miscellaneous hand tools.
- Means of acquiring accurate time from the United States Naval Observatory (USNO).
- Manufacturer's instrument manuals.

#### 2.7.4 B7.4 Meteorological Measurement Systems

The following instruments and materials listed are intended to be used by qualified technicians that understand general instrument operation and audit techniques. The individual sensor parameters and the audit standards used to verify those parameters are listed in Table 5. The following materials are required in addition to the specific instruments listed in Table B7.4

- CASTNET QAPP.
- SOP-02058-1300 – *Audit Procedures, Data Acquisition Systems (CASTNET Installations)*.
- SOP-02058-1000 – *Field Site Performance Audits (CASTNET Installations)*.
- Station Log.
- Laptop computer with approved FSAD and audit data forms (forms provided in Appendix A).
- Global Positioning System (GPS).
- Miscellaneous supplies.
- Manufacturer's instruction manuals.

**Table 5. Audit Instruments**

Variable	Parameter	Standard Mfg	Model	Description	Certifying Group	Frequency
Ozone	Accuracy	TEI	49C	NIST certified Transfer standard	EPA	Quarterly
		Envionics	6103			

Variable	Parameter	Standard Mfg	Model	Description	Certifying Group	Frequency
Flow Rate	Accuracy	Bios Internal	DCNS and DCL-MH	Primary Standard	Bios International	Annually
Precipitation	Accuracy	NALGENE®	Calibrated Ware	250ml graduated cylinder and separatory funnel	EEMS	Annually
Relative Humidity	Accuracy	Rotronics	A1H and Hygroclip Hygromer and aqueous salt solutions	Calibrated to ASTM	Rotronics	Annually
Solar Radiation	Accuracy	Eppley	PSP	WRR certified sensor	Eppley	Annually
Surface Wetness	Response	Various	N/A	Distilled water mist bottle		
Surface Wetness	Sensitivity	Ohmite	Ohm-Ranger	NIST traceable 1% accuracy decade	EEMS	Annually
Temperature and Temperature Difference	Accuracy	Eutechnics	4600 Thermometer	NIST certified electronic RTD	ICL Calibration Laboratory	Annually
Wind Direction	Orientation	Sokkia	PC-2 Surveyors Compass	NIST traceable Magnetic compass used with GPS and DeLorme Topo USA	Warren-Knight Instrument Company	Annually
Wind Direction	Linearity	R.M. Young; EEMS	1812 N/A	Vane angle test fixtures	EEMS	Annually

Variable	Parameter	Standard Mfg	Model	Description	Certifying Group	Frequency
Wind Direction	Threshold	R.M. Young	18331	Vane torque gauge	EEMS	Annually
Wind Speed	Accuracy	R.M. Young	18802 and 18831A	Anemometer synchronous drive 20-15,000 RPM	R.M. Young	Annually
Wind Speed	Threshold	R.M. Young	18310	Propeller/cup torque disc	EEMS	Annually

## 2.8 Section B8 – Inspection/Acceptance of Supplies and Consumables

Calibration standards, and independent references must be traceable to a NIST (or EPA equivalent) source. The safety requirements are checked with the material safety data sheets (MSDS) supplied by the manufacturer. The EEMS QA manager reviews and accepts all materials and references.

Upon receipt, the standard is cross-referenced to its purchase order to assure that the proper standard was received. The QA manager accepts the standard. The receipt date and initials are noted on each standard. All standards are stored in designated areas.

## 2.9 Section B9 – Non-direct Measurements

The CASTNET QAPP provided by the contractor operating the network site is reviewed to obtain current information regarding site location and sampling operation. Information required prior to the site audit includes site operator contact information and current variables measured at each site so the audit schedule can be defined and equipment can be prepared. During the site audit existing records and logs at the site are inspected and evaluated.

## 2.10 Section B10 – Data Management

Audit results are written on hard copy forms, and subsequently input into the electronic FSAD. Blank copies of the technical field systems audit forms are included in Appendix D. The forms listed in Table 6 below are used for the purpose indicated:

**Table 6. CASTNET Audit Program List of Forms and Use**

<b>Form</b>	<b>Parameter</b>
F-02058-1100-O3-rev001	Ozone
F-02058-1200-PRECP-rev002	Precipitation
F-02058-1200-RH-rev001	Relative Humidity
F-02058-1200-SR-rev002	Solar Radiation
F-02058-1200-WDR-rev001	Wind Direction
F-02058-1200-WSP-rev001	Wind Speed
F-02058-1300-DAS-rev001	DAS
F-02058-1400-MFC-rev001	MFC
F-02058-1400-T-rev001	Temperature and Delta Temperature
F-02058-1500-S1-rev003	Field Systems - General Site Information
F-02058-1500-S2-rev003	Field Systems - Siting Criteria
F-02058-1500-S3-rev003	Field Systems - Met sensor Siting Criteria
F-02058-1500-S4-rev003	Field Systems - Met sensors operations and maintenance
F-02058-1500-S5-rev003	Field Systems - Pollutant Analyzers and Deposition Equipment Siting
F-02058-1500-S6-rev003	Field Systems - DAS, Sensor Translators, and Peripheral Equipment Operations and Maintenance
F-02058-1500-S7-rev003	Field Systems - Documentation
F-02058-1500-S8-rev003	Field Systems - Site operation procedures
F-02058-1500-S9-rev003	Field Systems - Site operation procedures

If a site has been previously audited, that record will be available during the current audit, and used to determine if corrective actions were needed and implemented.

Examples of the FSAD audit reports can be found in Appendix E. The modified electronic forms and database tables will be provided upon completing the current revision to the EDD.



### **3.0 GROUP C: Assessment and Oversight**

The purpose of the CASTNET Audit Program is to ensure that good QA/QC practices are being applied as defined in the CASTNET QAPP. The assessment of each CASTNET site is strictly controlled by the implementation of the CASTNET Audit Program QAPP. The EPA QA manager for the CASTNET Audit Program oversees that the implementation of this QAPP.

#### **3.1 Section C1 – Assessments and Response Actions**

Reviews of data collected during each audit is performed during the data entry into the FSAD and upon completion of each of the audit reports, beginning with the “spot” report, followed by the quarterly report and finally while generating the annual report.

Routine maintenance and certification of instruments used during site audits are an integral part of the CASTNET Audit Program. These are performed as indicated in Section B, Table 5. It is EEMS’ QA manager responsibility to assure these procedures are followed.

In the event that, due to instrument failure or otherwise, it is unclear whether challenges to instruments are reliable, EPA will be notified immediately of the circumstances leading to the occurrence.

#### **3.2 Section C2 – Reports and Management**

The types, frequency and distribution of reports are presented in Section A9 and Table 4.

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## **4.0 GROUP D: Data Validation and Usability Elements**

If during the procedures described in the previous sections regarding audit standards, the QA Manager finds the audit instruments outside of the certification period or the instrument certification is determined to be unstable, the project manager and EPA are notified. Any questionable audit data will be identified in the subsequent report. The reason for the discrepancy and actions taken to correct the condition will be reported.

### **4.1 Section D1 – Data Review, Verification, and Validation**

All audit data are reviewed during the actual instrument test. Any test that is outside of acceptance criteria is scrutinized for the cause of the instrument and/or audit standard error. Only after ensuring that the test is being conducted in accordance with the SOP and the audit standard is not malfunctioning is the test result recorded.

### **4.2 Section D2 – Verification and Validation Methods**

All audit results are range tested during the database entry process. All calculations of average errors, maximum errors, and linear regressions are performed during the data collection process while completing the hard-copy field forms. The calculations are repeated automatically as data entry in the database is completed for each form. The results of the calculations are then compared. Discrepancies are investigated and errors are resolved.

This process resolves errors prior to data being available to the users. If an audit standard is found to be in error the questionable data will be reported to the users when the error is discovered. Questionable audit data will be identified and corrective actions reported in the next report of results.

### **4.3 Section D3 – Reconciliation with User Requirements**

The audit program and results are continually reviewed by the project manager and EPA project officer to identify changing or new requirements. The program documentation is updated with any changes in program requirements. Audit results and network operation assessments are discussed with users at management meetings. Recommendations for improvements to the program are incorporated following periodic program review by EPA and data users.