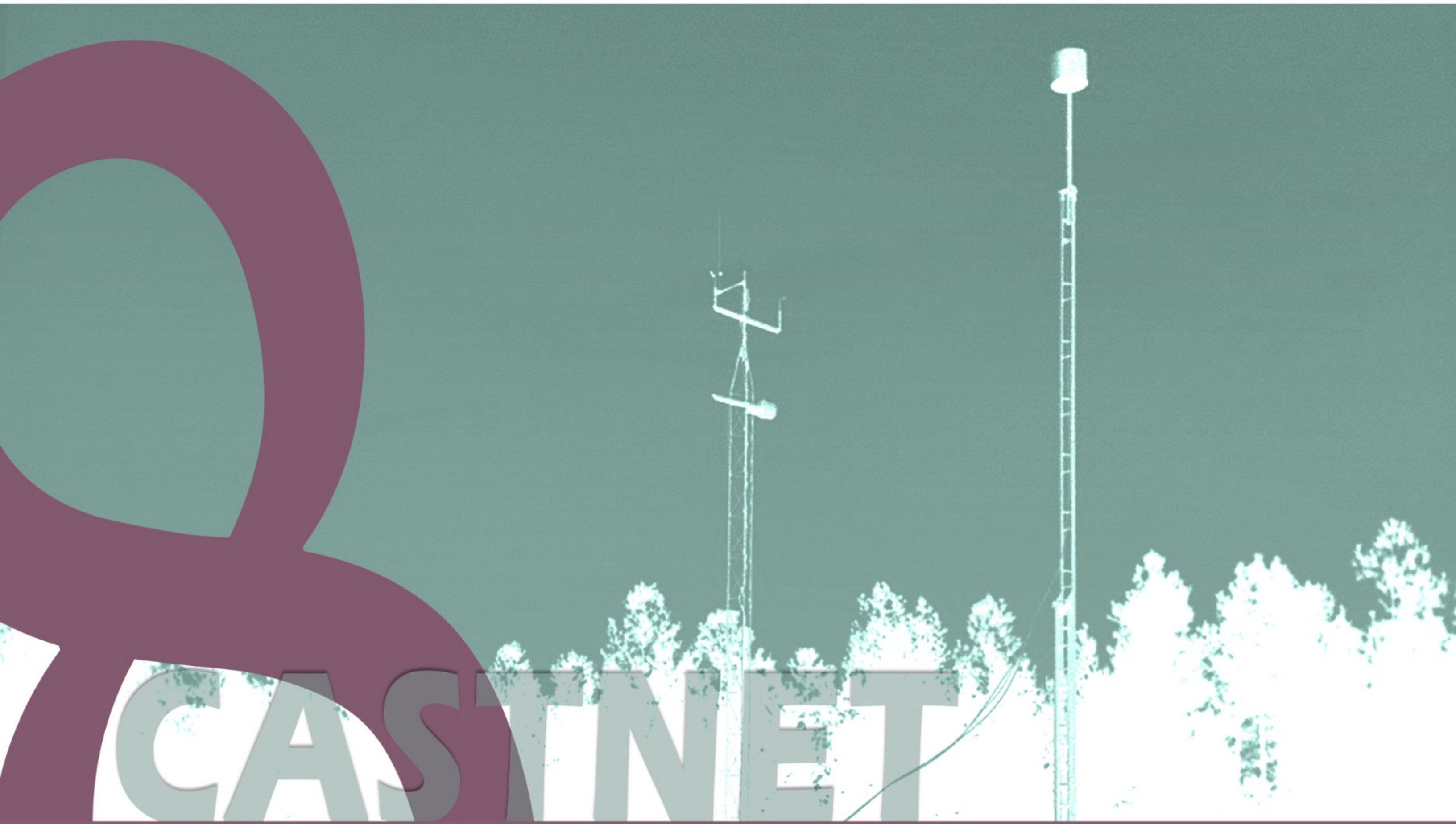

CASTNET

Quality Assurance Project Plan

Revision 8.3

Prepared for: US Environmental Protection Agency

Clean Air Status and Trends Network (CASTNET)

Quality Assurance Project Plan (QAPP)

Revision 8.3

October 2015

Title and Approval Sheet

Clean Air Status and Trends Network

Quality Assurance Project Plan

Amec Foster Wheeler Environment & Infrastructure, Inc.:

H. Kemp Howell — 12/18/2015
H. Kemp Howell, Date
Amec Foster Wheeler Project Manager

Ann Bernhardt — 12/10/2015
Ann Bernhardt, Date
Amec Foster Wheeler Project Quality Assurance Supervisor

Marcus O. Stewart — 12/10/15
Marcus O. Stewart, Date
Amec Foster Wheeler Quality Assurance Manager

United States Environmental Protection Agency

Melissa Puchalski — 11/30/15
Melissa Puchalski, Date
EPA Project Officer

Karen Orehowsky — 11/30/15
Karen Orehowsky, Date
EPA Quality Assurance Officer

National Park Service:

Barkley Sive — 11/5/2015
Barkley Sive, Date
Contracting Officer's Technical Representative

Bureau of Land Management:

Ryan McCammon — 11/3/2015
Ryan McCammon, Date
Air Resource Specialist

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List of Acronyms and Abbreviations

A2LA	American Association for Laboratory Accreditation
AA3	AutoAnalyzer 3
AACE™	Automated Analyzer Control and Evaluation
AC	alternating current
Amec Foster Wheeler	Amec Foster Wheeler Environment & Infrastructure, Inc.
ANSI	American National Standards Institute
API	Advanced Pollution Instruments
AQDBMS	Air Quality Database Management System
AQI	Air Quality Index
AQS	Air Quality System
ARPD	absolute relative percent difference
ARS	Air Resource Specialists, Inc.
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
BLM	Bureau of Land Management
BS	blank spike
Ca^{2+}	calcium ion
°C	degrees Celsius
CAAA	Clean Air Act Amendments of 1990
CAPMoN	Canadian Air and Precipitation Monitoring Network
CASTNET	Clean Air Status and Trends Network
CCV	continuing calibration verification samples
CD	compact disc
CDMSA	CASTNET Data Management System Application
CDRF	Continuous Data Review Form
CDVS	Continuous Data Validation Summary
CFR	Code of Federal Regulations
CH_4	methane
Cl^-	chloride ion
CLASS	Chemical Laboratory Analysis and Scheduling System
cm^2	square centimeter
CMAQ	Community Multiscale Air Quality Modeling System
CO_2	carbon dioxide
COTR	Contracting Officer's Technical Representative
DAS	data acquisition system
DC	direct current
DI	deionized
DMAIRM	Data Management, Analysis, Interpretation and Reporting Manager
DMC	Data Management Center
DQI	Data Quality Indicator
DQO	Data Quality Objective
EC	elemental carbon
ECAN	Environment Canada
EDD	electronic data deliverable
EDTA	ethylenediamine-tetraacetic acid

List of Acronyms and Abbreviations (continued)

EEPROM	electronically erasable programmable read only memory
EPA	U.S. Environmental Protection Agency
ESC	Environmental Systems Corporation
°F	degrees Fahrenheit
FAR	Federal Acquisition Regulations
FID	flame ionization detector
FOM	Field Operations Manager
FTP	file transfer protocol
GB	gigabyte
HCl	hydrochloric acid
Hg	mercury
HNO_3	nitric acid
IC	ion chromatography
ICP-AES	inductively coupled plasma - atomic emission spectrometry
ICP-OES	Inductively Coupled Plasma – Optical Emission Spectrometry
ID	identification
IEC	International Electrotechnical Commission
IMC	Information Management Center
IMPROVE	Interagency Monitoring of Protected Visual Environments
Interlab	USGS Interlaboratory
IP	Internet protocol
ISO	International Organization for Standardization
IT	information technology
K^+	potassium ion
kΩ	kilo Ohm
K_2CO_3	potassium carbonate
KCSTC	Kansas City Science & Technology Center
km	kilometer
KOH	potassium hydroxide
kΩ	kilo Ohm
L	liter
LAI	leaf area index
LAN	local area network
LCS	laboratory control sample
LED	light-emitting diode
Li-Cor	Li-Cor, Inc.
LIMS	laboratory information management system
LIS	Laboratory Information Specialists
LOM	Laboratory Operations Manager
Lpm	liters per minute
m	meter
m/sec	meters per second
MAD	mean absolute difference
MaD	mean arithmetic difference

List of Acronyms and Abbreviations (continued)

MARPD	mean absolute relative percent difference
MB	megabytes
MFC	mass flow controller
Mg^{2+}	magnesium ion
mg	milligram
MHz	mega Hertz
mL	milliliter
MLM	Multi-Layer Model
mm	millimeter
MS	Microsoft
MSDS	material safety data sheets
mV	millivolts
N	nitrogen
Na^{+}	sodium ion
Na_2CO_3	sodium carbonate
NADP	National Atmospheric Deposition Program
NAT	network address translation
NCAF	Non-Conformance/Corrective Action Form
NDDN	National Dry Deposition Network
NERL	National Exposure Research Laboratory
NH_4^+	particulate ammonium
NIST	National Institute of Standards and Technology
NLET	National Laboratory for Environmental Testing
nm	nanometer
NO_2^-	nitrite ion
NO_x	nitrogen oxides
NO_3^-	particulate nitrate
NPS	National Park Service
NTN	National Trends Network
NWRI	National Water Research Institute
NYSDEC	New York State Department of Environmental Conservation
NYSERDA	New York State Energy Research and Development Authority
O_3	ozone
OC	organic carbon
PC	personal computer
PCM	Property Control Manager
PDF	portable document format
PE	performance evaluation
pH	acid-base scale
$PM_{2.5}$	mass of particles with a mean diameter of less than 2.5 µm
ppb	parts per billion
ppm	parts per million
PSD	Prevention of Significant Deterioration
psi	pounds per square inch

List of Acronyms and Abbreviations (continued)

PTS	Problem Tracking System
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAID	Redundant Array of Independent Disks
RAM	random access memory
RDBMS	relational database management system
RH	relative humidity
RPD	relative percent difference
RSD	relative standard deviation
RTD	resistance temperature device
SCD	segmented-array charge-coupled-device detector
SCS	U.S. Soil Conservation Survey
SDS	safety data sheets
sigma theta	standard deviation of horizontal wind direction
SJRWMD	St. Johns River Water Management District
SLAMS	State and Local Monitoring Stations
SLIC	sample line integrity checks
SLIC	sample line integrity checks
SO_4^{2-}	particulate sulfate
SO_2	sulfur dioxide
SOP	standard operating procedures
SPMS	special purpose monitoring stations
SQL	structured query language
SR	solar radiation
SRM	standard reference material
SSRF	Site Status Report Form
STORET	storage and retrieval
STP	standard temperature and pressure
TDEP	total deposition
TFE	tetra fluoroethylene
TSA	technical systems audit
µg	microgram
$\mu g/cm^2$	micrograms per square centimeter
$\mu g/m^3$	micrograms per cubic meter
µm	micrometer
µS/cm	microsiemens per centimeter
UL	Underwriter's Laboratories
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USPS	US Postal Service
UV	ultraviolet
V_d	deposition velocities

List of Acronyms and Abbreviations (continued)

V	volt
VDC	volt direct current
VOC	volatile organic compound
W/m^2	Watts per square meter
WARMS	Wyoming Air Resources Monitoring System
z/s/p	zero /span/precision

Distribution List

Amec Foster Wheeler Environment & Infrastructure, Inc.:
H. Kemp Howell, Project Manager
Ann Bernhardt, Project QA Supervisor
Marcus O. Stewart, QA Manager
Kevin P. Mishoe, Field Operations Manager
Kathy Barry, Laboratory Operations Manager
Christopher M. Rogers, Data Management, Analysis, Interpretation, and Reporting Manager
Selma Isil, Property Control Manager

United States Environmental Protection Agency:
Melissa Puchalski, Project Officer
Gregory Beachley, Alternate Project Officer/Technical Monitor
Karen Orehowsky, QA Officer
Gary Lear, Technical Monitor
Timothy Sharac, Technical Monitor
Rob Gray, Contracting Officer

National Park Service:
Barkley Sive, Contracting Officer's Technical Representative

Bureau of Land Management:
Ryan McCammon, Air Resource Specialist

Air Resource Specialists, Inc.:
Joe Adlhoch, Program Manager
Christian Kirk, QA Officer
Jessica Ward, Data Management Section Manager
Mike Slate, Network Operations Section Manager

Field Services Contractors

1.0 Project Overview

1.1 Purpose/Background

The Clean Air Status and Trends Network (CASTNET) was established by the U.S. Environmental Protection Agency (EPA) in response to the requirements of the 1990 Clean Air Act Amendments (CAAA). CASTNET's primary goal is to operate effectively as a national, long-term ambient air pollutant and deposition monitoring network that provides information for assessing the effectiveness of current and future emission reductions. CASTNET's primary objectives are:

- To monitor the status and trends in air quality and atmospheric deposition;
- To provide atmospheric data on the dry deposition component of total acid deposition, rural ground-level ozone (O_3), and other forms of atmospheric pollution that enter the environment as particles and gases;
- To gauge compliance with O_3 National Ambient Air Quality Standards (NAAQS);
- To assess and report on geographic patterns and long-term, temporal trends in ambient air pollutant concentrations and acid deposition;
- To provide scientifically defensible data to gauge the effectiveness of EPA emission reduction programs;
- To improve understanding of particulate matter and ozone formation;
- To evaluate and improve atmospheric air quality/deposition models;
- To provide data for health-based research and epidemiology studies; and
- To support science and ecosystem studies.

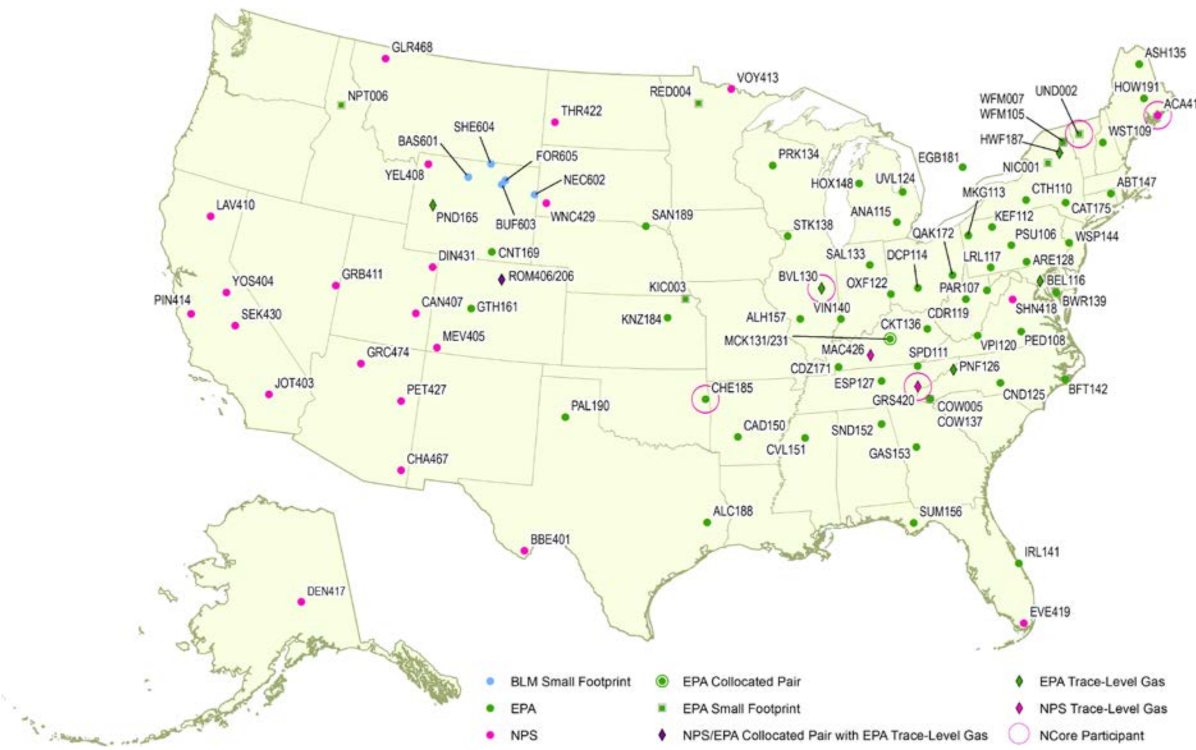
The CASTNET quality assurance (QA) program was designed to ensure that all reported data are of known and documented quality in order to meet CASTNET objectives and to be reproducible and comparable with data from other monitoring networks and laboratories. The CASTNET data quality objectives (DQO) were developed to support the primary objectives. DQO are quantitative and qualitative statements that when met, ensure CASTNET data are adequate for their intended use (Section 1.5). Data quality indicators (DQI) are quantitative statistics and qualitative descriptors used in interpreting the degree of acceptability and utility of the data collected. The DQI for CASTNET are precision, accuracy, bias, completeness, representativeness, and comparability.

This Quality Assurance Project Plan (QAPP) satisfies, in part, EPA Order CIO 2105.0, Policy and Program Requirements for the Mandatory Agency-Wide Quality System (EPA, 2001), which requires that all EPA-operated environmental programs comply fully with the American National Standard Quality Systems for Environmental Data and Technology Programs, Requirements with Guidance for Use, ANSI/ASQC E4-2004, American Society for Quality (2004). This document is written in accordance with EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5) (EPA, 2001), and EPA Guidance for Quality Assurance Project

Plans (EPA QA/G-5) (EPA, 2002), and contains all necessary elements for an EPA-approved QAPP. This QAPP is comprehensive and includes standards and policies for all components of project operation from site selection through final data reporting. Sections on field measurements, chemical analysis of field samples, data management, and assessments and response actions are included. Standard operating procedures are provided as appendices. The Amec Foster Wheeler CASTNET laboratory (analytical and field) is certified under the International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025:2005 accreditation by the American Association for Laboratory Accreditation (A2LA) for a scope that includes test methods performed at its primary facility and remote monitoring stations.

Figure 1-1 shows the locations of 93 CASTNET monitoring sites operated during 2015. Most CASTNET sites are located in rural or remote locations away from pollutant emission sources and heavily populated areas. Table 1-1 provides the location of each site by state and includes information on start date, latitude, longitude, elevation, and the parameters measured. For the purposes of this QAPP, CASTNET sites are called “western” or “eastern” depending on whether they are west or east of 100 degrees west longitude. In general, sample flow rates are set to 1.50 liters per minute (lpm) in the east and at a higher rate of 3.00 lpm in the west due to the lower pollutant concentrations generally found in the western United States.

Figure 1-1 CASTNET Sites Operational During 2015



CASTNET began operation as the National Dry Deposition Network (NDDN) in 1987. The 50 NDDN sites were transferred to CASTNET in 1991. During 2015 the network included 95 monitoring stations at 93 sites (Figure 1-1) throughout the contiguous United States, Alaska, and Canada. CASTNET is sponsored by EPA, the National Park Service (NPS), and the Bureau of Land Management (BLM). NPS began its participation in CASTNET in 1994 under an agreement with EPA. With the involvement of NPS, the network became a national, rather than a primarily eastern, network. NPS is responsible for the protection and enhancement of air quality and related values in national parks and wilderness areas. Twenty-five CASTNET sites were sponsored by NPS during 2015. The Bureau of Land Management (BLM) operated five sites in Wyoming.

CASTNET Ambient Measurements

- Sulfur species:
  - Sulfur dioxide
  - Particulate sulfate
- Nitrogen species:
  - Particulate nitrate
  - Nitric acid
  - Particulate ammonium
- Metal Cations:
  - Particulate calcium
  - Particulate sodium
  - Particulate magnesium
  - Particulate potassium
- Particulate chloride
- Ozone
- Meteorological variables
- Information on land use and vegetation

CASTNET Site Measurements*

- **95 sites**
  - 93 locations (two sites collocated)
  - 65 EPA
  - 25 NPS
  - 5 BLM
  - 80 sites measure ozone
  - 15 sites operate a filter pack only
- **Trace Gas Sites**
  - NO_y
    - 6 EPA
    - 2 NPS
  - SO_2
    - 2 EPA
    - 2 NPS
  - CO
    - 1 EPA
    - 2 NPS
- **36 Sites with Meteorological Measurements**
  - 6 EPA sites
  - 24 NPS sites
  - 5 BLM sites

****Individual site histories*** - http://java.epa.gov/castnet/epa_jsp/sites.jsp

****Network changes listed in annual reports*** - http://java.epa.gov/castnet/documents.do

The CASTNET design is based on measurement of rural, regionally representative concentrations of sulfur and nitrogen species and O_3 in order to estimate dry deposition fluxes, detect and quantify trends, and define the spatial distribution of pollutants and gauge compliance with O_3 NAAQS. The goal of estimating dry deposition also requires the measurement of a variety of meteorological parameters used in the Multi-Layer Model (MLM) together with information on land use and vegetation within 1 kilometer (km) of the site.

The principal measurements of CASTNET are sulfur dioxide (SO_2), particulate sulfate (SO_4^{2-}), nitric acid (HNO_3), particulate nitrate (NO_3^-), and ammonium particulate (NH_4^+). In addition to sulfur and nitrogen pollutants, each CASTNET site also includes measurements of metal cations and chloride (Cl^-), and supporting information on vegetation and land use. Continuous measurements of O_3 concentrations are collected using O_3 analyzers at 80 sites.

Small footprint sites, which do not use a walk-in shelter, are operated at eight sites shown in Figure 1-1.

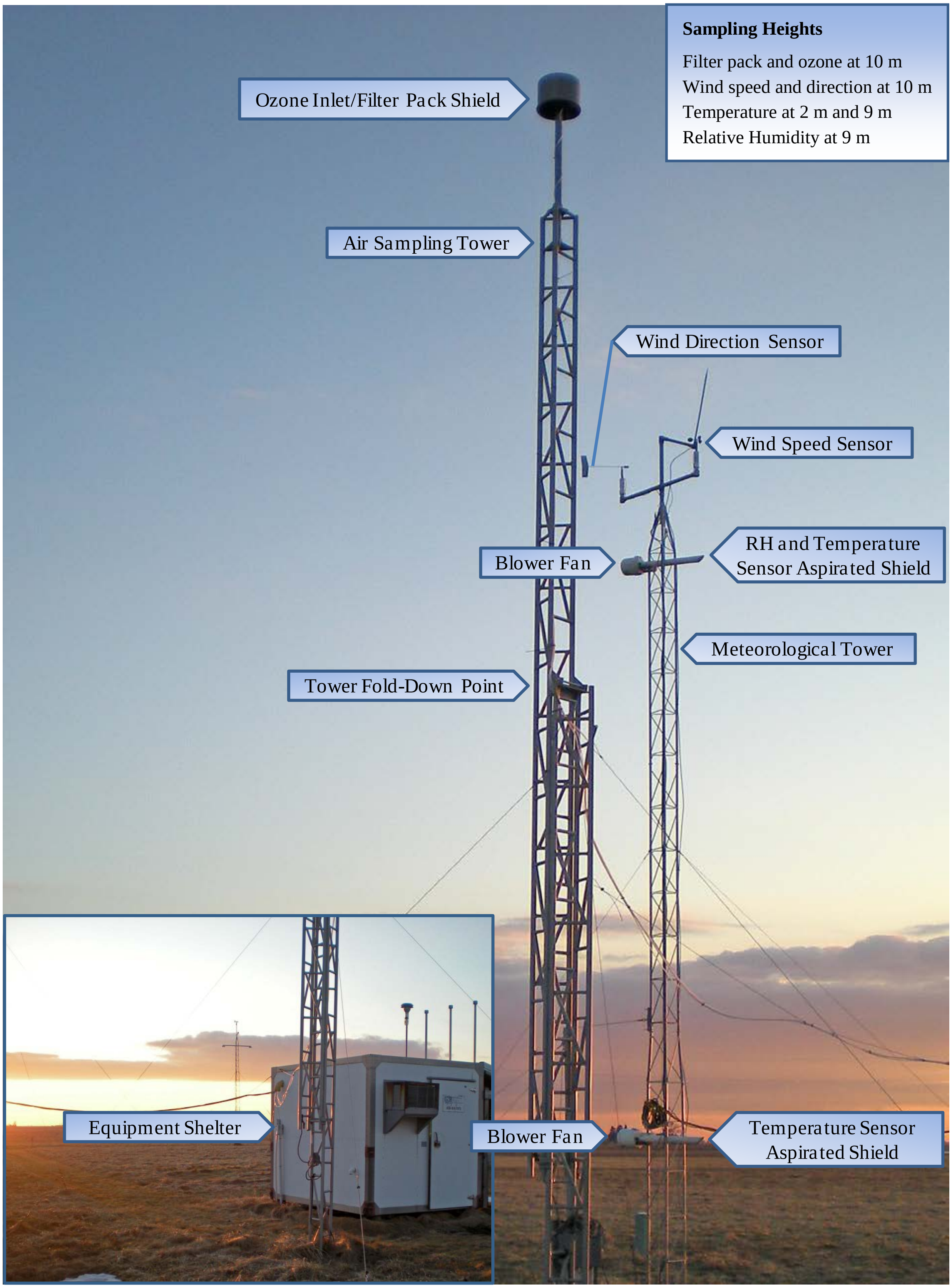
Trace-level gas monitoring for sulfur dioxide (SO_2), nitrogen oxide/total reactive oxides of nitrogen (NO/NO_y), and carbon monoxide (CO) is continuing at eight CASTNET sites. All CASTNET sites and the parameters measured at each site are listed in Table 1-1.

In addition to the air pollutant concentrations, six EPA-sponsored, five BLM-sponsored, and all NPS-sponsored CASTNET sites collect hourly meteorological measurements, which are used to understand atmospheric pollutant dispersion and, specifically, as input to the MLM, a numerical model used for estimating dry deposition to ecosystems in the atmospheric boundary layer. The six EPA-sponsored sites continuing all meteorological measurements are BEL116; BVL130; Palo Duro Canyon State Park, TX (PAL190); and Cherokee Nation, OK (CHE185); Pinedale, WY (PND165); and Indian River Lagoon, FL (IRL141). Nine-meter temperature is measured at all sites in the network to support filter pack concentration measurements. PND165 meteorological measurements are taken by BLM, and IRL141 meteorological systems are run by the Saint Johns River Water Management District (SJRWMD). While meteorological data collection is continuing at all NPS sites, NPS discontinued measurements of 2-meter temperature and surface wetness.

The five Wyoming sites are sponsored by BLM and are operated to support the Wyoming Air Resources Monitoring System (WARMS). The two New York sites are sponsored by the New York State Department of Environmental Conservation (NYSDEC) and New York State Energy Research and Development Authority (NYSERDA). The site in Vermont is sponsored by EPA. The WARMS sites measure temperature, barometric pressure, precipitation, relative humidity, scalar wind speed and direction, and solar radiation. The New York and Vermont sites operate filter packs but do not measure meteorological conditions as part of CASTNET.

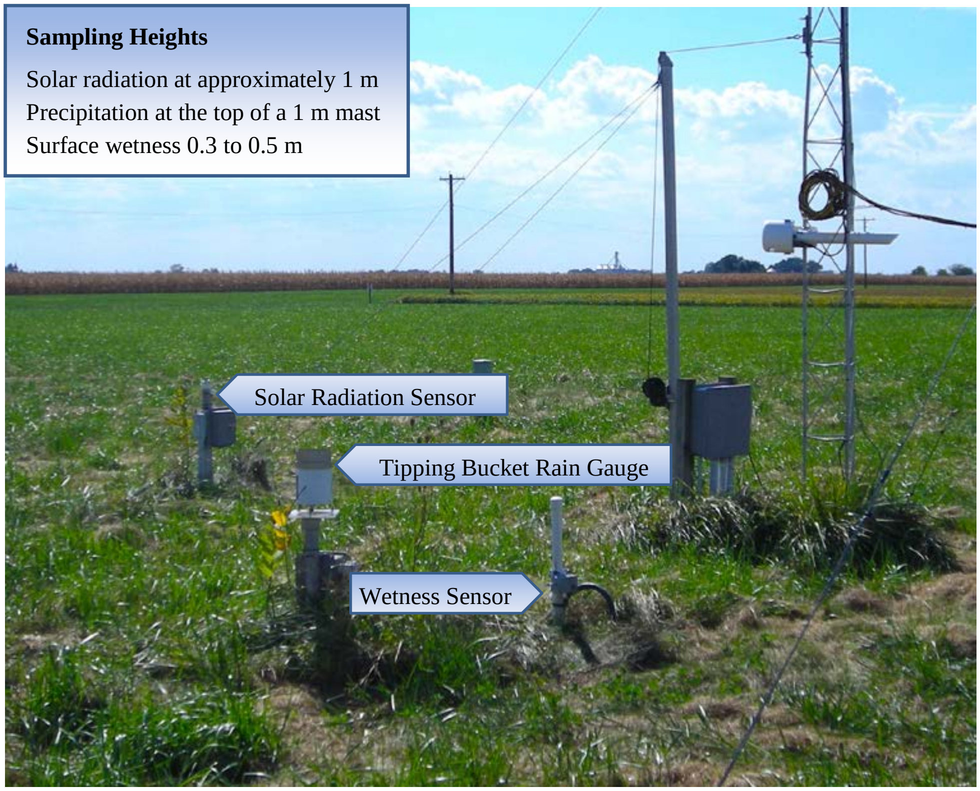
Figures 1-2 and 1-3 provide photographs that illustrate the typical configuration of monitoring instruments at CASTNET sites. Figure 1-2 depicts the air and meteorological sampling towers at Bondville, IL (BVL130). Additionally, a wet/dry bucket collector and a NOAH IV Total Precipitation rain gauge are included in Figure 1-3. These instruments are operated on behalf of the National Atmospheric Deposition Program (NADP)/National Trends Network (NTN). NADP/NTN collects wet deposition measurements at or near almost all CASTNET sites. The photograph in Figure 1-3 shows the CASTNET ground-level sensors, which include a tipping bucket rain gauge, a solar radiation sensor and a wetness sensor. Figure 1-4 provides a photograph of the small footprint site operated at Underhill, VT (UND002). The figure shows the sampling tower and the inside of the sampling box.

Figure 1-2 Typical CASTNET Air and Meteorological Sampling Towers and Instruments



Bondville, IL (BVL130) March 2010

Figure 1-3 Typical CASTNET Ground-Level Sensors



Bondville, IL (BVL130) September 2010

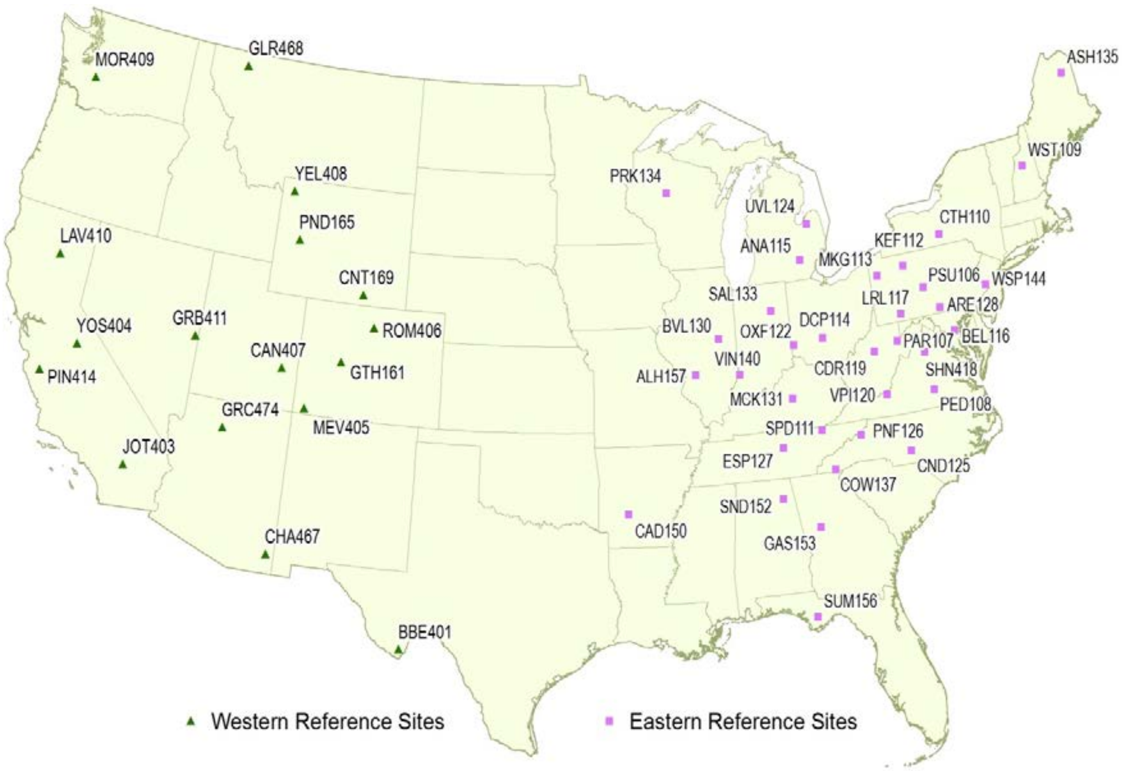
Figure 1-4 Small Footprint Site Operated at Underhill, VT

Interior of box

Underhill, VT (UND002)

Measurements from 34 CASTNET eastern and 16 western reference sites (Figure 1-5) are used to determine trends in concentrations and in rates of dry, wet, and total deposition. The 34 eastern sites have been reporting CASTNET measurements since at least 1990. The reference sites were selected using criteria similar to those used by EPA in its National Air Quality and Emissions Trends Report (2000). The criteria include site longevity and data completeness. The western reference sites have been operating since at least 1996.

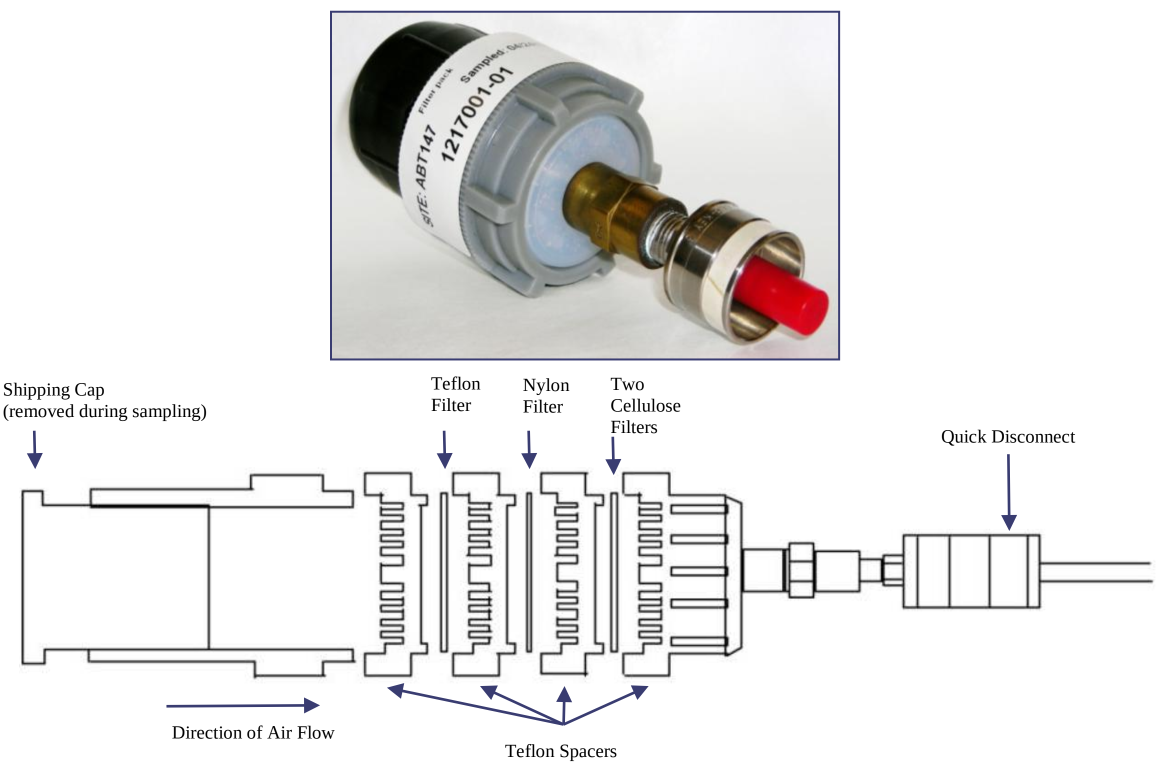
Figure 1-5 CASTNET Western and Eastern Reference Sites



CASTNET was designed primarily to measure trends in seasonal and annual average concentrations and to model depositions over many years. Consequently, measurement of weekly average concentrations was selected as the basic sampling strategy. Over the course of the seven days, air is drawn at a controlled flow rate through an open-face, 3-stage filter pack (Figure 1-6) mounted atop a 10-meter tower to collect air pollutants in the form of gases and particles. The first stage of the filter pack encloses a Teflon filter; the second, a nylon filter; and the third holds two potassium carbonate (K_2CO_3)-impregnated cellulose filters. The filter pack is changed out each Tuesday and shipped to the analytical chemistry laboratory for analysis.

The filter packs are prepared, loaded, shipped, received, extracted, and analyzed at the Amec Foster Wheeler Gainesville, FL laboratory. Following receipt from the field, exposed Teflon filters and blanks are extracted and then analyzed for SO_4^{2-}, NO_3^-, and concentrations of Cl^- by micromembrane-suppressed ion chromatography (IC) and also for NH_4^+ by the automated indophenol method with the Bran+Luebbe AutoAnalyzer 3. Additionally, Teflon filter extracts are analyzed for calcium (Ca^{2+}), sodium (Na^+), magnesium (Mg^{2+}), and potassium (K^+) by inductively coupled plasma-atomic emission spectrometry (ICP-AES) using a Perkin Elmer Optima 7300 Dual View spectrometer. The cellulose filter extracts are analyzed for SO_2 as SO_4^{2-} using IC.

Figure 1-6 Three-Stage Filter Pack



Cellulose	=	Gaseous: SO_2
Nylon	=	Gaseous: HNO_3, SO_2
Teflon	=	Particulate: SO_4^{2-}, NO_3^-, NH_4^+, K^+, Ca^{2+}, Mg^{2+}, Na^+, Cl^-

Filters used in the CASTNET 3-Stage Filter Pack

- One (1) Teflon filter:
  Whatman membrane filter or equivalent consisting of polytetrafluoroethelyne (PTFE) with polypropylene backing / 47 mm diameter / pore size 1.0 micrometer (µm)
- One (1) nylon filter:
  PALL Life Sciences Nylasorb filter or equivalent consisting of a nylon membrane / 47 mm diameter / pore size 1.0 µm
- Two (2) cellulose filters impregnated with K_2CO_3:
  Whatman 41 Ashless Circle filter or equivalent / 47 mm diameter

The nylon filter extracts are analyzed via IC for HNO_3 as nitrogen and for SO_2 as SO_4^{2-}. The SO_2 concentrations from the cellulose and nylon filters are summed to obtain total SO_2.

CASTNET also measures hourly O_3 concentrations, one of the major components of smog. Ambient O_3 concentrations at EPA-, NPS- and BLM-sponsored CASTNET sites are measured via ultraviolet (UV) absorbance with a variety of gas analyzers. Zero, span, and precision (z/s/p) checks of the O_3 analyzer at all ozone sites are performed daily. CASTNET was not originally designed to operate as a regulatory network. However, CASTNET O_3 monitoring systems at EPA-sponsored sites, except for the site at HOW191, ME, now comply with regulatory monitoring requirements described in 40 CFR Part 58, Appendix A (EPA 2014), and O_3 data collected are submitted monthly to the EPA Air Quality System (AQS). The O_3 monitoring systems at NPS-sponsored sites comply with regulatory requirements and NPS data are also submitted monthly to AQS. In addition, the trace-level gas concentration data are submitted monthly to AQS.

In addition to the air pollutant concentrations, hourly meteorological measurements are used as input to the MLM, a numerical model used for estimating dry deposition to ecosystems in the atmospheric boundary layer. The MLM utilizes meteorological data to model the deposition velocity (V_d) of a component, i.e. its rate of deposition. As of January 2011, meteorological parameters were discontinued at all but five of the EPA-sponsored CASTNET sites: PAL190, TX; CHE185, OK; BVL130, IL; and BEL116, MD; and BFT142, NC. In the first quarter 2013, meteorological (and NO_y) measurements were discontinued at BFT142, NC. In order to replace missing values for V_d caused by missing and discontinued meteorological parameters and improve data completeness, EPA selected a method based on the process developed by Bowker *et al*. (2011) to substitute hour-specific historical averages for missing V_d values at specific sites. The new hybrid approach (EPA, 2014a), which incorporates air quality monitoring data with Community Multiscale Air Quality Modeling System (CMAQ) output, was used for spatial analyses of dry and total deposition in 2015.

The maps in Figures 1-7 through 1-9 show 2014 annual mean SO_2 and total nitrate (HNO_3 + NO_3^-) concentration and fourth highest daily maximum 8-hour average (DM8A) O_3 concentrations for 2014 across the United States.

Figure 1-7 Annual Mean SO_2 Concentrations ($\mu g/m^3$) for 2014

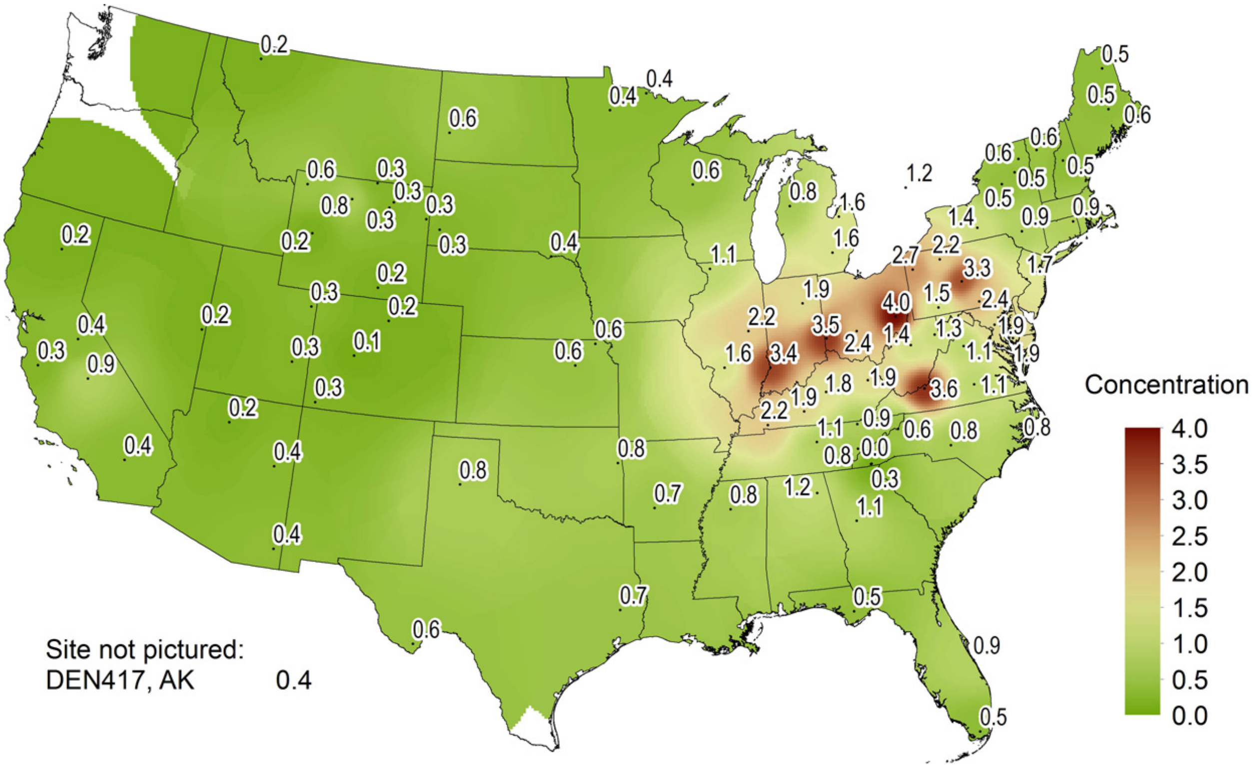


Figure 1-8 Annual Mean Total Nitrate Concentrations ($\mu g/m^3$) for 2014

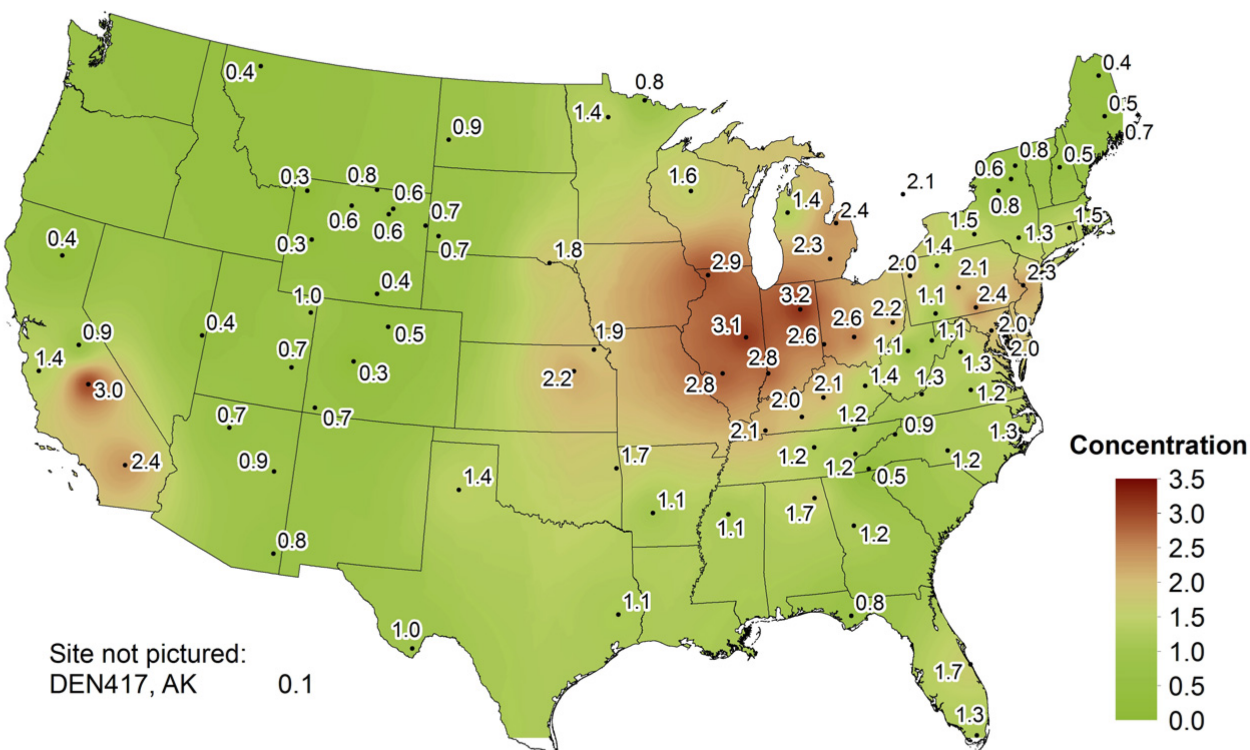
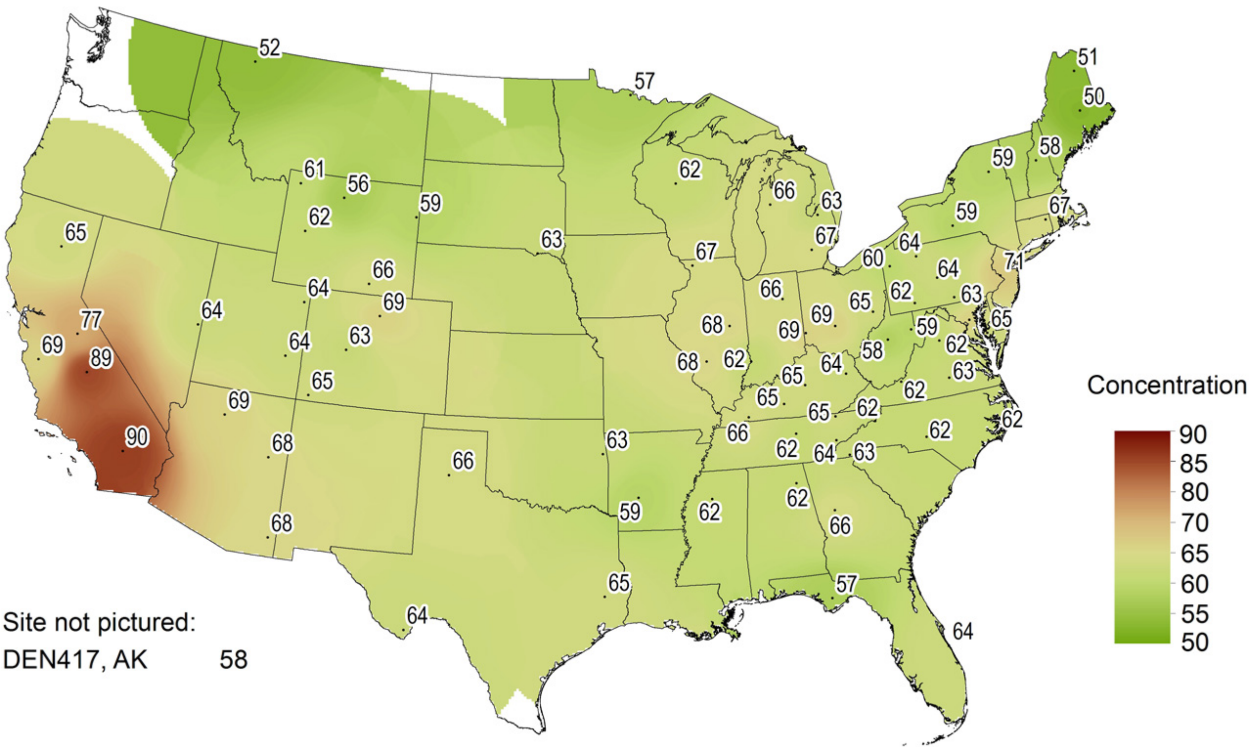


Figure 1-9 Fourth Highest DM8A O_3 Concentrations (ppb) for 2014



Dry deposition processes are modeled as resistances to deposition. The original network design was based on the assumption that dry deposition or flux could be estimated as the linear product of measured pollutant concentration (C) and modeled V_d. The equation to estimate flux is shown in Figure 1-10, which, historically, has been the basis for CASTNET dry deposition estimates. Measured atmospheric concentrations are calculated based on the mass of each analyte in each filter extract and the volume of air sampled. The deposition velocity is influenced by meteorological conditions, vegetation, and atmospheric and plant chemistry. The deposition velocity values for each site are calculated for each hour of each year using the MLM. The MLM is summarized by Meyers *et al*. (1998) and Finkelstein *et al*. (2000). The data used in the MLM to estimate dry deposition are derived from meteorological measurements and pollutant concentrations taken at the site together with an estimation of the vegetation leaf-out and leaf area index (LAI).

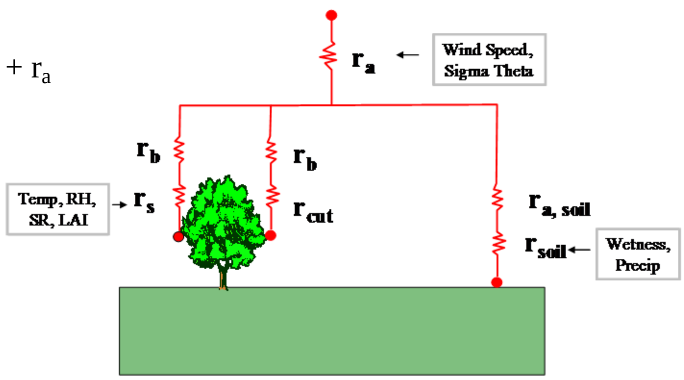
EPA discontinued meteorological measurements at all but four EPA-sponsored CASTNET sites. However, BLM collects meteorological measurements at PND165, WY and SJRWMD collects meteorological data at IRL141, FL. NPS sites are continuing meteorological measurements. Consequently, as an interim approach, missing deposition velocity (V_d) values resulting from missing meteorological data were replaced based on the results in Bowker *et al*. (2011). Bowker's method substitutes hour-specific historical averages of V_d for missing V_d values at specific sites. The substitution procedure was shown to result in long-term, unbiased estimates of the annual mean V_d. For 2013 measurements a variation of Bowker's method was applied to all sites with discontinued/missing meteorological data. Beginning with 2014 measurements the new total deposition (TDEP) hybrid approach (EPA, 2014a), which incorporates CMAQ output with air quality monitoring data, will be used for spatial analyses of dry and total deposition. The TDEP approach is summarized in the 2012 CASTNET Annual Report (Amec Foster Wheeler, 2014) and on the EPA total deposition web page (ftp://ftp.epa.gov/castnet/tdep/Total_Deposition_Documentation_current.pdf).

In summary, the schematic of the MLM in Figure 1-10 shows the relationships among the various resistances and illustrates the meteorological and other data that are required as model input. CASTNET deposition velocities and fluxes are calculated using the MLM or estimated from historical data using Bowker's method. Beginning in 2015, the TDEP approach became the primary method to estimate dry and wet deposition.

Figure 1-10 Multi-Layer Model

$$\text{Flux} = \overline{C} \; x \; \overline{V_d}$$

$$1/V_d = \frac{1}{\frac{1}{r_s + r_b} + \frac{1}{r_{cut} + r_b} + \frac{1}{r_{a,\,soil} + r_{soil}}} + r_a$$



Resistances

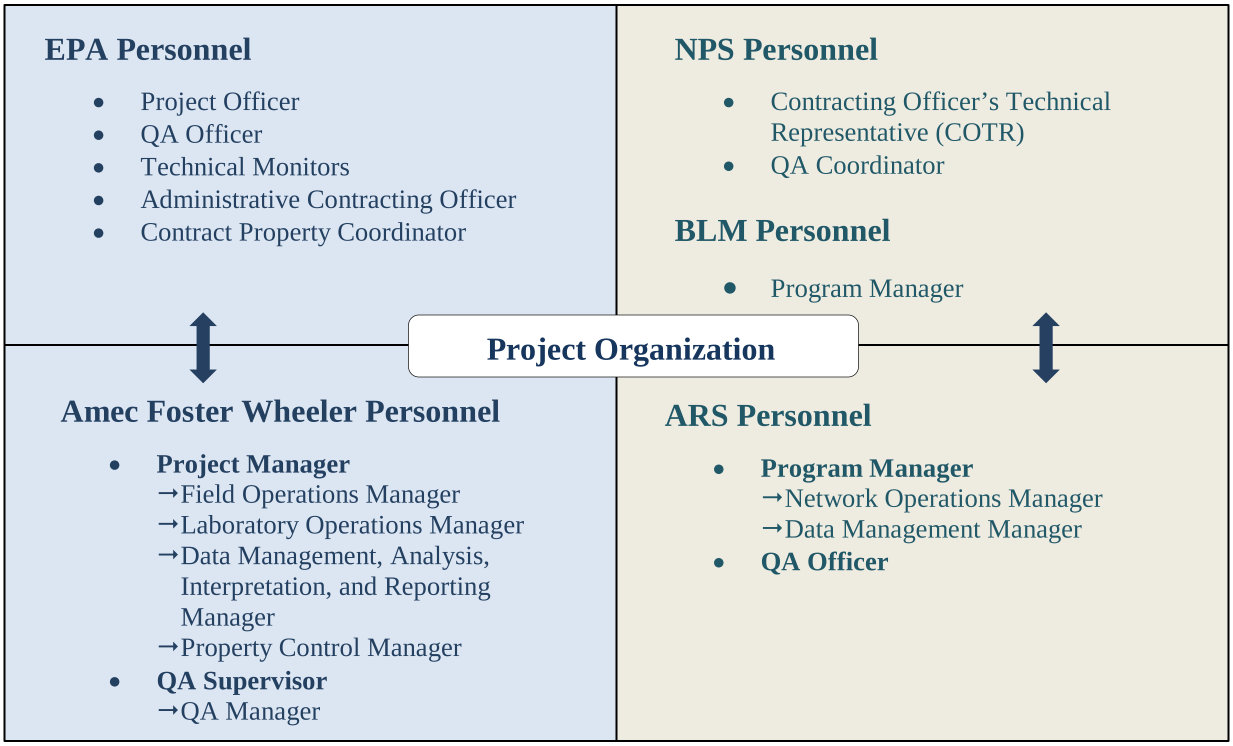
- r_a = aerodynamic
- $r_{a,\,soil}$ = aerodynamic near soil
- r_b = boundary layer in thin layer at surface
- r_{cut} = cuticular
- r_s = stomatal
- r_{soil} = soil

1.2 Project Organization

The primary sponsors for the management and operation of CASTNET are EPA, NPS, and BLM. As depicted in Figure 1-11, EPA's contractor is Amec Foster Wheeler and the contractor for NPS and BLM is Air Resource Specialists, Inc. (ARS). The EPA/Amec Foster Wheeler CASTNET project organization is shown in Figure 1-12. Select positions are designated in the appropriate boxes on the organizational chart. Specific roles, responsibilities, and authorities of Amec Foster Wheeler positions within CASTNET are described in Table 1-2. The NPS/BLM/ARS project organization is shown in Figure 1-13. While all program partners cooperate in managing and operating the network, EPA is the primary program sponsor and, therefore, establishes the program requirements. Each sponsoring agency has established their own monitoring objectives; however, there are common network objectives (Section 1.1) across the agencies. The contractor for each agency collects and validates network data according to the

QA program described in this QAPP and its appendices. Amec Foster Wheeler is responsible for common database management, data reporting, and all filter pack analyses. The program sponsors and their contractors communicate routinely through regularly scheduled meetings.

Figure 1-11 CASTNET Project Organization



The Amec Foster Wheeler CASTNET team is led by the Project Manager who interacts directly with EPA. The Amec Foster Wheeler team is organized according to its main operational functions:

- Field Operations,
- Laboratory Operations, and
- Data Management, Analysis, Interpretation, and Reporting.

An independent QA Manager leads the QA/QC assessment activities. The QA Manager reports to the Project QA Supervisor, who reports directly to the Amec Foster Wheeler Principal-In-Charge (Figure 1-12). The QA Manager is the overall leader for the CASTNET QA/QC program. He audits all field and laboratory data and reviews all reports and supporting analyses. He oversees the assessment program described in this QAPP and coordinates all QA activities.

Figure 1-12 EPA/Amec Foster Wheeler CASTNET Project Organization

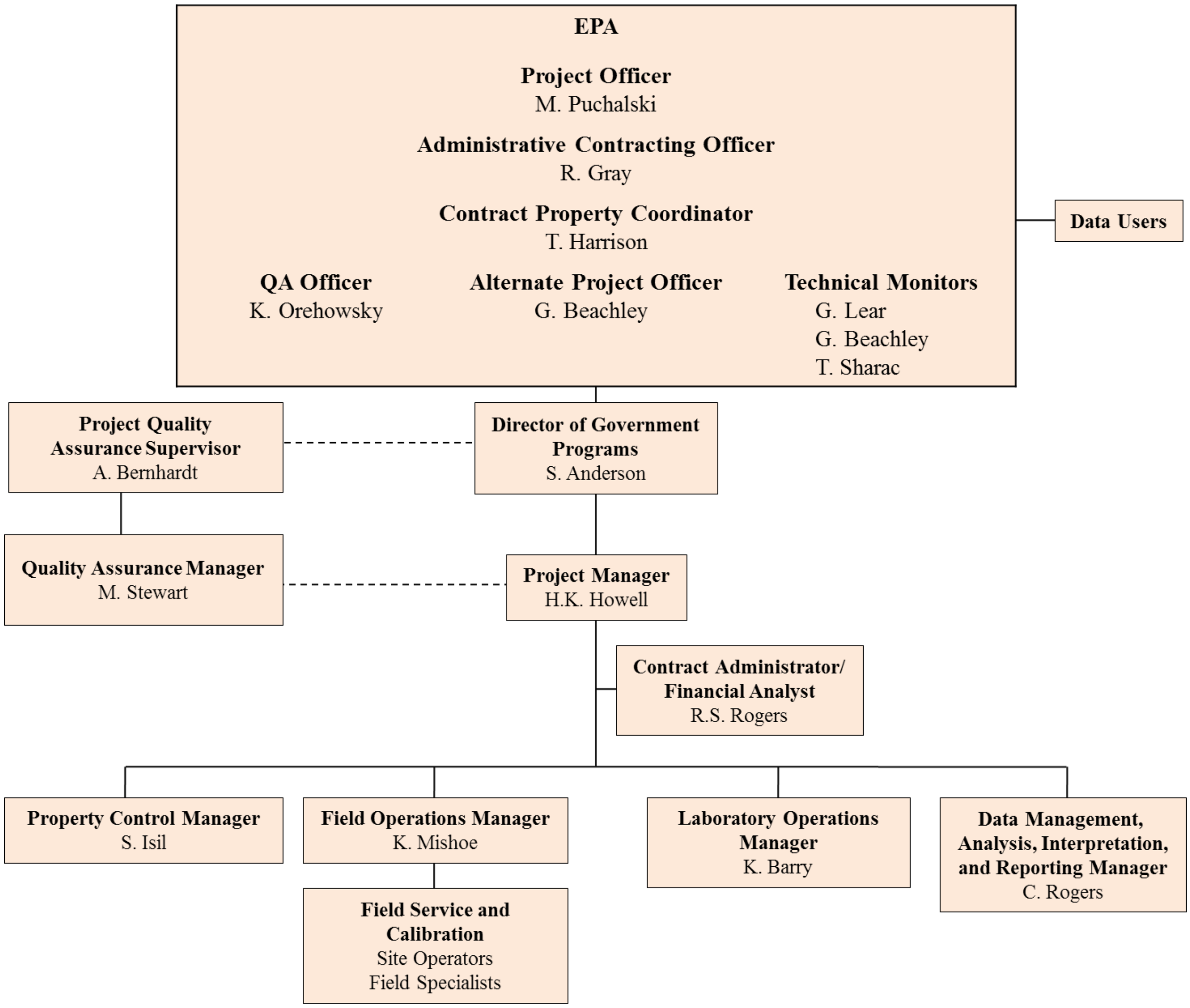
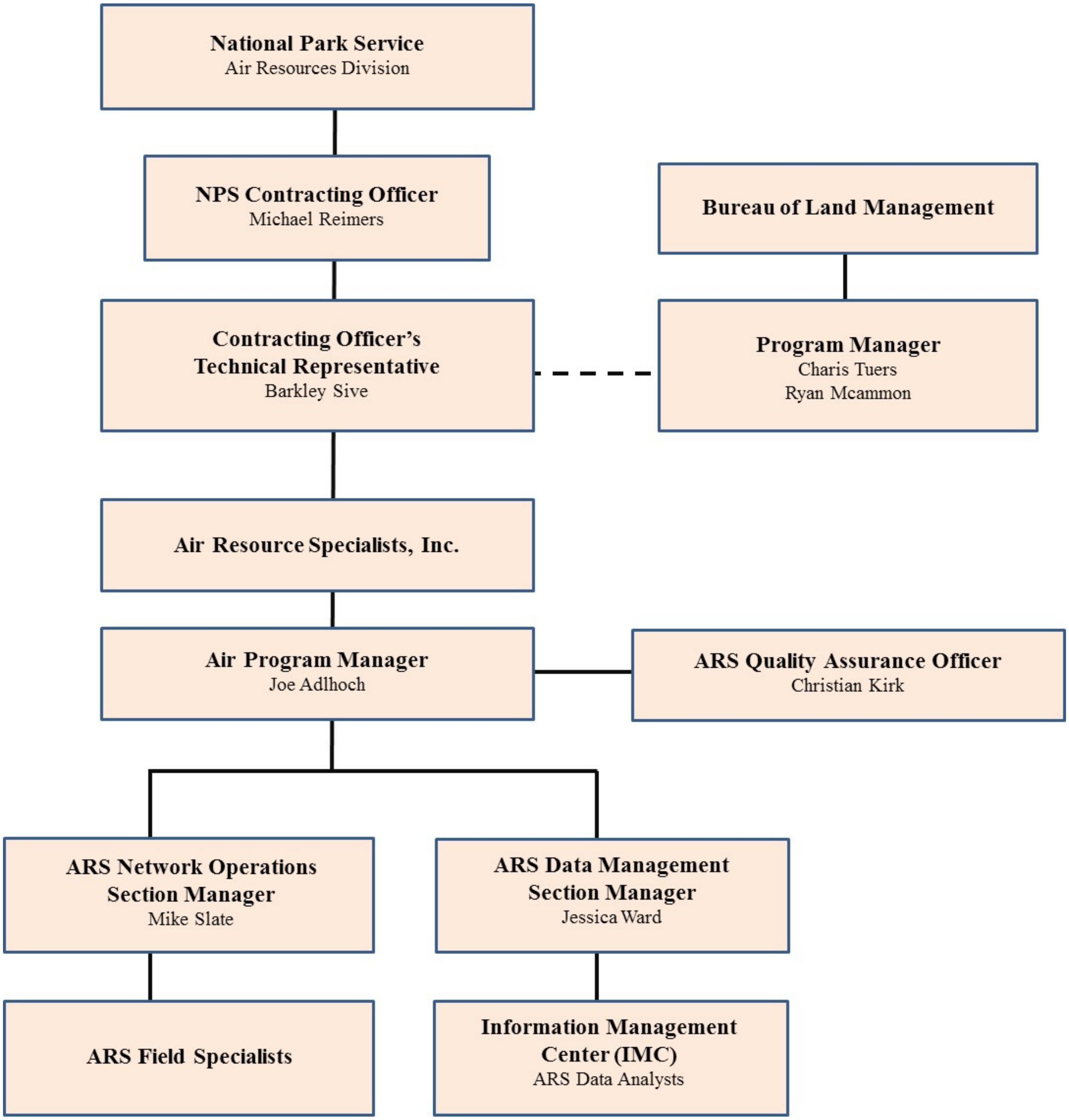


Figure 1-13 NPS/BLM/ARS CASTNET Project Organization



1.3 Network Description

CASTNET's primary goal is to operate an effective monitoring and assessment network for development of a scientific database to evaluate the results of emission control strategies. Establishing patterns and trends of dry deposition is an important objective. CASTNET measures concentrations of sulfur and nitrogen species and estimates dry deposition fluxes from modeled V_d. CASTNET also measures O_3 concentrations at most sites.

CASTNET is comprised of 65 sites sponsored by EPA, 25 sites operated by NPS at various national parks and monuments and five by BLM. EPA, NPS and BLM are responsible for operating their sites under a common set of QA standards and similar monitoring and data validation protocols. The measurements from the EPA, NPS and BLM sites are merged into a single database and delivered to EPA quarterly.

CASTNET site locations are shown in Figure 1-1. Ninety-five sites are operational at 93 distinct locations. All 95 sites are equipped with filter packs for measurement of pollutant concentrations and estimation of deposition rates. Two sites include collocated sampling systems for determining network precision. Eighty sites measure O_3. Precision for O_3 is calculated per analyzer as described later in Table 4-12. Table 1-1 lists, by state, all of the CASTNET sites and the operational characteristics for each site. The operational information includes site location, start date, latitude, longitude, elevation, and types of measurements. The table also indicates the nearest NADP/NTN wet deposition site and its distance from the CASTNET site. Also included is information on the type of surrounding terrain and land use, a designation regarding the representativeness of each site with respect to MLM modeling assumptions, and the sponsoring agency (EPA, NPS or BLM). Table 1-3 provides similar information for the discontinued sites. Table 1-3 lists WFM105, NY, which was operated as a standard CASTNET site until March 1993. WFM105, NY was restarted in November 2012 as a small footprint site. WFM007 operates a filter pack near the mountain summit.

In Figure 1-1 and Table 1-1, CASTNET sites are designated as 100-series sites for EPA-sponsored sites, 400-series for NPS-sponsored sites, and 600-series for BLM sites in Wyoming. The alphanumeric designation includes three letters and three numbers. The letters provide an approximate description of the site name or location, e.g., IRL – Indian River Lagoon, FL. The first digit designates sponsorship (1, 4 or 6) or if the site had included visibility/aerosol sampling equipment (5) in Tables 1-1 and 1-3. The second and third digits have no specific meaning.

One of the CASTNET sites is located in Egbert, Ontario, Canada (EGB181, ON). At this site, a standard weekly composite CASTNET filter pack is collected. This set-up provides the means to compare results from CASTNET with the Canadian Air and Precipitation Monitoring Network (CAPMoN), which collects 24-hour filter pack samples. O_3 is not measured at EGB181.

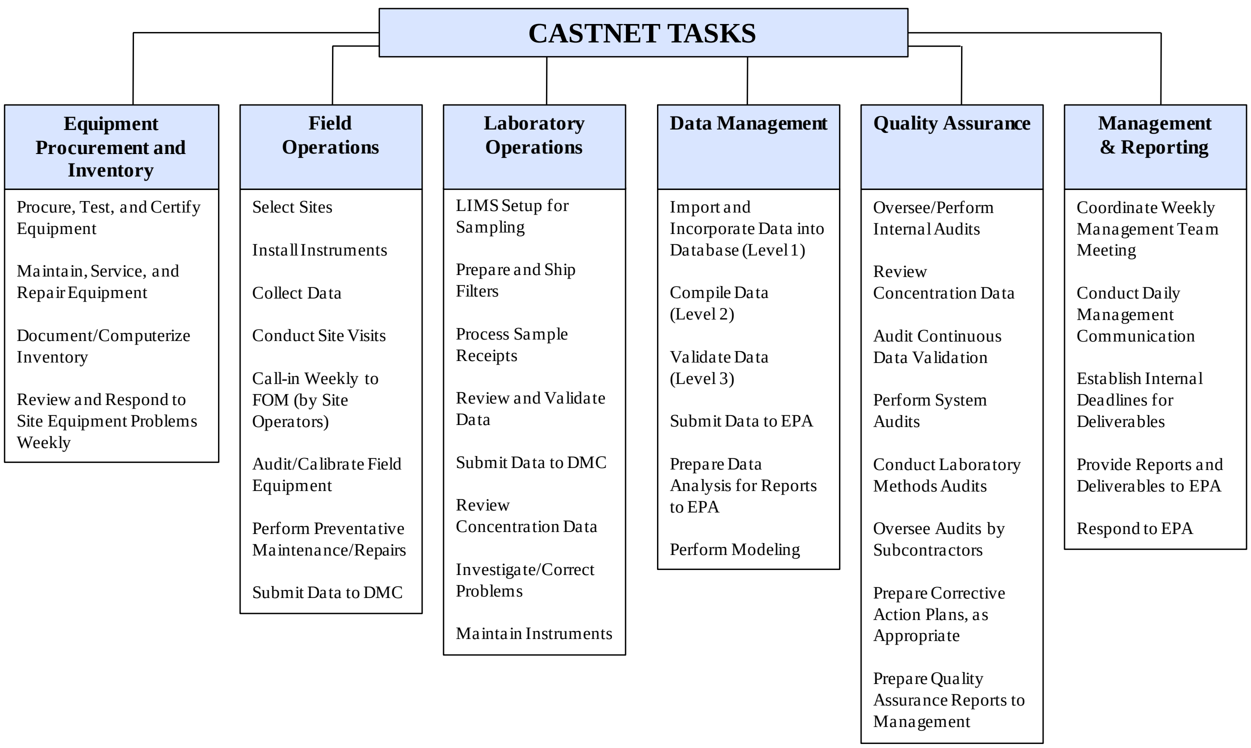
1.3.1 Task Descriptions

The operation of CASTNET and the work required to meet project objectives can be separated into six basic tasks.

1. Equipment Procurement and Inventory
2. Field Operations
3. Laboratory Operations
4. Data Management
5. Quality Assurance
6. Management and Reporting

These tasks and their key elements are presented in Figure 1-14. The following subsections provide a brief description of each task.

Figure 1-14 Overview of CASTNET Tasks



1.3.1.1 Equipment Procurement and Inventory

CASTNET Meteorological Measurements

- Winds:
  - Speed
  - Direction
  - Sigma theta (standard deviation of direction)
- Temperature:
  - Temperature (at 2 and 9 meters)
  - Delta temperature (difference between 2 and 9 meters)
- Relative Humidity
- Precipitation
- Solar Radiation
- Surface Wetness

CASTNET deploys a standard set (Figures 1-2, 1-3, and 1-4) of air pollutant sampling and meteorological monitoring equipment for the purpose of estimating dry deposition. This equipment includes an open-face, three-stage filter pack (Figure 1-6) to collect particulate and gaseous sulfur and nitrogen species, chloride, and base cations. A mass flow controller (MFC) is used to maintain a constant flow rate through the filter pack. O_3 concentrations are measured using analyzers based on UV absorbance. Four EPA-sponsored sites employ meteorological sensors to measure scalar and vector wind speed, the standard deviation of horizontal wind direction (sigma theta), temperature, temperature difference at 2 and 9m, relative humidity, precipitation, solar radiation, and surface wetness. NPS-sponsored sites measure these parameters with the exception of 2m temperature, which were discontinued at most NPS sites in 2011. During 2014, delta temperature was measured at the four EPA sites plus the NPS sites at Acadia National Park, ME (ACA416); Great Smoky Mountains National Park, TN (GRS420); and Rocky Mountain National Park, CO (ROM406). Surface wetness was measured at the four EPA sites.

Equipment that is purchased for the project meets the following requirements:

- Meets established criteria [e.g., Prevention of Significant Deterioration (PSD) Guidelines (EPA, 2015a) and EPA equivalency] or project objectives
- Compatible with network objectives, other networks, and system components
- Proven durability for project use
- Proven performance
- Cost effectiveness (including maintenance)

Equipment procurement is carried out according to the standard operating procedures (SOP) described in the CASTNET Government Property Control SOP that are included as Appendix 9.

The CASTNET Property Control Manager (PCM) or designee is responsible for the ordering and receipt of equipment, and for maintaining the property control information in the CASTNET database. All property entries into the database are checked by the PCM or Project Manager. The following procedures are employed for all equipment received by Amec Foster Wheeler:

- Physical inspection of the shipping container for damage
- Verification of the packing list by matching quantity and serial numbers of shipped items
- Assignment of a unique EPA 6-digit inventory number and cross-reference with serial number

- Entry of inventory numbers and equipment information into the CASTNET database

After receipt and login, if applicable, each item of monitoring equipment undergoes acceptance testing. These tests include comparison of instrument outputs to known, calibrated values and checks of zero and span drift, noise levels, response time, and detection limits. Equipment status is updated continually into the CASTNET inventory computer utility in the CASTNET Data Management Center Application (CDMSA). A written equipment report including itemized nonexpendable and expendable government equipment is provided annually to EPA and on request by the Project Officer or Administrative Contracting Officer.

1.3.1.2 Field Operations

Field operations encompass site selection, site installation, and site operations. The following subsections provide descriptions of these tasks.

1.3.1.2.1 Site Selection and Installation

The network is designed to satisfy the CASTNET objectives and to support the investigation of the relationships between emissions and atmospheric concentrations and dry deposition fluxes. The eastern sites were selected by considering:

- Regional representativeness,
- Avoidance of nearby pollution sources,
- Long-term availability,
- Accessibility, and
- Good overall geographic distribution of sites to ensure meaningful nationwide status and trends information.

Regional representativeness refers to the overall similarity of the site to a characteristic area (typically 100 km by 100 km) surrounding the site. This implies that concentrations must be representative of that area. Thus, major sources of SO_2 and/or oxides of nitrogen (NO_x) are avoided to reduce the likelihood of locally perturbed concentration fields. In addition, land use near the site matches, as much as possible, the dominant regional land use to make appropriate use of meteorological data in V_d calculations. Monitoring sites also need to be available for extended periods (40 years) in order to assess dry deposition trends. Finally, sites need to be accessible all year by field operations personnel for sampling, maintenance, and calibration activities.

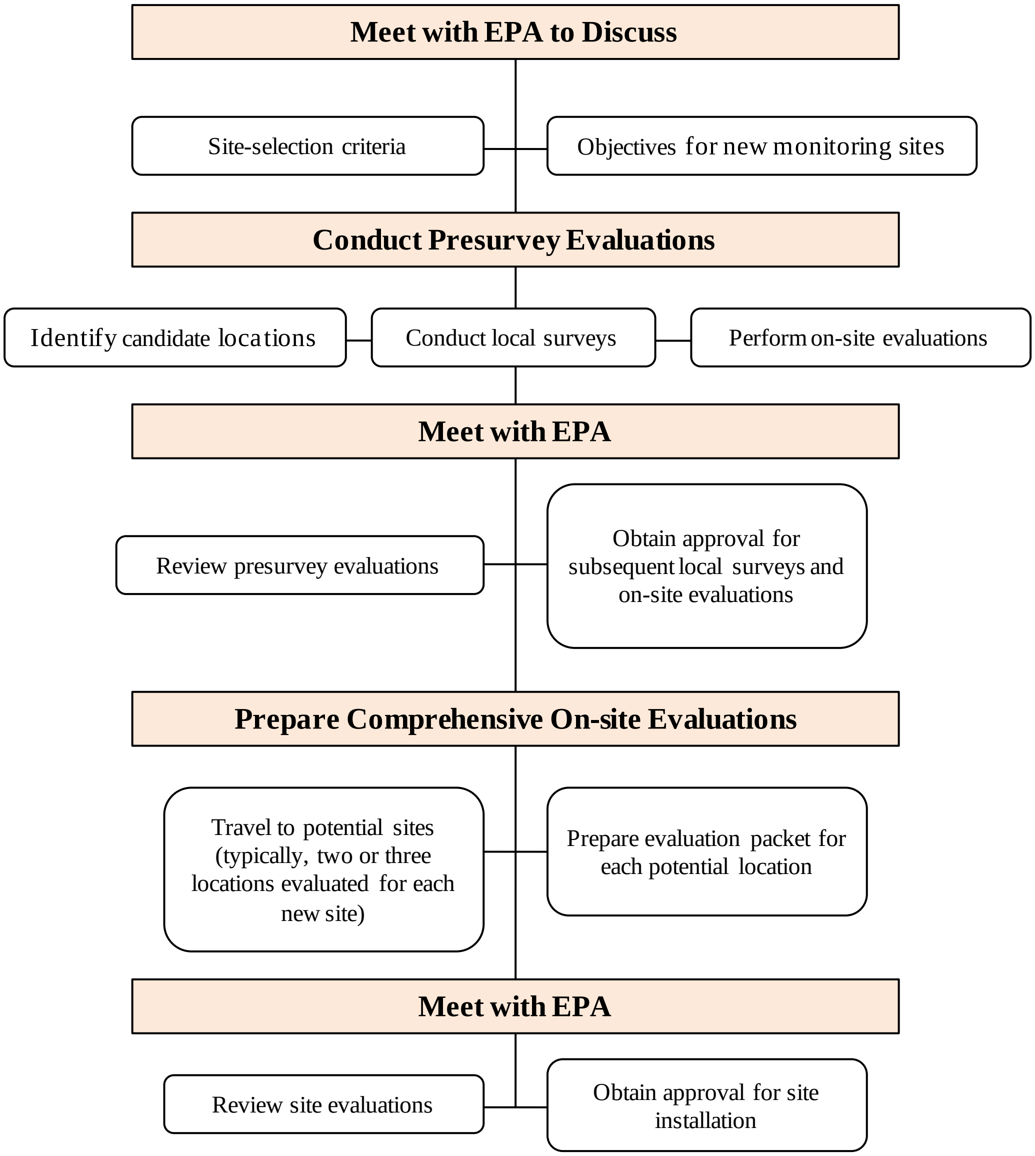
For the western United States, the relatively limited number of sites and higher geographic diversity of the region precludes rigorous determination of spatial patterns. Therefore, site selection focuses primarily on locations where natural resources are at risk (e.g., national parks) and where specific research issues can be addressed. These locations include calibrated watersheds such as Centennial, Wyoming (CNT169, WY), in which dry deposition information is needed to complete geochemical cycles for sulfur, nitrogen, and alkalinity.

The five-step site selection process illustrated in Figure 1-15 was followed for eastern sites established before 2002. More recently, CASTNET sites were selected in response to expressed interest by Native American tribes, government agencies (e.g., BLM), and universities and in an attempt to fill gaps in geographic coverage across the United States. Site selection includes completing any special arrangements required for a site. Table 1-1 lists the start date for each site.

Site-specific criteria also play a part in the site selection process. These criteria relate to adequate exposure of the sensors to ambient conditions in the immediate vicinity of a prospective monitoring site. Specifically, they concern local features that may perturb air quality and meteorological observations. Local sources of air contaminants and local features that may influence wind speed, wind direction, turbulence, and deposition patterns are the focus of these criteria.

For eastern sites established before 2002, the CASTNET site selection process followed the five-step procedure shown in Figure 1-15. Site selection procedures differ somewhat for different types of sites (traditional, filter pack only or gaseous pollutant monitoring) as discussed in Section 2.2). Currently, monitoring locations are often offered or recommended by tribal or governmental agencies. For example, the new sites in Wyoming were recommended by BLM. In these cases the on-site evaluations were limited to the environs of the recommended site locations. Limited site evaluations are more typical today. On the other hand, most of the CASTNET sites that were operated during NDDN and prior to 2002 underwent the full site selection process.

Figure 1-15 CASTNET Site Selection Process



1.3.1.2.2 Site Operations for Ambient Concentration and Meteorological Monitoring

CASTNET sampling is conducted on a weekly basis (from 0900 local time on Tuesday to 0900 the following Tuesday). Over the course of the week, air is drawn through the filter pack at a controlled flow rate to collect particles and selected gases on a sequence of filters (Figure 1-16). In general, sample flow rates are set to 1.50 liters per minute (lpm) in the east and at a higher rate of 3.00 lpm in the west due to the lower pollutant concentrations generally found in the western United States. The first filter, a Teflon filter, collects particulate SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Mg^{2+}, and Ca^{2+}. The second filter, a nylon filter, collects HNO_3 gas. The third filter is a set of two cellulose fiber filters impregnated with K_2CO_3 to collect SO_2. Some of the SO_2 is also trapped by the nylon filter, so the SO_2 collected on the nylon and cellulose filters are summed to provide weekly concentrations. Flow rate, ambient O_3 and trace pollutant concentrations and meteorological measurements are polled daily through remote connection to the data logger.

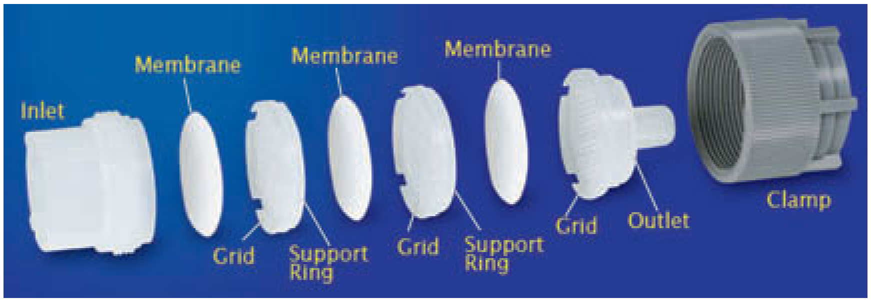
1.3.1.3 Laboratory Operations

The CASTNET laboratory at Amec Foster Wheeler is responsible for the preparation and analysis of the filters exposed on the three-stage filter pack from the dry deposition sites. The sampling media and analytical instrumentation are based on EPA reference methods. The CASTNET laboratory (analytical and field) is certified under the ISO/IEC accreditation by A2LA for a scope of test methods, which include those utilized for exposed CASTNET filters, at its primary facility and at remote monitoring stations.

CASTNET laboratory operations include preparation and shipment of sampling kits to site operators, receipt and analysis of sampling media, reporting of sample and QC data to the Data Management Center (DMC), and preparation of quarterly QC summaries. The CASTNET laboratory stores all sample extracts in a temperature controlled environment for one year after extraction. The extracts are then transferred to ambient storage for an additional year. Sample extracts may be discarded two years after extraction.

Amec Foster Wheeler uses the laboratory information management system (LIMS) Element Data System (Element) to provide a platform on which scientists manage, control, report, and provide feedback on laboratory performance. Element is used to organize and schedule the analyses performed by the CASTNET laboratory.

Figure 1-16 Filter Pack Assembly



The CASTNET laboratory prepares the open-face, three-stage filter packs for field sampling. Figures 1-6 and 1-16 illustrate the filter pack contents and assembly. The filter packs are prepared, loaded, shipped, received, extracted, and analyzed by Amec Foster Wheeler personnel at the Gainesville, FL laboratory. Following receipt from the field, exposed filters and blanks are extracted and then analyzed for SO_4^{2-}, NO_3^-, and Cl^- by micromembrane-suppressed IC. Teflon filter extracts are also analyzed for NH_4^+ by the automated indophenol method with the Bran+Luebbe AutoAnalyzer 3 (AA3). The filter extracts are additionally analyzed for Na^+, K^+, Mg^{2+}, and Ca^{2+} by ICP-AES using a Perkin Elmer Optima 7300 DV spectrometer. Results of all valid analyses are stored in Element.

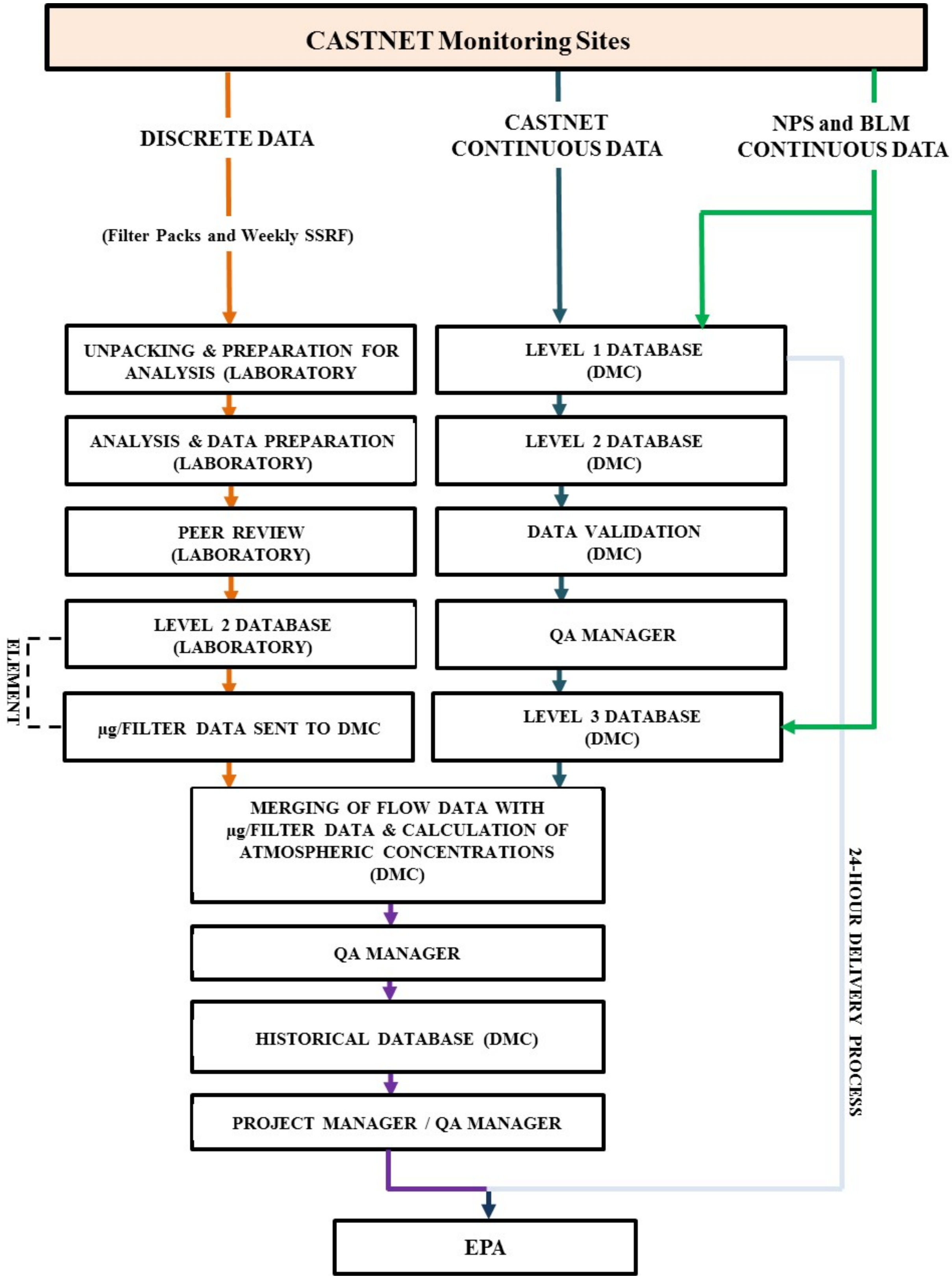
1.3.1.4 Data Management

The CASTNET database has been designed to support the project goal of providing information for assessing the effectiveness of ongoing and future emission reductions mandated under the CAAA. Two principal functions of CASTNET data management are the routine delivery of data to EPA and the analysis of data for presentation in project reports. The CASTNET data are managed and analyzed using Microsoft (MS) SQL Server and Oracle 11g Release 2, two fully relational database management systems (RDBMS). Defined tables are used to archive all measurements and supporting data. The Oracle database is also used for data archival and delivery of data to EPA. The database contains archives of concentrations measured on exposed filters; continuous meteorological, O_3, flow, and trace gas data; and MLM output of hourly, weekly, quarterly, and annual dry deposition fluxes over the period beginning in 1987.

1.3.1.4.1 Field Data

Field data, or continuous data, are handled by the DMC. The DMC activities consist of five major operations: data acquisition, data management, data validation, model operation, and data transmittal to EPA. CASTNET data flow is illustrated in Figure 1-17.

Figure 1-17 CASTNET Data Flow



Amec Foster Wheeler utilizes an automated Data Acquisition System (DAS) for collection of data from the sites. All EPA-sponsored sites, except for CHE185, OK, use Campbell Scientific CR3000 or CR850 Micrologger data loggers for on-site data collection. The CHE185, OK site uses an Environmental Systems Corporation (ESC) data logger and DataLink polling software. Measured data are collected hourly from a centralized server and automatically uploaded into the Amec Foster Wheeler database using Campbell's LoggerNet polling software. CASTNET Internet protocol (IP)-enabled sites use a Sierra Wireless AirLink Raven X modem to access the Internet through cellular service that provides a public static IP address. Multiple Ethernet-enabled devices share the Internet connection, as well as communicate locally. All sites capable of receiving cellular service are enabled for IP communication. Three sites are served by telephone modems.

The data logger program, which was developed by Amec Foster Wheeler, allows site operators and site calibrators access to CR3000 and CR850 data. The program acquires data in seven tables and also flags the data according to their status.

After daily polling of all stations, Level 1 validation procedures are initiated. Level 1 validation consists of a set of automated screening protocols that consist of three Visual Basic executables and two database triggers. The triggers initiate the transfer of data between tables, translation of data status flags, and data screening. The executables create the data template, generate reports on the completeness of the data and the results of data screening, and archive the data. Level 1 validation includes a data analyst reviewing data at the end of a month and retrieving missing data using LoggerNet. Level 1 validation is complete when the data for all time periods for all of the sampling sites have been accounted for, data have been recovered from the on-site data loggers and entered into the database, and sources of missing data are documented. The screened data are delivered via FTP to EPA daily. Hourly continuous measurements are delivered to EPA AIRNow (www.airnow.gov) to support forecasts of the Air Quality Index (AQI).

The purpose of Level 2 validation is archiving the completed (but not validated) database. Level 2 archives all collected data into a single processing table. At this point, all data that can be collected have been collected.

Level 3 validation involves a more detailed evaluation of the data. The Site Status Report Forms (SSRF), operator Site Narrative Log sheets, calibration data, and audit results are reviewed for each site. In addition, data are screened using CDMSA tools that identify potential problems such as values greater than the expected range and invalid combinations of status flags, values, and spikes. All review and editing activities are documented both electronically and on hard copy forms.

When all documentation is reviewed and the database is edited to the satisfaction of the Data Management, Analysis, Interpretation and Reporting Manager (DMAIRM) or designee, the QA Manager audits the database using the tools available in CDMSA. Upon completion of the QA review, the database is verified as Level 3.

All NPS and BLM continuous data (flow, O_3, and meteorological) are received from ARS validated at Level 3.

1.3.1.4.2 Laboratory Data

Data generated from filter pack samplers (discrete data) are managed by Element. Attainment of Level 2 validation for discrete data consists of meeting the following criteria:

- ♦ Data are determined to be reasonable based on the analyst's evaluation of the data batch QC sample results.
- ♦ Data transfer by electronic or manual entry into Element is completed properly as evaluated by the Laboratory Operations Manager (LOM). All data manually entered into the database are validated for accuracy through double entry.
- ♦ The appropriate analytical batches undergo peer review by a laboratory analyst and final review by the LOM. For each analytical batch, a data flag is generated if:
    - ◊ Insufficient QC data were run for the batch;
    - ◊ The correlation coefficient of the standard curve was less than 0.995 (see Appendix 4, CASTNET Laboratory SOP, for instrument SOPs and Batch Folder and Element Batch Review Checklist);
    - ◊ The 95 percent confidence limit of the Y-intercept exceeded the limit of quantitation;
    - ◊ Sample response exceeded the maximum standard response in the standard curve (i.e., the sample must be diluted to bring the response within the range of the curve);
    - ◊ Continuing calibration verification (CCV) sample spikes exceeded the recovery limits;
    - ◊ Reference samples exceeded the accuracy acceptance limit; or
    - ◊ Replicate samples exceeded the percent difference limits.

A batch with one or more flags requires written justification for batch approval, which allows the data in Element to be finalized and locked by the data administrator to prevent further changes.

Attainment of Level 3 validation for discrete data requires approval by the LOM and a review by CASTNET scientists. Specific procedures include the following:

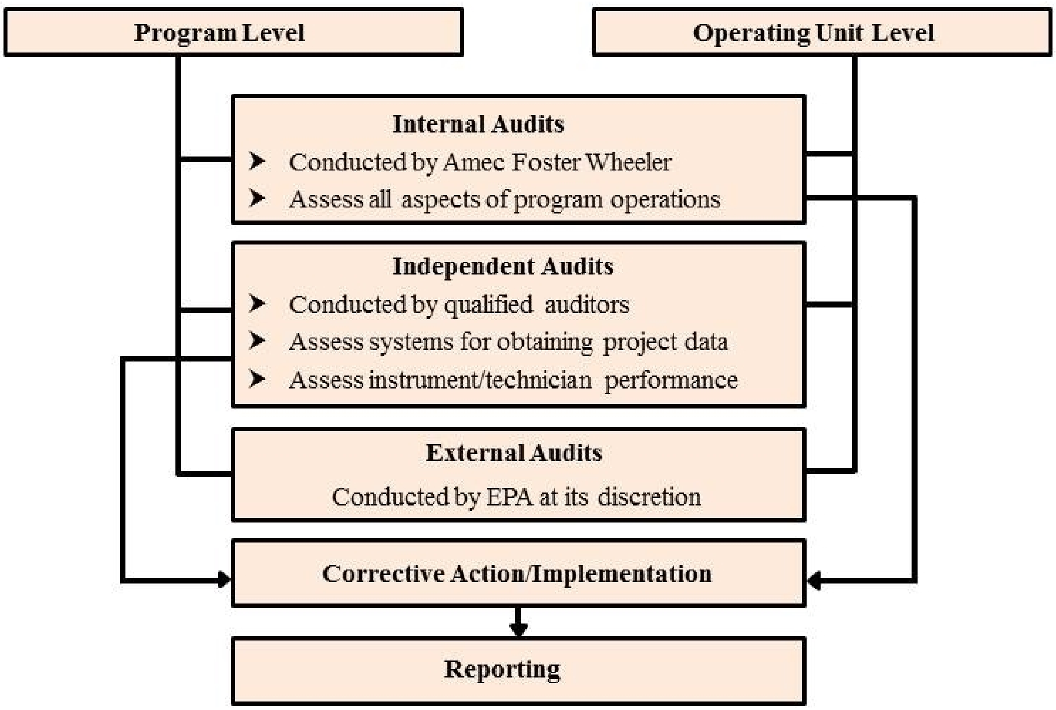
- ♦ All Level 2 data that meet QC criteria are reviewed by the LOM.
- ♦ Written justification for acceptance of data that did not meet QC criteria is reviewed and approved by a laboratory reviewer.
- ♦ Alarm flags are reviewed and evaluated by the LOM.
- ♦ Supporting field and laboratory data are reviewed by the QA Manager.

To calculate atmospheric concentrations from filter pack samples, filter pack flow data are merged with laboratory data at the DMC. Filter pack samples with greater than 75 percent but less than 90 percent valid flow data are flagged to indicate uncertainty in concentration calculations. Filter pack samples with less than 75 percent valid flow data are flagged to indicate the concentration data are invalid. Level 3 concentration data are archived in the CASTNET SQL and Oracle databases.

1.3.1.5 Quality Assurance

The CASTNET QA program encompasses all major QC procedures depicted in Figure 1-14 and Tables 1-4 and 1-5. Internal, independent, and external audit systems are utilized for all levels of project operations. Figure 1-18 illustrates program assessments.

Figure 1-18 Program Assessments



These audit systems are used to assess the components of the project and their compliance with the QA program. The project assessments in the following list are used in the CASTNET QA program.

- Program Level
  - Data quality assessments and response actions
  - Management systems reviews
  - Readiness reviews
  - Technical systems audits (TSA)
  - Performance evaluations (PE)
  - Surveillance
  - Assessments of DQI
  - Peer review of project deliverables
  - QA/QC reports to management
  - Review, revision, and approval of the CASTNET QAPP
- Operating Unit Level

  - ◊ Surveillance
  - ◊ TSA
  - ◊ PE
- ♦ Task Level
  - ◊ Readiness reviews
  - ◊ Surveillance

In addition to assessment, the audit systems incorporate corrective action and implementation systems and reporting procedures. Internal TSA and PE of the field, laboratory, and data operations components are performed by trained Amec Foster Wheeler and subcontractor field personnel. TSA and PE are also performed by qualified independent and external auditors. The internal audit program is managed and executed by Amec Foster Wheeler. The independent audit program is managed by Amec Foster Wheeler with input from EPA and executed by qualified, independent auditors. The external audit programs are managed and executed by EPA, at its discretion.

Third party audits may also be performed by EPA regions or state and local agencies. Access to CASTNET sites and equipment will be arranged upon request. Please refer to section 5.5.8 of this QAPP.

1.3.1.5.1 Internal and Independent Audits

The core of the QA program is the internal audit system. The internal audit program addresses all aspects of project operations from project level to task level. Internal audits are conducted routinely to assess all project components (Figure 1-14). Additional, non-routine internal audits are performed at the QA Manager's discretion and/or at the request of other project personnel. The routine audits use CDMSA tools to trace data from their origin into the final validated database. These audits verify that established protocols are followed, data quality is achieved and maintained, and updates to the database are performed correctly and documented accurately.

Independent audits are conducted by qualified auditors who are not participants in the CASTNET program. These audits are used to assess the systems for obtaining project data and the performance of the instruments and technicians collecting or processing the data. After the audits are complete, recommendations are made to the Project Manager with respect to changes in procedures and documentation.

The results of all QA activities are reported in monthly progress reports, quarterly reports, quarterly QA reports, and reports to the CASTNET Management Team. Internal and independent audits of project operations are classified in the following subsections.

1.3.1.5.1.1 Project-Wide Assessments

Project-wide assessments address all components of the project including field, laboratory, and data operations. Internal project-wide assessments are used to:

- Monitor if actions in one area of the project affect other areas of the project,
- Verify that QA/QC procedures are being conducted according to this QAPP and applicable SOP, and
- Provide a framework for quick detection and response to problems that may occur.

Internal audits such as surveillance, data quality assessments, and QA/QC reports to management provide continuous monitoring of project status. Assessments of DQI are conducted quarterly. Changes to this QAPP and SOP are reviewed, revised, and approved as necessary. The document is reviewed a minimum of once annually. Other internal assessments such as management systems reviews and readiness reviews are conducted as needed.

An independent gauge of overall project quality is provided in the form of peer review of the publications and conference papers that result from the data generated by the project.

1.3.1.5.1.2 Operating Unit Assessments

Internal and independent assessments address various components of the project at the operating unit level. Different assessments are used for each operating unit to satisfy specific QA/QC requirements and to verify that procedures are being conducted according to this QAPP and operating unit related SOP.

1.3.1.5.1.2.1 Field Operations Assessments

Internal assessments are used by Amec Foster Wheeler field and field subcontractor personnel on an ongoing basis. Surveillance of field activities is performed weekly on Tuesdays when site operators call Amec Foster Wheeler field personnel to report on site status and complete the SSRF that is returned to Amec Foster Wheeler with the exposed filter pack. Additional surveillance activities include weekly meetings and review of calibration documentation. Field surveillance activities verify that sites are operating properly and provide timely notification to Amec Foster Wheeler field personnel when a problem occurs. Field TSA are performed biannually to verify that stations are properly sited, installed, operated, and maintained and to verify conformance of field sampling activities with the CASTNET Field SOP (Appendix 1) and this QAPP. Field PE are performed biannually with the TSA to challenge each gaseous analyzer, filter pack/deposition monitor, meteorological sensor, and support system with a certified reference standard to verify that each is operating within CASTNET accuracy goals. Readiness reviews are conducted as needed, generally before site visits (e.g., repair or calibration visits) or before embarking on a multi-site task (e.g., upgrading the site ozone systems).

Independent field assessments are not performed for this contract.

1.3.1.5.1.2.2 Laboratory Operations Assessments

Internal laboratory assessments are conducted on an ongoing basis. Surveillance is used by the LOM and other personnel to verify that laboratory analytical procedures and instrumentation continue to meet project DQO. Surveillance activities include frequent review of laboratory data and QC documentation and weekly meetings. Internal TSA are conducted routinely by the QA Manager and consist of separate audits of data and procedures that, when combined, yield an overview of the entire process. Internal TSA consist of various types of audits such as method audits, life history audits of laboratory data, and filter acceptance audits. Internal PE are ongoing and consist of routine QC procedures implemented for each analytical method to verify achievement of project DQI. The CASTNET laboratory analyzes a reference sample of known value and traceable to NIST at the beginning and end of each analytical run for each group of CASTNET samples. Analytical accuracy is determined by the analysis of reference samples and CCV. Laboratory precision is estimated via analysis of replicate samples. Readiness reviews are performed as needed, generally when preparing for a special study or other non-routine activity.

Independent TSA are conducted every two years by a qualified auditor who is independent of the project. Additionally, laboratory performance is independently evaluated on a quarterly basis through participation in intercomparison studies conducted by Environment Canada (ECAN) and the U.S. Geological Survey (USGS) Interlab. Study results are reviewed by the LOM and QA Manager. The Project Manager is notified of the audit results.

1.3.1.5.1.2.3 Data Operations Assessments

Data generated by project activities must be as precise, accurate, complete, and usable as possible. The internal data assessment process is ongoing with both program level and operations level daily, weekly, quarterly, biannual, and annual assessments incorporated into the data review and data validation process (see Table 1-5, Project Assessments by Program Component). The data validation process involves each level of data processing from data collection and entry into the system through data delivery. In addition to the redundancies built into the data validation process, internal TSA and PE trace data points from field collection through laboratory analysis and data validation. In addition to the data validation process, the DMAIRM and data operations personnel take steps to ensure that the documentation and data processing, validation, and backup procedures conform to procedures described in this QAPP. Additionally, they verify that the computer software and hardware used for storage of CASTNET data and management of the DMC are operating within CASTNET goals. These internal TSA and PE are conducted annually by the DMAIRM and QA Manager.

A thorough, independent TSA by a qualified auditor not associated with CASTNET reviews data management activities from data ingestion through reporting to EPA. Independent data operations TSA are conducted every two years. Likewise, an independent PE is conducted every two years to verify that the hardware, CASTNET Data Management System software, data security, and computer programming necessary to manage, maintain, and deliver the CASTNET data are operating within CASTNET accuracy goals and in conformance with this QAPP. Results are evaluated by the DMAIRM and QA Manager and reported to the Project Manager.

1.3.1.5.1.3 Task Level Assessments

Task level assessments are built into daily project activities and are performed as needed. Surveillance is performed at all levels of the project by all project personnel. Readiness reviews are conducted as needed. For field operations, readiness reviews are generally performed before site visits (e.g., repair or calibration visits) or before embarking on a multi-site task (e.g., upgrading the site ozone systems). Readiness reviews for the laboratory and for data operations are performed as needed, generally when preparing for a special study or other non-routine activity.

1.3.1.5.2 External Audits

Audits conducted by EPA or its designee, are designated as external audits and are conducted outside the auspices of the project.

1.3.1.6 Management and Reporting

Reports and/or deliverables that are produced to meet project requirements and their submittal schedules are discussed in Sections 1.4 and 1.7. All project reports are assigned internal deadlines that precede the EPA submittal deadlines to allow sufficient time for review and updates. Deadlines are also assigned for revisions to reports and documents. All deliverables, reports, and revisions are reviewed either by the QA Manager and Project Manager or designee. Due dates and delivery dates for all written reports are tracked in the monthly progress reports. All data deliveries are tracked in a separate database.

Management team and/or coordination team meetings are held weekly to assess, among other things, progress on deliverables and the ability to meet deadlines. In addition, management team members constantly monitor the progress of deliverables and project activities through daily communication with other management team members and project staff.

1.4 Schedules and Deliverables

1.4.1 Schedules

The schedules of routine CASTNET deliverables are summarized in Table 1-6.

1.4.2 Deliverables

CASTNET internal and external deliverables are listed in Table 1-6. In addition to monthly and quarterly data submittals, the five types of reports provided to the EPA each year are:

- Monthly reports
- Quarterly data reports
- Quarterly QA reports

- Annual report
- Annual QA report

Descriptions of these reports are provided in Section 1.7 – Deliverables, Documents, and Records.

1.5 Data Quality Objectives and Criteria

1.5.1 Data Quality Objectives

The CASTNET DQO were developed to support CASTNET's primary objectives (i.e., intended uses of the data). DQO are qualitative and quantitative statements that:

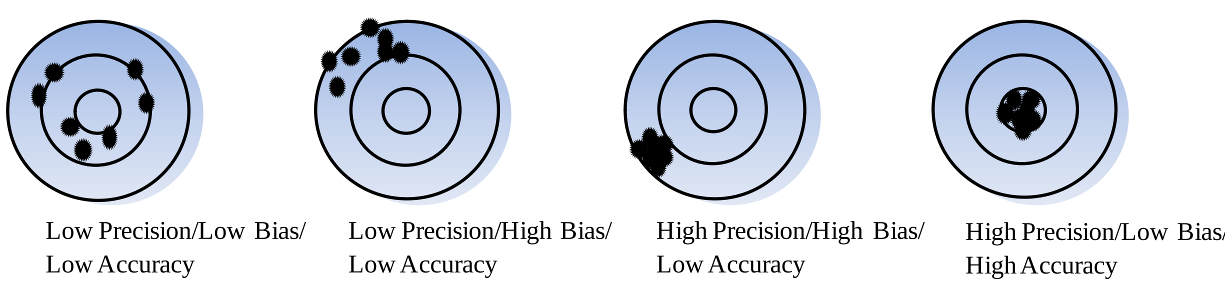
- Clarify the intended use of the data,
- Define the type of data needed to support decisions and policies,
- Identify the conditions under which the data should be collected, and
- Specify tolerable limits on the probability of making a decision error due to uncertainty in the data.

CASTNET DQO (Table 1-7) ensure that the data provided are adequate for their intended use. DQO apply to the continuous field data and the integrated samples, including exposed filters. Measurement criteria were determined based on MLM input requirements, as well as on instrument and method limitations.

1.5.2 Data Quality Indicators

The DQI for CASTNET are precision, accuracy, bias, completeness, representativeness and comparability. These terms represent qualitative and quantitative measures by which CASTNET data can be evaluated for reliability and repeatability. Comparability and representativeness are qualitative (i.e., subjective) concepts. Comparability and representativeness are assessed using indirect methods that provide weight of evidence via comparison with generally accepted standards. Precision, accuracy, bias, and completeness are quantitative (i.e., objective) measurements with a specific numerical output. Precision, accuracy, bias, and completeness are determined using direct methods. Figure 1-19 illustrates the concepts of precision, accuracy, and bias. Completeness is discussed in Section 1.5.2.4.

Figure 1-19 Precision, Accuracy, and Bias



1.5.2.1 Precision

The definition of precision is taken from International Organization of Standardization (ISO) 3534-1, which states that precision is, "… the closeness of agreement between independent test results obtained under stipulated conditions." CASTNET uses measurements from collocated site pairs, duplicate analyses of laboratory samples, and routine single point checks for gas analyzers to assess precision. The precision of measured ozone concentrations is estimated using the procedures listed in Table 4-12.

The mean of the absolute value of single or aggregated relative percent difference (MARPD) is used to express precision of concentration measurements, flow data, and meteorological data whose differences are expressed as percentages. MARPD is calculated as shown in Equation 1-1:

$$MARPD = \frac{1}{k}\sum_{j=1}^{k}\left(\frac{|S1-S2|}{S1+S2}\right)_j x\ 200$$

Eq. 1-1

Where:

S1	=	The value for the primary measurement
S2	=	The value for the collocated or reference measurement
k	=	The number of pairs of valid data

For reporting purposes, the absolute value of the relative percent difference is used when a single pair is evaluated and is referred to simply as ARPD or RPD. The formula shown in Equation 1-1 then reduces to:

$$RPD = \left(\frac{|S1-S2|}{S1+S2}\right) x\ 200$$

Eq. 1-2

Note: Signed results (positive and negative) are not generally used for reporting. An exception to this is in the reporting of bias as discussed later.

Mean Absolute Difference (MAD) is the precision for those meteorological measurements whose criteria (Table 2-6) are expressed in terms of difference. Mean absolute difference is the mean of the absolute differences between the values for the primary and secondary samplers. MAD is calculated as shown in Equation 1-3.

$$MAD = \frac{1}{k}\sum_{j=1}^{k}(|S1-S2|)_j$$

Eq. 1-3

Where:

S1	=	The value for the primary measurement
S2	=	The value for the collocated or reference measurement
k	=	The number of pairs of valid data

1.5.2.2 Accuracy

Accuracy is defined as the closeness of agreement between a “true” or reference value and an associated measurement result. CASTNET uses certified references traceable to NIST to obtain the true value used for assessment. Accuracy is measured by the percent recovery which is the amount measured as compared to the “true” value, expressed as a percentage. Equation 1-4 provides the formula for percent recovery (%R).

$$\%R = \left(\frac{Y - X}{X}\right) x100 \qquad \text{Eq. 1-4}$$

Where:

Y	=	The measured value
X	=	The true value

1.5.2.3 Bias

Bias is defined as a systematic error in measurement wherein the measured value displays a consistent positive or negative error as compared to a true value. Bias measurements are calculated either as a percent difference (%D) or as a mean arithmetic difference (MaD). Percent difference is the difference between the amount measured and the “true” value, expressed as a percentage. Mean arithmetic difference is the arithmetic difference between the amount measured and the “true” value. The signed arithmetic difference is used for assessment where values are too small or too close to the limit of detection to calculate a meaningful %D. The formula for the two measures of bias is given in Equation 1-5 and 1-6.

$$\%D = \frac{1}{k}\sum_{j=1}^{k}\left(\frac{Y - X}{X}\right)_j x100 \qquad \text{Eq. 1-5}$$

Where:

Y	=	The measured value
X	=	The true value
k	=	The number of valid comparisons

And:

$$\text{MaD} = \frac{1}{k}\sum_{j=1}^{k}\left(Y - X\right)_j \qquad \text{Eq. 1-6}$$

Where:

Y	=	The measured value
X	=	The true value
k	=	The number of valid comparisons

1.5.2.4 Completeness

Completeness is defined as the percentage (%C) of valid data points relative to total possible data points. Equation 1-7 provides the formula for percent completeness. Figure 1-20 shows historical and 2012 percent completeness of measurements and MLM-modeled parameters.

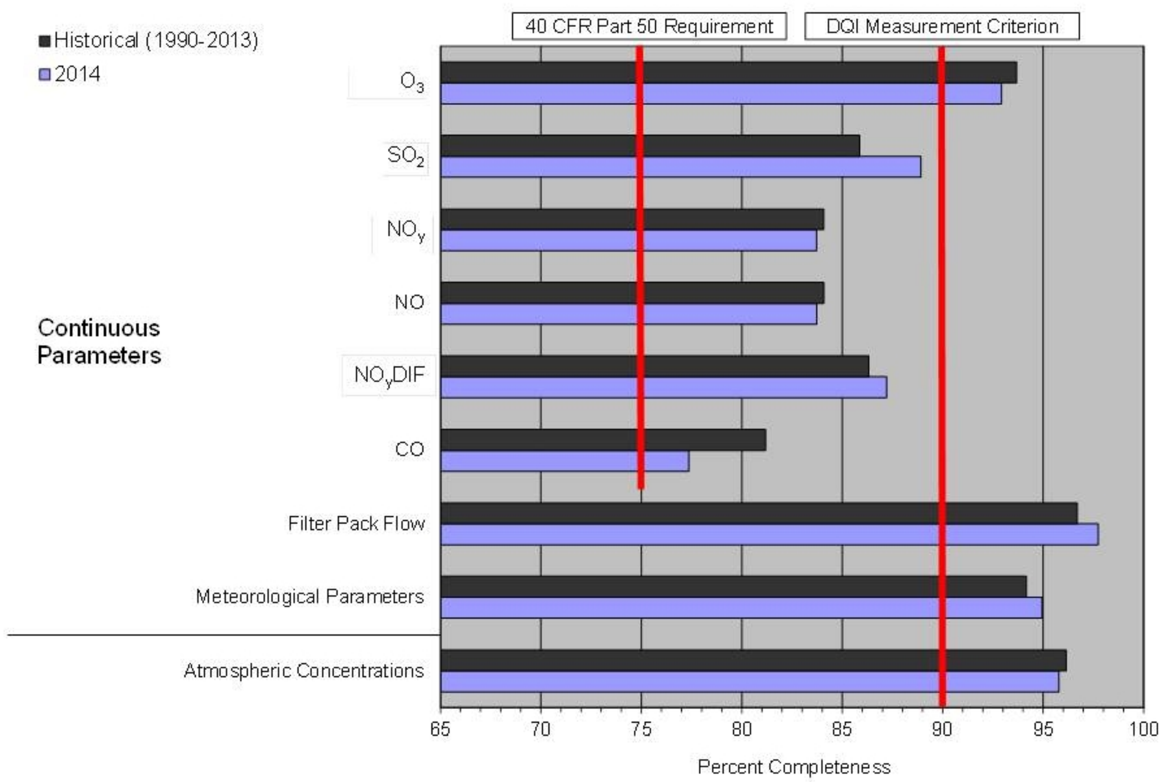
$$\%C = \left[1 + \left(\frac{Y - X}{X}\right)\right] x100$$

Eq. 1-7

Where:

Y = The number of valid data points
X = The total possible number of data points

Figure 1-20 Historical and 2014 Percent Completeness of Measurements and Modeled Estimates (black bars are 1990–2013)



1.5.2.5 Comparability

EPA guidance document QA/G-5 defines comparability as a, "qualitative term that expresses the confidence that two data sets can contribute to a common analysis and interpolation … whether two data sets can be considered equivalent in regard to the measurement of a specific variable or groups of variables." Comparability is established via the same methods used for ensuring representativeness plus the use of conventional and standard units for reporting. In addition, the

Amec Foster Wheeler laboratory participates regularly in laboratory intercomparison studies wherein blind samples are supplied to a group of participating laboratories.

1.5.2.6 Representativeness

EPA guidance document QA/G-5 defines representativeness as, "a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point or for a process condition or environmental condition. Representativeness is a qualitative term that should be evaluated to determine whether *in situ* and other measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the media and phenomenon measured or studied." CASTNET representativeness is established via adherence to specified siting criteria, uniformity in equipment procurement and deployment, and uniform implementation of all SOPs.

1.6 Special Training

An effective and well-organized training program for CASTNET has been developed to ensure production of high-quality data. A training program unifies personnel activities and ensures, through proper job performance, accomplishment of project objectives. CASTNET site operator training is discussed in Section 2.3.

Although no specialized health and safety training is required for this project, all Amec Foster Wheeler field personnel and site operators undergo health and safety training according to the guidelines in the CASTNET Health and Safety Plan (Appendix 5).

There are no specific training certification requirements for the CASTNET project.

1.7 Deliverables, Documents, and Records

1.7.1 Monthly Progress Reports

Monthly Progress Reports consist of detailed financial reports and descriptions of technical activities. Each report provides the following information:

- Description of work performed during the reporting period
- Difficulties encountered and remedial action taken
- Deliverables submitted during the reporting period
- Anticipated activity during the next reporting period
- Deliverables scheduled during next reporting period
- Outstanding actions awaiting contracting officer authorization
- Financial statement

These reports are submitted electronically to EPA by the 15th of each month.

1.7.2 Daily Data Delivery

Screened continuous measurements are delivered to EPA daily via Oracle. Hourly continuous measurements are delivered to AIRNow.

1.7.3 Monthly Data Delivery

A 6-month data set consisting of validated Level 3 site data from a completed site calibration group is delivered to EPA via Oracle at the end of each calendar month. These data are subsequently made available to the user community by EPA via the CASTNET Web site (www.epa.gov/castnet). O_3 and trace-level concentration data are delivered to the EPA Air Quality System monthly.

1.7.4 Quarterly Data Submittals and Reports

Quarterly data are submitted to EPA via Oracle. Quarterly reports summarize network activities for the period and present results of all field and laboratory QC checks. The quarterly reports elucidate any significant changes in air quality from previous quarters and include maps of concentration data from CASTNET filter packs. Trends analysis and time series plots are also presented. O_3 concentrations are presented in terms of fourth highest daily maximum and 8-hour average concentrations. Quarterly QA reports include DQI results, QA sample counts by QA codes, percentage of suspect or invalid samples, QC blank results by type, field problems and resolutions, and calibration failures. Quarterly reports and quarterly QA reports are provided via e-mail as PDF and, also via the Amec Foster Wheeler file transfer protocol (FTP) Web site.

1.7.5 Annual Reports

Annual reports are provided as PDF. A draft report is due by August 15 of the following year with a final report due 30 days after receipt of comments from EPA. The annual report focuses on data and trends analyses from the previous year and includes comparisons of data across the years that the network has operated. An annual report typically includes

- an overview of CASTNET operations and a discussion of any changes in sampling and analytical methods, together with an analysis of the potential implications on reported concentrations
- current year maps of annual mean concentrations of sulfur and nitrogen species and fourth highest DM8A O_3 levels and their trends
- modeled dry deposition rates, measured wet deposition rates, and estimates of total sulfur and nitrogen deposition for the current year and trends in deposition rates
- analyses of trace-level pollutant concentrations measured at CASTNET sites
- special topics of interest, e.g., air quality in regions of the United States with energy development and effect of weather on air quality

- Maps of critical loads of sulfur and nitrogen pollutants across United States
- QC data for the network used to estimate the precision, accuracy, completeness, and other indicators for each measurement system.

The fourth of the quarterly QA reports for each year also serves as the annual QA report. It includes a discussion of any significant events that might affect data quality, DQI indicator results, completeness statistics, percentage of suspect or invalid samples by measurement, QC blank results by type, field problems and resolutions, and calibration results together with a summary of the previous three quarters.

1.7.6 Quality Assurance Project Plan

This QAPP identifies reporting and feedback channels to ensure early detection of problems and implementation of corrective actions if DQO monitoring criteria are not met (Section 5.0 and Table 5-2). It includes provisions to keep management informed in a timely manner of all QA/QC problems and mechanisms for corrective actions. The QAPP also includes detailed descriptions of all project operations, and thus provides a blueprint to the operation and coordination of the entire project. Since the QAPP is a working document, it will be updated and revised to incorporate changes and additions to the program. The QAPP is supported by the comprehensive CASTNET SOP, which are included as appendices.

1.7.6.1 Update Procedures, Schedules, and Distribution

The QAPP will require updates and revisions as the project progresses and new or improved procedures are developed. When changes to the QAPP are required, the QA Manager will verify that the changes to the document are initiated by appropriate personnel and have the approval of the appropriate task managers, the Project Manager, and the EPA Project Officer. The QA Manager will then finalize approval of the changes and maintain documentation of the approvals. The revised document, incorporating the approved changes, will be disseminated to the personnel on the QAPP distribution list according to the procedure described below.

Each year, the QAPP and associated SOPs will be reviewed and, if warranted, revised by the QA Manager, Project Manager, and selected project personnel. The QA Manager ensures distribution of updated SOPs and checklists. The QA Manager also ensures the removal of obsolete documents from the laboratory and other CASTNET operations. Necessary updates and revisions, identified throughout the previous year, will be incorporated into the QAPP during the annual QAPP review period. The only exception to this rule will be if a revision to procedures is so significant and/or important to the operation of the project that the new information requires immediate dissemination to all QAPP recipients. In such a case, the updated sections will be e-mailed to all names on the QAPP distribution list along with a receipt verification form. The receipt verification forms will be returned to Amec Foster Wheeler and checked against the QAPP distribution list to verify that all identified parties have received the updated sections. An e-mail message will also be sent to all QAPP recipients listing the updated sections and requesting a reply to the e-mail as another form of acknowledgment of receipt. The reply e-mail will be printed and stored as proof of receipt. This system provides two avenues for verifying receipt of all updates.

All changes identified during the annual review period will be documented by section or subsection number with a brief description of the change and sent to the EPA. The identified changes will then be made to the QAPP, and the revised QAPP, or appropriate replacement pages, will be sent to all recipients on the QAPP distribution list. Receipt of the revised QAPP will be verified by the procedure described previously.

If during the annual QAPP review period no changes are identified, the QA Manager will record (date and initial) that the QAPP has been reviewed.

1.7.6.2 Version and Revision Control

The document control number is located in the document control block printed in the lower left-hand corner of each page following the title and approval sheet. Each of the QAPP sections/subsections will initially be assigned control number 0.0. The number to the left of the decimal represents the revision number; the number to the right of the decimal represents the version number. If a section/subsection is updated prior to the annual review, the version number on the updated pages is increased by one. If during the annual review period changes made over the past year are noted as significant in their substance (e.g., program changes per EPA instruction) or extent (e.g., updates to five or more subsections), the revision number of the QAPP is increased by one. An increase in the revision number will always apply to the entire document and result in version numbers being reset to 0.

All updates will be documented yearly using a brief description recorded on the cumulative Revision Tracking Sheet in Section 7.0. The description will note the subsection number and the revision number associated with the change.

1.7.7 Archiving Procedures

Hard copy records are indexed and stored in sequentially numbered banker’s boxes. Satellite archives are set up at the Amec Foster Wheeler office in Gainesville, FL for up to five years. Records may be transferred to secure off-site storage, if necessary. Archived records are discarded after a total of five years. The EPA may request records scheduled for disposal to be transferred to them at their expense.

The disposal procedure will be as follows: When a group of documents that is five years or older has been designated for disposal, a notice of impending disposal will be sent to EPA describing the basic types of documents and their approximate date range. If no response is received within four weeks of notice, it will be assumed that the documents may be discarded.

Electronic copies of the data are archived on the Oracle server in Gainesville, FL. The Amec Foster Wheeler database is considered the primary source of all the CASTNET data. All requests for data from EPA are generated from the Oracle database. Table 1-8 provides a brief description of the CASTNET data, databases, records, and reports that are produced by the project. The table also identifies location, format, update frequency, archive location and details, and whether or not the item is submitted to EPA.

Table 1-1 Locational and Operational Characteristics of Existing CASTNET Sites (1 of 6)

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Trace Gas Measurements	Nearby NADP Site	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Alabama													
SND152	Sand Mountain	12/27/88	34.2894	85.9704	352	•	•		AL99	Agri.	Rolling	Y	EPA
Alaska													
DEN417	Denali National Park	10/06/98	63.7258	148.9633	661	•	•		AK03	Forested	Complex	N	NPS
Arizona													
CHA467	Chiricahua National Monument	04/25/89	32.0092	109.3892	1570	•	•		AZ98	Range	Complex	N	NPS
GRC474	Grand Canyon National Park	05/16/89	36.0597	112.1822	2073	•	•		AZ03	Forested	Complex	M	NPS
PET427	Petrified Forest National Park	09/24/02	34.8225	109.8919	1723	•	•		AZ97	Desert	Flat	Y	NPS
Arkansas													
CAD150	Caddo Valley	10/04/88	34.1792	93.0989	71	•	•		AR03	Forested	Rolling	N	EPA
California													
JOT403	Joshua Tree National Monument	02/16/95	34.0714	116.3906	1244	•	•		CA67	Desert	Complex	M	NPS
LAV410	Lassen Volcanic National Park	07/25/95	40.5403	121.5764	1756	•	•		CA96	Forested	Complex	M	NPS
PIN414	Pinnacles National Monument	05/16/95	36.4850	121.1556	335	•	•		CA66	Forested	Complex	M	NPS
SEK430	Sequoia National Park	04/07/05	36.4894	118.8269	457	•	•		CA75	Forested	Mountaintop	N	NPS
YOS404	Yosemite National Park	09/25/95	37.7133	119.7061	1605	•	•		CA99	Forested	Complex	N	NPS
Colorado													
GTH161	Gothic	05/16/89	38.9573	106.9854	2926	•	•		CO10	Range	Complex	N	EPA
MEV405	Mesa Verde National Park	01/10/95	37.1983	108.4903	2165	•	•		CO99	Forested	Complex	M	NPS
ROM206	Rocky Mountain National Park	07/03/01	40.2778	105.5453	2743	•	•	c	CO98	Forested	Complex	M	EPA
ROM406	Rocky Mountain National Park	12/20/94	40.2778	105.5453	2743	•	•		CO98	Forested	Complex	M	NPS
Connecticut													
ABT147	Abington	12/28/93	41.8402	72.0111	209	•	•		CT15	Urban-Agri.	Rolling	M	EPA
Florida													
EVE419	Everglades National Park	10/06/98	25.3911	80.6806	2	•	•[4]		FL11	Swamp	Flat	Y	NPS
IRL141	Indian River Lagoon	07/09/01	30.1065	80.4554	2	•	•		FL99	Beach	Flat	Y	EPA
SUM156	Sumatra	12/28/88	30.1065	84.9938	14	•	•		FL23	Forested	Flat	Y	EPA

Table 1-1 Locational and Operational Characteristics of Existing CASTNET Sites (2 of 6)

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Trace Gas Measurements	Nearby NADP Site	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Georgia													
GAS153	Georgia Station	06/28/88	33.1812	84.4100	270	•	•		GA41	Agri.	Rolling	M	EPA
Illinois													
ALH157	Alhambra	06/28/88	38.8690	89.6229	164	•	•		IL46	Agri.	Flat	Y	EPA
BVL130	Bondville	02/09/88	40.0520	88.3725	212	•	•	a	IL11	Agri.	Flat	Y	EPA
STK138	Stockton	12/28/93	42.2872	89.9998	274	•	•		IL18	Agri.	Rolling	M	EPA
Indiana													
SAL133	Salamonie Reservoir	06/28/88	40.8164	85.6608	250	•	•		IN20	Agri.	Flat	Y	EPA
VIN140	Vincennes	08/04/87	38.7406	87.4844	134	•	•		IN22	Agri.	Rolling	M	EPA
Kansas													
KIC003	Kickapoo	02/18/14	39.8539	95.6578	334	•	•[4]			Prairie	Rolling	Y	EPA/Kickapoo Tribe
KNZ184	Konza Prairie	03/26/02	39.1021	96.6096	348	•	•[4]		KS31	Prairie	Flat	Y	EPA
Kentucky													
CDZ171	Cadiz	10/01/93	36.7841	87.8500	189	•	•		KY99	Agri.	Rolling	M	EPA
CKT136	Crockett	08/24/93	37.9211	83.0658	455	•	•		KY35	Agri.	Rolling	Y	EPA
MAC426	Mammoth Cave National Park	07/24/02	37.1319	86.1478	243	•	•	a	KY10	Agri./Forested	Rolling	M	NPS
MCK131	Mackville	07/31/90	37.7044	85.0483	353	•	•		KY03	Agri.	Rolling	M	EPA
Maine													
ACA416	Acadia National Park	12/01/98	44.3769	68.2608	158	•	•		ME98	Forested	Complex	M	NPS
ASH135	Ashland	12/20/88	46.6039	68.4142	235	•	•		ME00	Agri.	Flat	Y	EPA
HOW191	Howland AmeriFlux	09/16/11	45.2041	68.7402	60	•	•		ME09	Forested	Rolling	N	EPA
Maryland													
BEL116	Beltsville	11/01/88	39.0283	76.8175	46	•	•	b	MD99	Urban-Agri.	Flat	N	EPA
BWR139	Blackwater National Wildlife Refuge	07/04/95	38.4448	76.1115	4	•	•		MD15	Forest-Marsh	Coastal	M	EPA

Table 1-1 Locational and Operational Characteristics of Existing CASTNET Sites (3 of 6)

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Trace Gas Measurements	Nearby NADP Site	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Michigan													
ANA115	Ann Arbor	06/28/88	42.4164	83.9019	267	•	•		MI52	Forested	Flat	M	EPA
HOX148	Hoxeyville	10/31/00	44.1809	85.7390	298	•	•		MI53	Forested	Flat	Y	EPA
UVL124	Unionville	06/28/88	43.6139	83.3597	201	•	•		MI51	Agri.	Flat	Y	EPA
Minnesota													
RED004	Red Lake	08/26/14	47.8631	94.83659	373	•	•[4]			Grassland/ small bushes	Flat	Y	EPA/Red Lake Nation
VOY413	Voyageurs National Park	06/13/96	48.4128	92.8292	429	•	•		MN32	Forested	Rolling	M	NPS
Mississippi													
CVL151	Coffeeville	12/27/88	34.0028	89.7989	134	•	•		MS30	Forested	Rolling	M	EPA
Montana													
GLR468	Glacier National Park	12/27/88	48.5103	113.9956	976	•	•		MT05	Forested	Complex	N	NPS
Nebraska													
SAN189	Santee Sioux	07/05/06	42.8292	97.8541	429	•	•		SD99	Agri.	Rolling	N	EPA
Nevada													
GRB411	Great Basin National Park	05/16/95	39.0053	114.2158	2060	•	•		NV05	Forested	Complex	M	NPS
New Hampshire													
WST109	Woodstock	12/27/88	43.9446	71.7008	258	•	•		NH02	Forested	Complex	N	EPA
New Jersey													
WSP144	Washington's Crossing	12/27/88	40.3133	74.8726	61	•	•		NJ99	Urban-Agri.	Rolling	M	EPA
New York													
CAT175	Claryville	05/10/94	41.9423	74.5519	765	•	•[4, 5]		NY68	Forested	Complex	N	EPA
CTH110	Connecticut Hill	09/28/87	42.4010	76.6535	515	•	•		NY67	Forested	Rolling	N	EPA
HWF187	Huntington Wildlife Forest	05/28/02	43.9732	74.2232	502	•	•	c	NY20	Forested	Complex	N	EPA
NIC001	Nicks Lake	11/20/12	43.6806	74.98917	525	•	•[4]		NY29	Forested	Rolling	N	EPA
WFM105	Whiteface Mountain	11/20/12	44.39	73.86	570	•	•[4]		NY98	Forested	Complex	N	EPA
WFM007	Whiteface Mountain Summit	06/04/15	44.36608	73.90312	1415	*	•[4]		NY98	Forested	Complex	N	EPA

Table 1-1 Locational and Operational Characteristics of Existing CASTNET Sites (4 of 6)

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Trace Gas Measurements	Nearby NADP Site	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
North Carolina													
BFT142	Beaufort	12/28/93	34.8843	76.6213	2	•	•		NC06	Agri.	Flat	Y	EPA
CND125	Candor	09/25/90	35.2643	79.8382	198	•	•		NC36	Forested	Rolling	M	EPA
COW005	Coweeta Screwdriver Knob	11/18/14	35.0469	83.4531	960	*	•		NC25	Forested	Complex	N	EPA
COW137	Coweeta	11/04/87	35.0605	83.4302	686	•	•		NC25	Forested	Complex	N	EPA
PNF126	Cranberry	12/27/88	36.1040	82.0448	1250	•	•	c	NC45	Forested	Mountaintop	M	EPA
North Dakota													
THR422	Theodore Roosevelt National Park	10/06/98	46.8947	103.3778	850	•	•		ND00	Range	Rolling	Y	NPS
Ohio													
DCP114	Deer Creek State Park	09/28/88	39.6358	83.2600	267	•	•		OH54	Agri.	Rolling	Y	EPA
OXF122	Oxford	08/18/87	39.5314	84.7231	284	•	•		OH09	Agri.	Rolling	N	EPA
QAK172	Quaker City	09/28/93	39.9431	81.3378	372	•	•		OH49	Agri.	Rolling	M	EPA
Oklahoma													
CHE185	Cherokee Nation	04/02/02	35.7507	94.6700	299	•	•		AR27	Agri.	Rolling	Y	EPA
Ontario													
EGB181	Egbert, Ontario	12/27/94	44.2317	79.7840	251	•	•[4]		NY10	Agri.	Rolling	Y	EPA
Pennsylvania													
ARE128	Arendtsville	06/28/88	39.9231	77.3078	269	•	•		PA00	Agri.	Rolling	M	EPA
KEF112	Kane Experimental Forest	01/03/89	41.5981	78.7683	622	•	•		PA29	Forested	Rolling	Y	EPA
LRL117	Laurel Hill State Park	12/15/87	39.9883	79.2522	615	•	•		MD08	Forested	Complex	N	EPA
MKG113	M.K. Goddard State Park	01/12/88	41.4250	80.1447	384	•	•		NY10	Forested	Rolling	N	EPA
PSU106	Penn. State University	01/06/87	40.7209	77.9316	376	•	•		PA42	Agri.	Rolling	M	EPA
South Dakota													
WNC429	Wind Cave National Park	11/18/03	43.5578	103.4839	1292	•	•		SD04	Prairie	Rolling	M	NPS

Table 1-1 Locational and Operational Characteristics of Existing CASTNET Sites (5 of 6)

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Trace Gas Measurements	Nearby NADP Site	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Tennessee													
ESP127	Edgar Evins State Park	03/22/88	36.0389	85.7330	302	•	•		KY10	Forested	Rolling	N	EPA
GRS420	Great Smoky Mountains National Park	10/06/98	35.6331	83.9422	793	•	•	a	TN11	Forested	Complex	N	NPS
SPD111	Speedwell	06/12/89	36.4698	83.8265	361	•	•		TN04	Agri.	Rolling	Y	EPA
Texas													
ALC188	Alabama-Coushatta	04/02/04	30.4210	94.4045	101	•	•		TX10	Forested	Rolling	Y	EPA
BBE401	Big Bend National Park	07/18/95	29.3022	103.1772	1052	•	•		TX04	Forested	Complex	M	NPS
PAL190	Palo Duro Canyon State Park	04/24/07	34.8803	101.6649	1050	•	•		TX43	Prairie	Complex	M	EPA
Utah													
DIN431	Dinosaur National Monument	11/20/13	40.4373	109.3046	1464	•	•		CO15	Desert	Complex	N	NPS
CAN407	Canyonlands National Park	01/24/95	38.4586	109.8211	1809	•	•		UT09	Desert	Complex	M	NPS
Virginia													
PED108	Prince Edward	11/03/87	37.1653	78.3070	150	•	•		VA24	Forested	Rolling	M	EPA
SHN418	Shenandoah National Park	06/28/88	38.5231	78.4347	1073	•	•		VA28	Forested	Mountaintop	M	NPS
VPI120	Horton Station	06/02/87	37.3300	80.5573	920	•	•		VA13	Forested	Mountaintop	N	EPA
Vermont													
UND002	Underhill	11/13/12	44.52839	72.8688	399	•	•[4]		VT99	Forested	Complex	N	EPA
West Virginia													
CDR119	Cedar Creek State Park	11/10/87	38.8794	80.8478	234	•	•		WV05	Forested	Complex	N	EPA
PAR107	Parsons	01/19/88	39.0906	79.6614	510	•	•		WV18	Forested	Complex	N	EPA
Wisconsin													
PRK134	Perkinstown	09/27/88	45.2066	90.5972	472	•	•		WI35	Agri.	Rolling	M	EPA

Table 1-1 Locational and Operational Characteristics of Existing CASTNET Sites (6 of 6)

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Trace Gas Measurements	Nearby NADP Site	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Wyoming													
CNT169	Centennial	08/19/91	41.3722	106.2422	3178	•	•		WY95	Range	Complex	M	EPA
PND165	Pinedale	12/27/88	42.9214	109.7900	2388	•	•	c	WY06	Range	Rolling	M	EPA
YEL408	Yellowstone National Park	06/26/96	44.5597	110.4006	2400	•	•		WY08	Forested	Rolling	N	NPS
BAS601	Basin	11/06/12	44.28	108.0411	1242	•	•		MT00	Prairie	Rolling	M	BLM
NEC602	Newcastle	11/07/12	43.87306	104.1919	1468	•	•		WY99	Prairie	Rolling	M	BLM
BUF603	Buffalo	11/06/12	44.1442	106.1089	1324	•	•[4]		WY99	Prairie	Rolling	M	BLM
SHE604	Sheridan	11/06/12	44.93	106.85	1115	•	•[4]		MT00	Prairie	Rolling	M	BLM
FOR605	Fortification Creek	04/30/13	44.33953	105.9198	1408	•	•[4]		WY99	Prairie	Rolling	M	BLM

1. The dry deposition filters are analyzed for the following constituents:

   Teflon = SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Mg^{2+}, Ca^{2+}

   Nylon = SO_4^{2-}, NO_3^- (reported as HNO_3)

   Cellulose = SO_4^{2-} (reported as SO_2)

2. Temperature is measured at all sites. Other meteorological measurements have been discontinued at all 100 and 200 series sites with the exception of PAL190,TX; CHE185, OK; BVL130, IL; and BEL116, MD. Delta temperature was discontinued at all 400 series sites with the exception of ACA416, ME; GRS420, TN; and ROM406, CO. Surface wetness was discontinued at all 400 series sites. Meteorological sensors include temperature, delta temperature, relative humidity, solar radiation, vector wind speed, scalar wind speed, wind direction, sigma theta, surface wetness, and precipitation via tipping bucket rain gauge.

3. N = No; Y = Yes; M = Marginal.

4. O_3 not measured.

5. Solar-powered site.

• Indicates current monitoring.

a. Measures CO, SO_2 and NO/NO_y

b. Measures SO_2 and NO/NO_y

c. Measures NO/NO_y

100 and 200 series = EPA – Operated Sites

400 series = NPS – Operated Sites

600 series = BLM – Operated Sites

Table 1-2 Roles, Responsibilities, and Authorities of Amec Foster Wheeler CASTNET Team Members (1 of 4)

Position	Duties and Responsibilities	Authorities
Director, Government Programs	• Reviews performance with Project Manager • Conducts periodic and special project review meetings • Establishes independent communication link with EPA • Reviews performance with Project QA Supervisor • Resolves problems	• Acts as the corporate signatory, as required • Delegates appropriate authority downward to project personnel
Project Manager	• Primary point-of-contact with EPA • Provides overall program leadership and direction • Directs contractual commitments • Reviews and approves all deliverables • Adheres to program and corporate guidelines and protocols • Ensures compliance with QC procedures • Compiles and submits Work Plans and monthly reports • Negotiates Level-of-Effort Task Orders • Recognizes and resolves problems • Communicates frequently with EPA with regard to day-to-day program progress and activities • Is accountable for compliance with project scope, schedule, and budgets • Identifies appropriate technical staff/resources • Approves or disapproves any labor, materials, or subcontractor charges • Conducts periodic status reviews of task order progress	• Accepts task orders and scopes of work • Approves policies and procedures • Approves budgets/expenses • Approves major equipment expenditures • Has stop-work and cost accountability for all activities • Approves all deliverables • Approves personnel assignments • Allocates resources and personnel • Approves QAPP
Project QA Supervisor	• Monitors and periodically audits to ensure that QA procedures identified in the QAPP, Laboratory Operations, Field Operations, and Data Management SOPs are followed by the project team • Ensures the appropriate level of QA is assigned to each task order • Reviews QA audit reports from external QA auditors for laboratory and field operations assignments	• Independently reports to the Director, Government Programs • Approves QAPP • Issues stop work for non-compliance with QA procedures
QA Manager	• Maintains and distributes approved QAPP • Conducts traceability audits of field and laboratory data • Evaluates fidelity of data transfers from all sources to DMC and from DMC to EPA • Reviews all reports and supporting analyses • Oversees audit program described in QAPP • Coordinates all other QA activities for non-core programs	• Stops delivery of all products and reports that do not meet QA requirements • Issues corrective actions • Approves implemented corrective actions • Approves QAPP • Prepares annual and quarterly QA reports

Table 1-2 Roles, Responsibilities, and Authorities of Amec Foster Wheeler CASTNET Team Members (2 of 4)

Position	Duties and Responsibilities	Authorities
Field Operations Manager	• Coordinates and monitors all aspects of field operations • Schedules calibration and preventative maintenance visits • Schedules installation of new monitoring sites • Trains site operators • Coordinates subcontractor site calibrations • Coordinates special visits for repairs • Reviews SOP for field operations, equipment calibration, instrument certification, and repairs • Oversees design and development of monitoring systems	• Oversees operations of all monitoring sites • Oversees assignment of field technicians • Recommends acceptance of site operator performance • Responsible for subcontractors performing field calibrations • Ensures sufficient equipment is available
Laboratory Operations Manager	• Coordinates and monitors all aspects of laboratory operations • Supervises sample media testing and sample shipment, handling, and analysis • Reviews analytical and associated QC data • Reviews and resolves QC deficiencies • Prepares analytical and QC data reports for QA review • Submits analytical and QC data electronically to DMC • Works with Data Management, Analysis, and Reporting Manager (DMAIRM) to maintain and update LIMS • Has responsibility for all updates to LIMS	• Assigns analysis • Scheduling • Procures laboratory supplies • Approves analytical batches
Data Management, Analysis, and Reporting Manager (DMAIRM)	• Acquires continuous field measurements • Validates all CASTNET measurements • Calculates filter concentration data • Designs upgrades and improvements to database management systems • Maintains CASTNET databases • Delivers data to EPA • Oversees management of DMC • Runs deposition models	• Assigns DMC personnel • Approves all software used in DMC • Approves all data • Maintains databases • Institutes all database disaster recovery procedures

Table 1-2 Roles, Responsibilities, and Authorities of Amec Foster Wheeler CASTNET Team Members (3 of 4)

Position	Duties and Responsibilities	Authorities
Contracts Administrator	• Ensures compliance with FAR in performance of the contract including negotiating procedures, cost and pricing, subcontract management, Equal Employment Opportunity, and small business utilization • Assures that subcontractor procurement and subcontracts are complying with contract and FAR requirements • Monitors attainment goals for SB/SDB/WOB subcontracts • Files appropriate reports on SB/SDB/WOB subcontracting activity • Notifies Project Manager of SB/SDB/WOB subcontracting goal attainment • Assists Project Manager with task order negotiation • Monitors performance of submittal of contract deliverables • Reviews and approves subcontractor invoices • Interfaces with EPA Contracting Officer and Task Order Managers on contracting issues	• Approves terms and conditions of subcontracts and prime contract • Negotiates terms and conditions of prime contract
Property Control Manager	• Manages all government furnished property • Procures, inspects, and controls inventory of all equipment and expendables • Completes monthly and annual reports on property • Maintains computerized equipment inventory in the CASTNET database	• Approves purchasing • Manages all vendors • Assures timely payment of vendors • Assures required vendors remain active in procurement system
Data Analysts	• Validate continuous data stored in the DMC database • Verify that stored data have met project data collection requirements • Acquire data from each site daily	• Apply status flags describing the quality of continuous data
Laboratory Analysts	• Prepare and analyze field samples • Validate and verify analysis results • Enter laboratory data into Element • Report to the Laboratory Operations Manager (LOM) • Peer review other analysts' data before submittal to LOM	• Add comment codes to reported laboratory data • Stop or repeat analysis as required by the QAPP

Table 1-2 Roles, Responsibilities, and Authorities of Amec Foster Wheeler CASTNET Team Members (4 of 4)

Position	Duties and Responsibilities	Authorities
Assistant Field Operations Manager	• Detects problems or potential problems with all equipment • Resolves problems that could affect data quality • Reports all problems, resolutions, and the effect, if any, on data accuracy or collection • Communicates with the site operators each week or as necessary to resolve problems • Reviews site calibration results • Adds information to the problem tracking database to assist data validation • Supports both the site operators and field technicians	• Directs field technicians to unscheduled sites for repair • Procures supplies • Schedules special efforts for field certification laboratory
Amec Foster Wheeler and Subcontractor Field Technicians	• Calibrate all field instruments • Provide field equipment status and inventory monitoring during site visits • Conduct field equipment repair • Participate in site operator training	• Replace instrumentation or other site equipment when necessary and with approval of Field Operations Coordinator
Site Operators	• Visit site every Tuesday at approximately 0900 • Change out filter packs • Inspect and maintain site and equipment • Evaluate equipment status and performance since previous visit • Note status in logbook • Log condition of nearby vegetation, ground cover, or snow cover • Complete SSRF • Check values of meteorological and O_3 measurements for reasonableness • Ship exposed filter packs and all site documentation to Amec Foster Wheeler • Participate in Tuesday call-in with FOM and/or field operations personnel	

Note: SB/SDB/WOB = small business/small disadvantaged business/woman-owned business

Table 1-3 Discontinued CASTNET Sites (1 of 2)

Site ID	Site Name	Reporting Dates	Latitude (°N)	Longitude (°W)[1]	Elevation (m)	Deposition Filter Pack[2]	Ozone and Meteorology[3]	Aerosol Filter Pack[4]	Optical Scattering[5]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[6]	Sponsor
Alaska														
POF425	Poker Flats Research Range	07/01-02/04	65.12	147.43	495	•	•				Forested	Complex	M	NPS
KVA428	Kobuk Valley National Park	05/04-10/05	67.18	157.89	88	•	•[7]				Forested	Complex	N	NPS
California														
CON186	Converse Station	06/03-01/11	34.1941	116.9130	1837	•	•				Agri./Forested	Complex	N	EPA
SEK402	Sequoia National Park (Lookout Point)	02/97-02/05	36.4292	118.7625	1225	•	•				Forested	Mountaintop	N	NPS
DEV412	Death Valley National Monument	02/21/95	36.5092	116.8481	125	•	•				Desert	Complex	Y	NPS
Hawaii														
HVT424	Hawaii Volcanoes National Park	09/99-07/04	19.42	155.24	1199	•	•				Forested	Complex	N	NPS
Idaho														
RCK163	Reynolds Creek	05/89-09/93	43.21	116.75	1198	•	•				Range	Flat	Y	EPA
Illinois														
ANL146	Argonne	07/87-04/93	41.70	88.00	229	•	•				Agri./Urban	Rolling	N	EPA
Indiana														
LIV573	Livonia	10/93-03/01	38.54	86.26	229			•			Agri.	Rolling	N/A	EPA
Kentucky														
LCW121	Lilley Cornett Woods	01/88-12/93	37.08	82.99	335	•	•				Forested	Complex	N	EPA
PBF129	Perryville	08/87-07/90	37.68	84.97	279	•	•				Agri.	Rolling	M	EPA
Louisiana														
SIK570	Sikes	10/93-03/01	32.06	92.43	68			•	•[8]		Agri.	Flat	N/A	EPA
Maine														
HOW132	Howland	11/24/92	45.2158	68.7085	69	•	•				Forested	Rolling	Y	EPA
Michigan														
WEL149	Wellston	05/88-10/00	44.22	85.82	295	•	•				Forested	Flat	Y	EPA
Nevada														
SAV164	Saval Ranch	05/89-09/93	41.29	115.86	1873	•	•				Range	Flat	Y	EPA
New Hampshire														
HBR183	Woodstock (ridge site)	12/92-03/93	43.95	71.70	258	•	•				Forested	Complex	N	EPA

Table 1-3 Discontinued CASTNET Sties (2 of 2)

Site ID	Site Name	Reporting Dates	Latitude (°N)	Longitude (°W)[1]	Elevation (m)	Deposition Filter Pack[2]	Ozone and Meteorology[3]	Aerosol Filter Pack[4]	Optical Scattering[5]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[6]	Sponsor
New York														
WFM105	Whiteface Mountain[9]	01/87-03/93	44.39	73.86	570	•	•				Forested	Complex	N	EPA
WPA103	West Point-A	01/87-09/88	41.35	74.05	203	•	•				Forested	Complex	M	EPA
WPB104	West Point-B	01/87-09/93	41.35	74.05	203	•	•				Forested	Complex	M	EPA
North Carolina														
COW182	Coweeta (ridge site)	10/91-12/91	35.05	83.44	686	•	•				Forested	Complex	N	EPA
RTP101	Research Triangle Park	01/87-01/90	35.91	78.88	94	•	•				Agri./Urban	Rolling	N	EPA
Ohio														
LYK123	Lykens	09/88-10/10	40.9169	82.9981	303	•	•				Agri.	Flat	M	EPA
Pennsylvania														
SCR180	Scotia Range	02/93-02/99	40.79	77.92	378	•[10]	•[10]			•	Forested	Rolling	M	EPA
Tennessee														
ONL102	Oak Ridge	01/87-12/88	35.96	84.29	341	•	•				Forested	Rolling	N	EPA
Utah														
UIN162	Unita	05/89-09/93	40.55	110.32	2502	•	•			•	Range	Complex	N	EPA
Vermont														
LYE145	Lye Brook	03/94-04/07	43.05	73.06	730	•	•				Forested	Mountaintop	N	EPA
Virgin Islands														
VII423	Virgin Islands National Park	10/98-01/04	18.3364	64.7964	80	•	•				Jungle	Coastal	N	NPS
Washington														
OLY421	Olympic National Park	10/98-02/05	48.10	123.43	125	•	•				Forested	Complex	N	NPS
NCS415	North Cascades National Park	02/96	48.5397	121.4472	109	•	•				Forested	Complex	M	NPS
MOR409	Mount Rainier National Park	08/95-09/13	46.7583	122.1244	415	*	*				Forested	Complex	N	NPS

1. The dry deposition filters were analyzed for the following constituents:
   Teflon = SO_4^{2-}, NO_3^-, NH_4^+
   Nylon = SO_4^{2-}, HNO_3
   Cellulose = SO_4^{2-} (reported as SO_2)
2. Meteorological measurements: temperature, delta temperature, relative humidity, solar radiation, vector wind speed, scalar wind speed, wind direction, sigma theta, surface wetness, and precipitation via tipping bucket rain gauge.
3. The aerosol filters were analyzed for the following constituents:
   Teflon = mass, Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Zr, Mo, Pd, Ag, Cd, In, Sn, Sb, Ba, La, Hg, Pb
   Nylon = SO_4^{2-}, NO_3^-
   Quartz = Organic carbon, elemental carbon
4. Nephelometers were operated by ARS.
5. N = No; Y = Yes; M = Marginal; N/A = Not Applicable
6. O_3 not measured
7. Reporting dates are from 10/93-11/95
8. Restarted on 11/20/12
9. Reporting dates are from 10/89-06/90

Table 1-4 Assessments and Assessment Activities (1 of 2)

Assessment Type	Activities/Purpose
Program Level	
Data Quality Assessments and Response Actions (Sections 5.4 and 5.5)	• Assess key project activities that affect the achievement and maintenance of project DQO • Initiate timely corrective actions with efficacy of the action confirmed • Implement long-term and short-term corrective actions
Surveillance* (Section 5.5.5)	• Monitor overall project status including identifying action items, upcoming events, deliverable schedules, status of corrective actions, and project deadlines • Discuss and review project activities including field sampling, infrastructure integrity, laboratory analyses, data collection and validation, and data management by the project manager, QA supervisor, operating unit managers, task order managers, and other personnel as needed • Identify if actions taken in one area of the project unexpectedly affect other areas of the project
Assessment of DQI (Sections 1.5.2 and 5.5.6)	• Use qualitative and quantitative descriptors to interpret the acceptability or utility of the data collected • Quantitative DQI: precision, accuracy, completeness, and bias • Qualitative DQI: representativeness and comparability • Ensure processes for field and laboratory data collection are functioning as intended to meet program goals
QA/QC Reports to Management (Section 5.6)	• Disseminate information on the results of the various QA/QC activities taking place throughout all levels of the program • Alert program and operating unit managers of potential problems and possible ramifications to other project components • Ensure DQO are met by providing assessment information to all program managers
Review, Revision, and Approval of CASTNET QAPP (Section 1.7.6)	• Ensure consistency of program components, procedures, and actions to meet project DQO • Ensure production of high-quality, reproducible data
Management Systems Review (Section 5.5.2)	• Verify that management structure, policies, practices, and procedures of subcontractors meet project objectives
Peer Review and Presentation of Data (Section 5.5.7)	• Submit project data and findings to reputable scientific journals or conferences • Project data reviewed by independent scientific reviewers with appropriate technical expertise

Table 1-4 Assessments and Assessment Activities (2 of 2)

Operating Unit Level	
Surveillance* (Section 5.5.5)	• Review operating unit status with regard to data quality, timeliness of activities, status of corrective actions, and deadlines • Involve all personnel in monitoring procedures, instrument and equipment operation, and data collection
Technical Systems Audits (Section 5.5.4)	• Perform systematic on-site qualitative and quantitative audits of facility, equipment, personnel, training, procedures, record keeping, data validation, data management, and reporting • Use results to monitor the effectiveness of the QC system
Performance Evaluations (Section 5.5.4)	• Perform systematic evaluation of the quantitative data generated by measurement or processing systems • Compare routinely obtained data with data obtained independently to evaluate the precision, accuracy, or proficiency of a field or laboratory instrument, laboratory analytical method, or computer program
Task Level	
Readiness Review (Section 5.5.3)	• Evaluate if sufficient manpower, equipment, and supplies are available • Determine that all components are in place prior to beginning work on a specific task • Recruit participation from all personnel, including subcontractors
Surveillance (Section 5.5.5)	• Review task status with regard to data quality, timeliness of activities, and deadlines • Involve task personnel in monitoring task activities

Note: * Conducted at program level, operating unit level, and task level

Table 1-5 Project Assessments by Program Component (1 of 2)

Program Component	Assessment	Assessment Type	Frequency	Assessment Personnel
Program Level				
Program-wide	Data Quality Assessments	Internal	Ongoing	DMAIRM, FOM, LOM, QA Supervisor, QA Manager, Project Manager
	Surveillance	Internal	Weekly	CASTNET Project Personnel
	Assessment of DQI	Internal	Quarterly	DMAIRM, FOM, LOM, QA Manager, Project Manager
	QA/QC Reports to Management	Internal	Ongoing	QA Manager
	Review, Revision, and Approval of CASTNET QAPP	Internal	Annually or as needed	QA Manager, QA Supervisor
		External	Annually or as needed	EPA, NPS
	Management Systems Review	Internal Review of Subcontractors	As needed	Project Manager, QA Manager, or QA Supervisor
	Peer Review and Presentation of Data	Independent	Minimum of once per year	Qualified reviewers
Operating Unit/Task Level				
Field Operations	Surveillance	Internal	Weekly	Site Operators, FOM, Field Coordinators
Technical systems audits and performance evaluations take place at the same time	Technical Systems Audits	Internal	Biannually at calibration	Amec Foster Wheeler Field calibrators and subcontractors
		Independent	Not performed for current contract	NA
		External	Biennially for meteorological and flow systems Annually for ozone systems	As determined by EPA
	Performance Evaluations	Internal	Biannually at calibration	Field calibrators and subcontractors
		Independent	Not performed for current contract	NA
		External	Biennially for flow and meteorological systems Annually for ozone systems	As determined by EPA
	Readiness Review	Internal	As needed	Project Manager, QA Manager, FOM, LOM, DMAIRM, Task Order Managers, Field Coordinators

Table 1-5 Project Assessments by Program Component (2 of 2)

Program Component	Assessment	Assessment Type	Frequency	Assessment Personnel
Operating Unit/Task Level (continued)				
Laboratory Operations	Surveillance	Internal	Weekly	LOM, QA Manager, analysts
	Technical systems audits	Internal	Depends on audit type	LOM, QA Manager, analysts
		Independent	Biennially	RTI*
		External	As determined by EPA	As determined by EPA
	Performance evaluations	Internal	Ongoing	LOM, QA Manager, analysts
		Independent	Biennially and quarterly	Environment Canada and U.S. Geological Survey proficiency testing and evaluation personnel
		External	As determined by EPA	As determined by EPA
	Readiness Review	Internal	As needed	Project Manager, QA Manager, FOM, LOM, DMAIRM, Work Assignment Managers, Field Coordinators
Data Operations	Surveillance	Internal	Weekly	DMAIRM, QA Manager, data validators
	Technical systems audits	Internal	Annually	QA Manager
		Independent	Biennially	RTI*
		External	As determined by EPA	As determined by EPA
	Performance evaluations	Internal	Annually	QA Manager
		Independent	Biennially	RTI*
		External	As determined by EPA	As determined by EPA
	Readiness Review	Internal	As needed	Project Manager, QA Manager, FOM, LOM, DMAIRM, Work Assignment Managers, Field Coordinators

Note: * Research Triangle Institute, International, Inc.

Table 1-6 CASTNET Routine Data Reporting (1 of 3)

Prepared by	Delivered to	Report Type	Delivery Schedule	Information Contained
CASTNET Management	EPA	Monthly Progress Report	15th of each month	Project Manager's report with financial statement, work performed, difficulties and remedial actions, submitted deliverables, projected activities, scheduled deliverables
		Quarterly Report	Within 120 days of quarter's end	Validated and audited quarterly data set with precision and accuracy data, concentration/pattern change descriptions, figures/maps/tables, other explanatory text
		Quarterly QA Report	Within 30 days of quarter's end	DQI results as graphs, count of QA samples by QA code, percentage of suspect or invalid samples by QA code, count of field problems and resolutions with length of time to resolution, calibration failure by location and parameter, and QC blank results by type.
		Annual Report	Draft by 8/15 of following year. Final 30 days after receipt of comments from EPA	Statistical summaries; trends; unusual event descriptions; temporal intercomparison; concentration/pattern change descriptions; figures/maps/tables; method change description; other explanatory text; QC data summary with precision, accuracy, and completeness
		Annual QA Report	Within 30 days of the end of the 4th quarter	Summary of previous three quarters, control charts, DQI results as graphs, count of QA samples by QA code, percentage of suspect or invalid samples by QA code, count of field problems and resolutions with length of time to resolution, calibration failure by location and parameter, and QC blank results by type
		Monthly Dry Deposition Report	30 days after calibration	Number of sites, sites in group, data range, delivery date, dry chemistry concentration data
Field Operations	CASTNET Management	Field Operations section of Monthly Progress Report	10th of each month	Description of current and projected activities
	Data Operations	Polled site data	Daily	Data updated from previous poll
		Site documents	Monthly	SSRF and narrative log
		Field calibration results	As completed	Completed electronic field calibration forms, assembled calibration folder with laboratory certifications

Table 1-6 CASTNET Routine Data Reporting (2 of 3)

Prepared by	Delivered to	Report Type	Delivery Schedule	Information Contained
Laboratory Operations	CASTNET Management	Laboratory Operations section of Monthly Progress Report	10th of each month	Description of current and projected activities
	Field Operations	Filter pack late list report	Weekly	Filter packs not returned on schedule
	Data Operations	Filter pack data	Monthly	Filter concentration data
		QC data	Within 60 days of quarter's end	Precision and accuracy statistics
Data Operations	EPA	Monthly data tables	End of each month	Validated and audited meteorological data and chemistry concentrations from appropriate site groups, validated NPS data
		Quarterly data tables	Within 120 days of quarter's end	Filter pack data and comments, SSRF data, meteorological data changes
		Site Photographs	Quarterly	Site photographs
		Annual data tables	By 8/15 of following year By 11/30 of following year	Dry deposition values, ozone values Equipment inventory
		Screened continuous measurements	Daily	Hourly ozone concentrations and meteorological parameters
	CASTNET Management	Data Operations section of Monthly Progress Report	10th of each month	Description of current and projected activities
		Figures, maps, and tables for Quarterly Report	Within 120 days of quarter's end	Level 3 validated and audited 6-month data sets from the appropriate site group(s), Level 2 data set, NPS data, filter pack data
		Figures, maps, and tables for Annual Report	Draft by 7/21 of following year Final 15 days after receipt of comments from EPA	Validated and audited data from all sites for the year of record, all filter pack and visibility data for the year of record
		Atmospheric Concentration Reports	Upon request	Filter pack and flow data
		Problem Report	Twice weekly	All available problem information

Table 1-6 CASTNET Routine Data Reporting (3 of 3)

Prepared by	Delivered to	Report Type	Delivery Schedule	Information Contained
Quality Assurance	CASTNET Management	QA section of Monthly Progress Report	10th of each month	Description of current and projected activities
		Quarterly QA Report	Within 30 days of quarter's end	DQI results as graphs, count of QA samples by QA code, percentage of suspect or invalid samples by QA code, count of field problems and resolutions with length of time to resolution, calibration failure by location and parameter, and QC blank results by type
		Annual QA Report	Within 30 days of the end of the 4th quarter	Summary of previous three quarters, control charts, DQI results as graphs, count of QA samples by QA code, percentage of suspect or invalid samples by QA code, count of field problems and resolutions with length of time to resolution, calibration failure by location and parameter, and QC blank results by type
		Semiannual method audit	Twice per year – one before July 1st and one after July 1st but before December 1st, and as needed	Method audit results
		Monthly field calibration data audit	Within 30 days of quarter's end	Field calibration data audit results
		Annual Systems Audit	By mid-November	Systems audit results for Analytical Laboratory, Field Calibration Laboratory, and the DMC
		Continuous data validation audit report	1 week after completion of monthly validation	Data validation audit results

Table 1-7 CASTNET Data Quality Objectives: An Overview

Project Objective	Required Data	DQO
Estimate dry deposition fluxes	Ambient concentration data for sulfur species, nitrogen species and O_3 along with several meteorological parameters and information on vegetation and land use	No standards or standard methods are available to determine the accuracy of the CASTNET deposition model. However, model evaluation and intercomparison studies indicate that the model generally underestimates SO_2 and HNO_3 dry deposition. The extent and scope of the field measurements used in these analyses were insufficient to gauge the degree of underestimation. In order to better assess model performance the model output will have to be compared to recent, independent, multi-year flux measurements.
Detect and quantify seasonal and annual trends in concentrations and dry deposition fluxes for sulfur species, nitrogen species, and O_3	10-year record of ambient concentration data along with several meteorological parameters and related data	To detect a minimum annual trend of 1.0 percent in the concentration of selected chemical species with 10 years of data at a given site in the eastern united states region with a statistical confidence of 95 percent.
Define the spatial distribution of pollutants	Ambient concentration data for sulfur species, nitrogen species and O_3 collected over a large number of sites that constitute sufficient geographic coverage	Preliminary kriging studies show that where the maximum interpolated concentration (MAX) for SO_2 at eastern sites exceeds the minimum interpolated concentration by at least a factor of 2, the difference is statistically significant with 90 percent confidence. Furthermore, wherever the local kriging absolute standard deviation (KASD) is less than or equal to 25 percent of the MAX, the error is assumed low enough that validity of the apparent spatial pattern is not compromised. More experience with the local KASD criterion is needed to quantify its statistical significance. Spatial distributions of nationwide SO_2, SO_4^{2-}, total nitrate, and NH_4^+ concentrations are consistent with simulations produced by documented models such as Community Multiscale Air Quality (CMAQ) modeling system. Evaluations/tests of spatial distribution data for O_3, SO_4^{2-}, NH_4^+, and N concentrations for western sites are not available, other than comparison against CMAQ model output. Western site data have not been evaluated rigorously. It is unlikely that sufficient geographic coverage currently exists in the west. MLM estimates should not be extrapolated geographically.

Table 1-8 Records Generated (1 of 4)

Document/ Record	Format	Description	Frequency of Updates	Sent to EPA	Archive Location
Records Generated at Amec Foster Wheeler, Gainesville, FL					
QAPP	Electronic	• Identifies reporting and feedback channels to ensure early detection of problems and implementation of corrective actions if DQO are not met • Includes provisions to keep management informed in a timely manner of all QA/QC problems with mechanisms for corrective actions • Provides detailed descriptions of all project operations	Annually, or as needed	Yes	SharePoint[1]
CASTNET SOP	Electronic	• Provide detailed information on field and analytical measurements and other processes	Annually, or as needed	Yes	SharePoint[1]
Monthly Progress Report	Electronic	• Provides descriptions of work performed during the reporting period and difficulties encountered and remedial action taken • Provides lists of deliverables submitted for the current month and anticipated for the following month • Projects anticipated activity planned for the next reporting period • Lists outstanding actions awaiting the contracting officer's authorization • Includes a financial statement with current, unbilled allowable, and projected costs	Monthly	Yes, due the 15th of each month	SharePoint[1]
Quarterly Report	Electronic	• Validated quarterly data with corresponding QC precision and accuracy data • Focuses on emerging issues, including significant changes at individual sites, for all components of base operations • Includes analyses in terms of figures, maps, tables, and explanatory text	Quarterly	Yes, due within 120 days of end of quarter	SharePoint[1]
Quarterly QA Report	Electronic	• Contains DQI results (as graphs) • Count of QA samples by QA code and percentage of suspect and invalid samples by QA code (i.e., failure type) • Count of field problems/resolutions and length of time to resolution • Calibration failures by location and parameter	Quarterly	Yes, due within 30 days of end of quarter	SharePoint[1]

Table 1-8 Records Generated (2 of 4)

Document/ Record	Format	Description	Frequency of Updates	Sent to EPA	Archive Location
Records Generated at Amec Foster Wheeler, Gainesville, FL (continued)					
Annual Report	Electronic	• Contains statistical summary of annual data as well as any trends and unusual events • Includes intercomparison of data across the years the network has operated and descriptions of spatial and temporal patterns in terms of figures, maps, tables, and explanatory text • All changes in sampling and analytical methodology are included with discussion of potential implications on reported concentrations • QC data for the network are summarized and used to determine overall precision, accuracy, and completeness for each measurement system	Annually	Yes, draft due 8/15 of following year; final due 30 days after receipt of comments from EPA	SharePoint[1]
Annual QA Report (Fourth Quarter QA Report with annual summary)	Electronic	• Contains summaries of previous three quarters • DQI results (as graphs) • Count of QA samples by QA code and percentage of suspect and invalid samples by QA code (i.e., failure type) • Count of field problems/resolutions and length of time of resolution • Calibration failure by location and parameter	Annually	Yes, due within 30 days of end of 4th quarter	SharePoint[1]
Site Contact List	Electronic	• Pertinent information for each site within CASTNET (contacts, operators, shipping information, directions to site, latitude, longitude, elevation, etc.)	As needed	No	CASTNET database on dedicated server
Site History Notebook	Hard Copy	• Contains SSRF, narrative logs, and CDVS for 2-year period for a particular site	Weekly	No	Gainesville Office

Table 1-8 Records Generated (3 of 4)

Document/ Record	Format	Description	Frequency of Updates	Sent to EPA	Archive Location
Records Generated at CASTNET Field Sites					
Calibration Forms Folder	Electronic	• Completed calibration data forms for each site's sensors for winds, temperature, relative humidity, precipitation and wetness, solar radiation, flow (pre- and post-calibration), and data acquisition • Includes site information form	By Calibration Period	No	Gainesville Office
Site Narrative Log	Hard Copy	• Documents all activities and instrument responses during any site visit	Weekly, as needed	No	Gainesville Office
SSRF	Hard Copy	• Documents all activities and instrument responses during routine Tuesday site visits at dry deposition sites • Serves as filter chain-of-custody form	Weekly	No	Gainesville Office
Records Generated at Amec Foster Wheeler's Analytical Laboratory, Gainesville, FL					
Project Files	Hard Copy	• Contains pre-field setup form • SSRF • Project changes and problems documentation	As needed	No	Gainesville Office
Sample Preparation Records	Hard Copy	• Filter preparation documentation • shipment to field documentation	Daily	No	Gainesville Office
Sample Receipt Records	Hard Copy	• Samples received and unpacked with problems noted	Daily	No	Gainesville Office
Instrument Maintenance Log	Hard Copy	• Documents all activities for each instrument • One log for each instrument	As needed	No	Gainesville Office
Laboratory Notebooks	Hard Copy	• Documents all preparation and analysis activities	Daily	No	Gainesville Office

Table 1-8 Records Generated (4 of 4)

Document/ Record	Format	Description	Frequency of Updates	Sent to EPA	Archive Location
Records Generated at Amec Foster Wheeler's Analytical Laboratory, Gainesville, FL (continued)					
Data Batch Folder	Hard Copy	• Contains copies of laboratory notebook pages for preparation and analysis of batch • Copy of instrument output • Certificate of analysis of standards • Batch printout with listing of raw data, calibration curves, calculation results of samples and QC, QC summary, checklists, and signatures • Comments of analyst and reviewers	Only if needed once batch is final	No	Gainesville Office
Raw Data Files	Electronic	• Instrument output for analyses	Daily	No	Gainesville Office
Element Data Files	Electronic	• Data files for project, samples, analyses, and QC	Daily	No	Gainesville Office/ SharePoint[1]
Records Generated at Amec Foster Wheeler Data Management Center					
Missing Data Report	Electronic	• Lists all missing data in database	Daily	No	Gainesville Office
CDVS Report	Hard Copy	• Level 3 validation checklist and comment form • Used for summaries of information related to semiannual post-calibration checks, independent audits, and standard changes applied to data	Semiannually by calibration period	No	Gainesville Office

Notes: [1]All final projects are archived electronically in SharePoint, which is located on the Amec Foster Wheeler server in Alpharetta, GA

2.0 Field Operations

2.1 Network Monitoring Design and Rationale

2.1.1 Sampling Process Design

The CASTNET design was based on measurement of rural, regionally representative concentrations of sulfur and nitrogen species and O_3 in order to estimate dry deposition fluxes, detect and quantify trends, and define the spatial distribution of pollutants, and gauge the effectiveness of current and future emission control programs. The goal of estimating dry deposition had also required the measurement of a variety of meteorological parameters used in the MLM. The background and goals of CASTNET are summarized in Section 1.1.

2.1.1.1 Rationale

The network was designed primarily to measure seasonal and annual average concentrations and depositions over many years. Consequently, measurement of weekly average concentrations was selected as the basic sampling strategy. An open-face, three-stage filter pack that exposes three types of sequential filters (Teflon, nylon, and dual K_2CO_3-impregnated cellulose filters) to ambient air at a constant flow rate for a week is the basic sampling device. See the discussion in Section 1.3. The current network design satisfies the CASTNET objectives and supports the investigation of the relationships between emissions and emission changes and atmospheric concentrations/depositions and their changes.

CASTNET also was designed to depict rural O_3 concentrations. Continuous analyzers measure O_3 and determine hourly average concentrations. Continuous instruments also were selected for the meteorological measurements, which are archived as hourly averages. The specific meteorological measurements were selected to provide input to the MLM and to provide information about the geographic distribution and magnitude of concentrations and depositions. Currently, four EPA-sponsored, five BLM-sponsored and all NPS-sponsored CASTNET sites collect hourly meteorological measurements (Section 1.1). Additionally, trace-level concentrations of sulfur dioxide (SO_2) and nitrogen oxide/all reactive nitrogen oxides (NO/NO_y) are measured continuously at the Beltsville, MD (BEL116) and Bondville, IL (BVL130) sites. BVL130 also measures carbon monoxide (CO); and NO/NO_y levels are measured at Huntington Wildlife Forest, NY (HWF187), Rocky Mountain National Park, CO (ROM206) and Cranberry, NC (PNF126). NPS measures NO/NO_y concentrations at Mammoth Cave National Park, KY (MAC426) and Great Smoky Mountains National Park, TN (GRS420). The Ammonia Monitoring Network (AMoN) operates passive ammonia (NH_3) samplers at about 92 sites with about 65 of the AMoN sites at or near CASTNET locations. AMoN provides information on 2-week average NH_3 concentrations. The trace-level instruments are operated to support NCore monitoring requirements (Appendix 11).

As mentioned in Section 1.0, CASTNET previously had included sites that measured parameters related to visibility and visual quality. The objective of the CASTNET visibility network was to measure air quality and related parameters thought to affect visibility. The visibility sites were operated by EPA from 1993 to May 2001 using Interagency Monitoring of Protected Visual Environments (IMPROVE) protocols to guide instrument specifications, siting criteria, sampling frequency, and analytical techniques. Three single-stage filter packs with particle size selective cyclones were chosen to measure $PM_{2.5}$ and its chemical constituents. The EPA-sponsored visibility network consisted of eight-stations that spanned the eastern United States. Six of the sites were collocated with standard dry deposition sites. Seven of the visibility sites were transferred to IMPROVE as of May 2001. The eighth site was terminated. Over the history of the CASTNET visibility network, sampling techniques included measurement of visual quality through the use of photographs of scenic vistas and the measurement of light scattering with nephelometers.

Additionally, CASTNET was tasked to collect precipitation samples at those CASTNET sites located more than approximately 50 km from National Atmospheric Deposition Program/National Trends Network (NADP/NTN) sites. Prior to 1999, weekly precipitation samples were collected in polyethylene buckets using a wet/dry collector and a protocol similar to that used by NADP/NTN. In 1999, all wet deposition monitoring activities were transferred to the NADP/NTN protocol to promote nationwide consistency in wet deposition monitoring. NADP/NTN assumed responsibility at 15 CASTNET sites for the administration of wet deposition monitoring activities including collection, analysis, and reporting of the wet deposition samples. NADP/NTN sampling is currently either collocated with or located near all EPA- and NPS-sponsored CASTNET sites.

2.1.1.2 Current Measurements

See Table 1-1 for the current types of measurements collected.

2.1.1.3 Method Development, Changes and Approvals

All methods listed in this QAPP were developed to meet project requirements and were approved by EPA prior to implementation. Additional methods and all subsequent changes to current methods will be approved by EPA prior to implementation. Specific criteria for method development have not yet been established.

2.1.2 Site Operations for Ambient Concentrations and Dry Deposition Monitoring

Ambient measurements for SO_2, particulate SO_4^{2-}, particulate NO_3^-, HNO_3, particulate NH_4^+, particulate Cl^-, particulate K^+, particulate Na^+, particulate Mg^{2+}, and particulate Ca^{2+} meteorological variables required for dry deposition calculations are performed at each CASTNET site (Table 1-1). Meteorological variables required for dry deposition calculations are measured at about one-third of the CASTNET sites. O_3 concentrations are measured at 80 operating sites. Atmospheric sampling for sulfur and nitrogen species is integrated over weekly collection periods using an open-face, three-stage filter pack. In this approach, particles and selected gases are collected by passing air at a controlled flow rate through a sequence of Teflon, nylon, and cellulose filters. The Teflon filter collects particulate SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Mg^{2+}, and Ca^{2+}; the nylon filter collects HNO_3. The cellulose filter is a cellulose fiber base that is impregnated with K_2CO_3 and is used for collection of SO_2. Two cellulose filters are used. In practice, a fraction (usually < 20%) of ambient SO_2 is captured on the nylon filter. The nylon filters SO_2 and cellulose filters SO_2 are summed to provide weekly average concentrations. The nylon filter HNO_3 is converted to NO_3^- and added to the Teflon filter NO_3^- to provide weekly total NO_3^- concentrations.

Filter packs are prepared by the Amec Foster Wheeler analytical laboratory and shipped to the field weekly. The filter packs are exchanged at each site every Tuesday at approximately 0900 local time by the local site operator. Ninety-five percent of exposed filter pack samples from EPA-sponsored sites must be received by the CASTNET analytical laboratory within 14 days of removal from the sampling tower. Amec Foster Wheeler monitors sample receipt and identifies missing filter packs if samples are not received within seven days of removal from the tower. Blank filter packs (i.e., field blanks) are collected quarterly to evaluate potential contamination during shipment and handling.

Filter pack sampling and O_3 measurements are performed at 10 meters (m) using a tilt-down aluminum tower manufactured by Aluma Tower, Inc. Filter pack flow is maintained at 1.50 Lpm at eastern sites and 3.00 Lpm at western sites and some eastern sites with low concentration values, for standard conditions of 25 degrees Celsius (°C) and 760 millimeters (mm) of mercury (Hg) with a mass flow controller (MFC).

Ambient O_3 concentrations are measured via UV absorbance with Thermo 49i analyzers. Zero, span, and precision (z/s/p) checks of the O_3 analyzer are performed daily. Amec Foster Wheeler acquires, stores, and reports the data for CASTNET. CASTNET continuous measurements are delivered to AIRNow (www.airnow.gov) hourly and to EPA daily.

CASTNET was not originally designed to operate as a regulatory network. However, in 2011 all EPA-sponsored sites were upgraded to comply with the monitoring requirements described in 40 CFR Part 58, Appendix A (EPA, 2014) and data are submitted monthly to AQS. The EPA-sponsored deposition research site, HOW191, ME, does not comply with the regulatory siting requirements and is therefore not used for NAAQS determinations. The O_3 monitoring systems at NPS-sponsored sites comply with regulatory requirements and NPS O_3 data are also submitted monthly to AQS. Two of the five BLM WARMS sites comply with Part 58 ozone monitoring requirements. O_3 data from all WARMS sites are submitted to AQS quarterly.

NADP deploys Radiello samplers for 2-week periods to measure 2-week integrated NH_3 concentrations. Samplers are operated at about 65 CASTNET sites.

The trace-level pollutant instruments, which are operated at BVL130, IL; BEL116, MD; HWF187, NY; ROM206, CO; PNF126, NC; PND165, WY; MAC426, KY and GRS420, TN. support NCore monitoring requirements. Trace-level pollutant data are submitted to EPA daily and AQS monthly.

Site operators visit each CASTNET site every Tuesday. The operator replaces the exposed filter pack and ships it to the analytical laboratory. The site operator also evaluates equipment status and performance and performs preventative maintenance. Site operators also participate in Tuesday telephone calls with the Field Operations Manager (FOM) or designated field or data operations personnel. Site operators record surface conditions (e.g., dew, frost, snow) and vegetation status weekly on SSRF. Vegetation status and land-use information are archived in the CASTNET database and are used to estimate the distribution and condition of plant species around each site that could influence deposition rates for gases and particles. Vegetation data are obtained to track evolution of the dominant plant canopy from leaf emergence (or germination) to senescence (or harvesting) during the year.

All field equipment is subjected to semiannual inspections and multipoint calibrations using standards traceable to the National Institute of Standards and Technology (NIST). Results of field calibrations are used to assess sensor accuracy and flag, adjust, or invalidate field data. In addition, sites are audited by an independent auditor at EPA's discretion.

2.1.3 Measurements of Leaf Area Index

LAI measurements were taken at all existing CASTNET sites during the summers of 1991 and 1992, and at most of the NPS sites during the summer of 1997. LAI is the one-sided leaf area of the plant canopy per unit area of ground at full leaf emergence. LAI has been shown to play an important role in atmosphere-canopy exchange processes (McMillen, 1990). LAI measurements are useful in evaluating transfer rates of materials from the atmosphere to the plant canopy. Estimates of LAI are used as input to the MLM. LAI was measured using an LAI-2000 Plant Canopy Analyzer manufactured by LI-COR Biosciences (LI-COR), Lincoln, NE. The LAI-2000 makes indirect (i.e., nondestructive) estimates of LAI from simultaneous measurements of light interception by the plant canopy at five angles of inclination (LI-COR, 1989). Amec Foster Wheeler personnel walked the area around each site to perform LAI measurements and "ground-truth" verification of the land cover and land use classification maps that were obtained from the USGS (Anderson, *et al.*, 1978). LAI measurements and ground-truth verification were performed for all of the sites in operation through 1997. Any changes to the land cover classification discovered during the ground-truth verification were incorporated into the CASTNET database. LAI data for sites installed after 1997 were estimated from the 1991−1997 LAI database and from aerial photographs of vegetative cover within one kilometer of the new site, and from any related information on completed SSRF.

2.1.4 Site Operations for Precipitation Monitoring

Sixty-six active CASTNET sites [EPA (44), NPS (21), and BLM (1)] have precipitation chemistry (wet deposition) sites within 10 km of their location. Sixty-five of these wet deposition sites are operated as part of NADP/NTN. In addition, CTH110, NY is collocated with an NADP/AIRMoN wet deposition site that features event based sampling. Wet deposition samples are collected weekly and shipped to the NADP/NTN laboratory for chemical analysis. Precipitation amounts are measured using a NOAH IV digital rain gauge. Wet deposition samples are collected in precleaned polyethylene buckets using an Aerochem Metrics, Inc. precipitation sampler. Buckets are placed on the sampler on Tuesday and removed, whether or not rainfall has occurred, the following Tuesday. Buckets are weighed in the field, decanted to a polyethylene bottle, if applicable, sealed, and shipped to NADP/NTN for chemical analysis.

2.1.5 Sampling Locations and Frequency

The original concept behind CASTNET was to establish a network of approximately 100 sites throughout the United States. Ninety-three sites are operational. Figure 1-1 shows the locations of CASTNET sites operated during 2015. Table 1-1 provides the location and operational characteristics of each CASTNET site by state. Table 1-3 lists discontinued sites. The geographic density of the eastern sites is sufficient to meet CASTNET objectives. However, additional sites are needed to meet the original goal of CASTNET.

Most of the eastern network sites were installed and began collecting data by July 1989. Fourteen sites were discontinued (Table 1-3), mostly due to inadequate siting conditions. In 1994, EPA and NPS began a collaborative effort to expand dry deposition measurements in the western United States (primarily at national parks and monuments). NPS agreed to operate 19 sites in 1994 and has since added sites for a total of 25. The NPS sites are designated as 400-series sites in Figure 1-1. BLM began operating four CASTNET sites in Wyoming in November 2012 and one site in April 2013. The BLM sites are designated as 600-series sites in Figure 1-1. New filter pack only sites are operating in upstate New York (three), Vermont, North Carolina, Kansas, Minnesota, and Idaho.

CASTNET currently includes the following major components:

- Ninety-five sites, all of which collect weekly filter pack measurements, are operated throughout the contiguous United States. Eighty sites measure O_3. BEL116, MD and BVL130, IL measure SO_2 and NO/NO_y. BVL130, IL measures CO; and HWF187, NY, ROM206, CO, PNF126, NC, MAC426, KY and GRS420, TN measure NO/NO_y.
- Two collocated sites measure the precision of network measurements. An EPA-sponsored site (ROM206, CO) is operated adjacent to an NPS-sponsored site (ROM406, CO) at Rocky Mountain National Park, CO. Two duplicate systems are operated by EPA at the Mackville, KY (MCK131/231) site. Precision for O_3 is calculated for each analyzer as described in Table 4-12.

- Sixty-six precipitation chemistry (wet deposition) sites are operated according to NADP/NTN protocols. All 66 sites are located with 10 km of dry deposition sites.
- Estimates of V_d and dry deposition fluxes are modeled (using TDEP and MLM) or estimated for all sites.
- The CASTNET database (historical EPA and NPS data and recent BLM data) from 1987 through the current quarter is maintained and regularly updated.

2.2 Siting Procedures

2.2.1 General Siting Criteria

Project-wide and site-specific objectives are considered when determining the location of a monitoring site. In addition to meeting the project-wide objectives described in Section 1.3.1, the physical and chemical environment of each site must be consistent with objectives for that site. Guidance for site selection is based on agency requirements, e.g., 40 CFR Part 58 Appendix E Tables E-1 and E-2 and Figure E-1, and CASTNET site-selection criteria. Site selection procedures differ somewhat for different types of sites (traditional, filter pack only or gaseous pollutant monitoring). A list of the site-specific siting criteria used in the site selection process for classic CASTNET sites is shown in Table 2-1. The siting criteria for filter pack only sites are listed in Table 2-2. Siting criteria for gas measurements are provided in Table 2-3.

2.2.2 New Site Selection

The location of a monitoring site can have a major influence on overall data quality and representativeness. Therefore, selection of monitoring sites requires close interaction with the EPA Project Officer and technical monitors. Results of all site evaluations are documented by Amec Foster Wheeler and approved by the EPA Project Officer prior to execution of lease agreements or initiation of installation activities.

An iterative process for selecting dry deposition monitoring sites is followed. The principal steps include:

- Identification of general geographic areas for inclusion in the network;
- Review of emissions inventory, population, vehicular traffic, and land-use data to identify areas that are regionally representative;
- Visits to areas designated in the previous steps to identify and evaluate candidate sites; and
- Discussion and selection of sites with EPA.

2.2.2.1 Identification of New Candidate Sites

Prior to engaging in on-site field surveys, advance work is accomplished by Amec Foster Wheeler. This includes review of information (e.g., site summaries, site descriptions, and any air quality and meteorological data) available from other networks about existing sites they are currently using that could provide candidate sites for CASTNET. Additional information is collected through contacts with respective state, tribal and federal agencies. CASTNET experience has shown that the U.S. Forest Service (USFS), BLM, and universities are frequently willing to host monitoring sites. Although public land is preferable, private property and soil conservation set-aside programs also are investigated.

Once possible candidate sites are identified, additional background information in the form of maps is acquired in advance of field survey activities. [U.S. Geological Survey (USGS) maps (1:24,000 and 1:250,000 scale)] are obtained for each candidate site. Quadrangle maps provide on-site determination of latitude, longitude, and elevation, and they also provide an overview of surrounding features (terrain, roads, and towns). The 1:250,000 scale maps display regional terrain features and distances to industrial complexes, major population centers, and transportation corridors. If possible, U.S. Soil Conservation Survey (SCS) maps are acquired because they provide geological data, land-use patterns, and ownership information. Web-based geographic data (e.g., from Google Earth) are also used.

The NPS sites are designated for national parks and monuments. Once a park or monument has been selected, NPS/ARS follows the procedures discussed in Sections 2.2.2.2 and 2.3.2.

2.2.2.2 Installation and Initiation

2.2.2.2.1 Equipment Procurement

CASTNET deploys a standard set of ambient monitoring equipment. Equipment procurement is carried out according to the SOP described in the CASTNET Government Property Control SOP, which is included as Appendix 9.

Order and receipt of equipment are the responsibility of the CASTNET PCM. The following procedures are employed upon receipt of all equipment at Amec Foster Wheeler:

- Physical inspection of shipping container for damage
- Verification of the packing list by matching quantity and serial numbers of shipped items
- Assignment of a unique EPA 5-digit inventory number and cross-reference with the serial number
- Entry of inventory numbers and equipment information into the CASTNET database

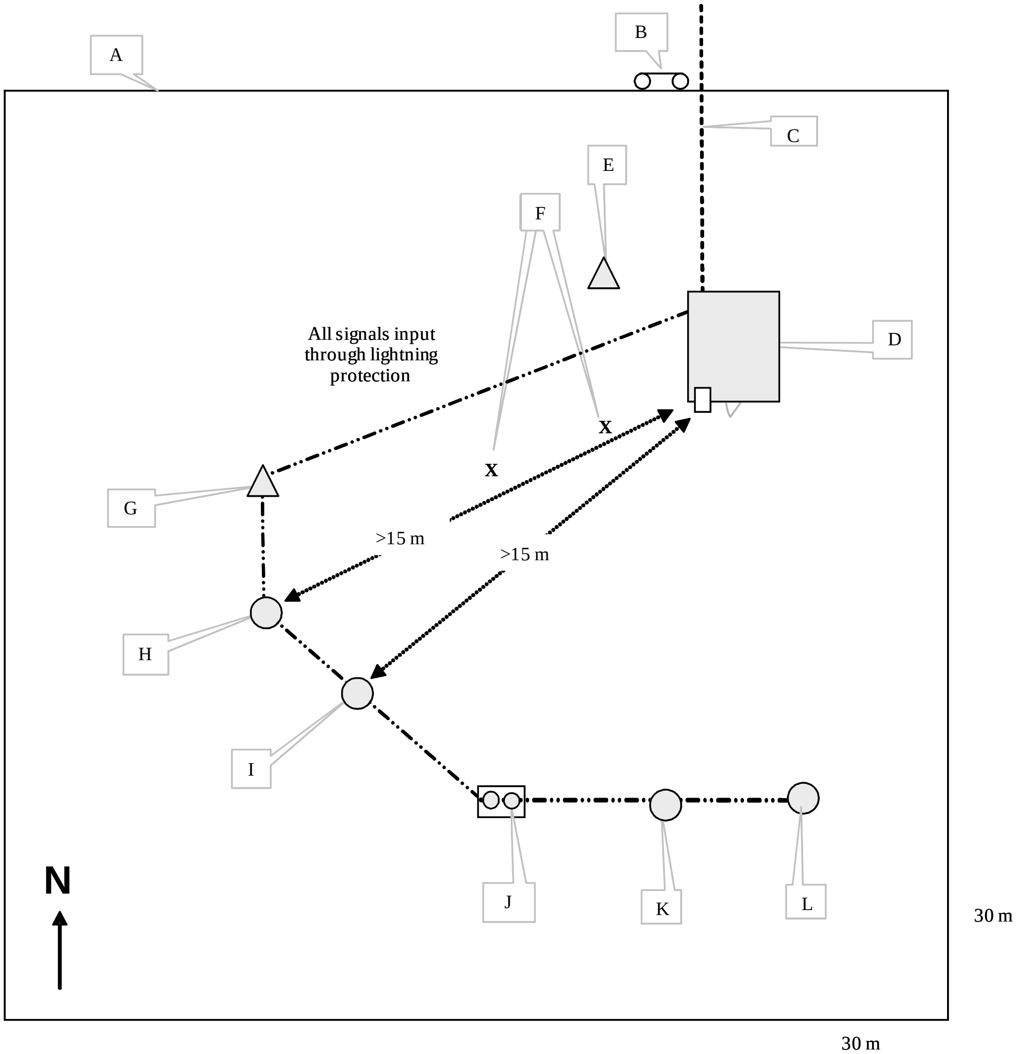
After receipt and log in, if applicable, each item of monitoring equipment undergoes acceptance testing. These tests include comparing instrument outputs to known, calibrated values and checks of zero and span drift, noise levels, response time, and detection limits. Equipment that does not meet acceptance criteria is returned to the manufacturer for replacement or is repaired by Amec Foster Wheeler technicians. An equipment report, which includes itemized, nonexpendable and expendable government equipment, is sent annually to EPA.

2.2.2.2.2 Installation and Initiation

The goal of site installation and initiation is to minimize travel and shipment of equipment while maximizing the efficiency of the process. Table 2-4 summarizes the activities involving site installation and initiation. Some tasks listed in Table 2-4 have not been executed for many newly installed sites because site infrastructure had already existed and a local site operator was available from the cooperating organization. A typical site configuration for a standard, full suite CASTNET site is shown in Figure 2-1. A typical site configuration for a small footprint, filter pack only site is given in Figure 2-2. All physical components shown are installed, as necessary, by field technicians. Variations occur to accommodate existing facilities, security, or other site-specific considerations. All instruments are installed following recommendations and requirements specified in Quality Assurance Requirements for SLAMS (EPA, 2013), special purpose monitoring stations (SPMS), prevention of significant deterioration (PSD) Air Monitoring, Appendix A, 40 CFR 58 (EPA, 2014), and the QA Handbook for Air Pollution Measurement Systems, Volumes I, II, and IV (EPA, 2013; 2015; 2008). Detailed procedures are provided in the CASTNET Field SOP I, Site Selection Procedures (Appendix 1).

Site-specific inventory forms, generated prior to equipment mobilization (Figure 2-3), document all instruments and equipment located at the site and their assigned EPA 5-digit inventory numbers. Figure 2-4 shows an inventory form for a small footprint site. The inventory forms are verified prior to the field technician's departure from the site. Upon return to the Amec Foster Wheeler office, the verified inventory document is used for crosschecking with the computerized inventory table, which is maintained by the PCM in the CDMSA. If discrepancies exist, the computerized table is corrected to reflect the actual, as installed, equipment inventory. The electronic Site Information Form (Figures 2-5 and 2-6) is also completed by the field technician/calibrator prior to leaving the site.

Figure 2-1 Typical EPA-Sponsored CASTNET Site Configuration with Full Suite



A – Site Perimeter
B – Stub Pole, Disconnect, Electric Meter
C – 220 VAC/100 amp and Telephone Line (underground for at least the final 15 to 35 meters)
D – 8' x 10' Aluminum Environmental Shelter (Temperature Controlled)
E – Air Sampling Tower
F – Approximate Position of Tower Tops when lowered
G – Meteorological Tower
H – Tipping Bucket Rain Gauge (> 15m from shelter)
I – Solar Radiation Sensor (>15 m from shelter)
J – NADP/NTN Wet/Dry Collection (optional)
K – NADP/NTN NOAH IV Electronic Rain Gauge (optional)
L – Wetness Sensor

Figure 2-2 Small Footprint Site Operated at Nicks Lake, NY

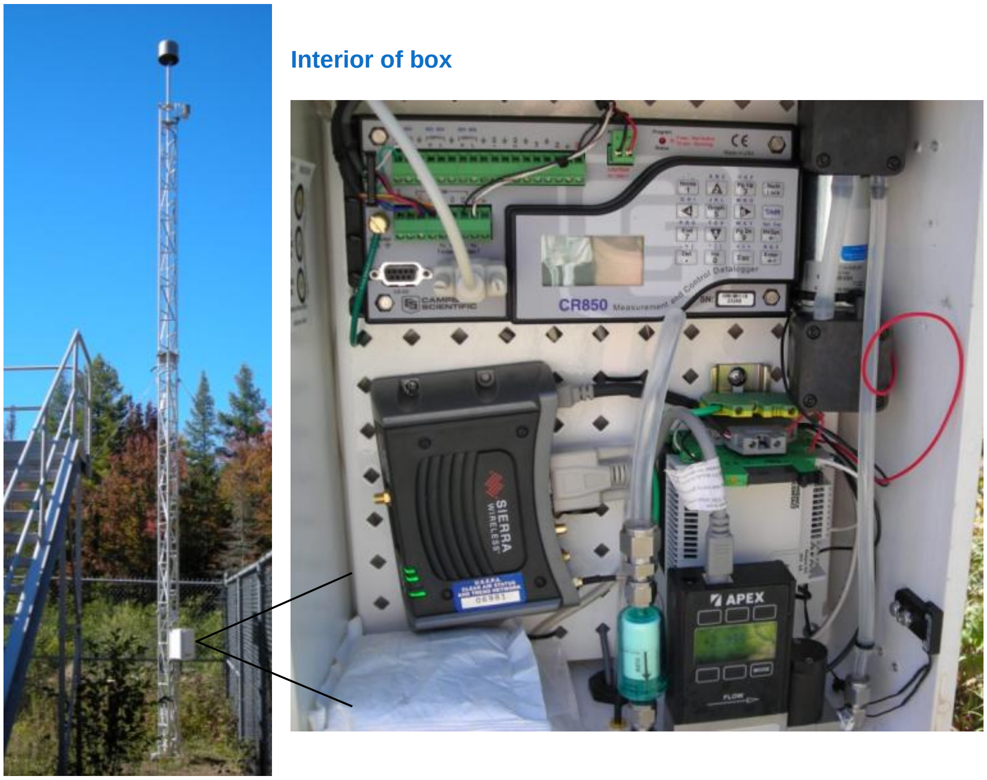


Figure 2-3 Sample Site Inventory Form for PAL190, TX

CLEAN AIR STATUS AND TRENDS NETWORK SITE INVENTORY LIST
Sorted by EPA Bar Code within Site

Monday, October 03, 2011

EPA BAR CODE	CASTNet # ▲	EQUIPMENT NAME ▲	SERIAL #	SITE ID ▲
000725		A-ANALYZER, OZONE	1105347326	PAL190
000214		A-ANALYZER, OZONE - SITE XFER STD	0622717855	PAL190
	06929	A-COMPRESSOR, AIR	000829173	PAL190
	06437	D-COMPACT FLASH	2468	PAL190
000296		D-COMPUTER, LAPTOP	7XFNHB1	PAL190
000347		D-DATA LOGGER	2126	PAL190
	06808	D-MODEM, DIGITAL - RAVEN X HSDPA	0934411667	PAL190
	06342	D-MODEM, EXTERNAL	1509	PAL190
000592		F-CONTROLLER, MASS FLOW	50728	PAL190
000594		F-CONTROLLER, MASS FLOW	50730	PAL190
000602		F-CONTROLLER, MASS FLOW	50750	PAL190
000604		F-CONTROLLER, MASS FLOW	50751	PAL190
810717X	01423	F-PUMP, VACUUM	0000256	PAL190
	04286	F-PUMP, VACUUM	129800010141	PAL190
000384		F-TOWER, FLOW	N/A	PAL190
	04695	M-MONITOR-AQ, WIND	49437	PAL190
	06307	M-RAIN GAUGE, TIPPING BUCKET	41276-107	PAL190
	06223	M-SENSOR, RELATIVE HUMIDITY	B3220003	PAL190
	06311	M-SENSOR, SOLAR RADIATION	PY05510	PAL190
	06302	M-SENSOR, TEMPERATURE-TRANSLATOR	12541	PAL190
	06303	M-SENSOR, TEMPERATURE-TRANSLATOR	12542	PAL190
	06151	M-SENSOR, WETNESS	N/A	PAL190
	06166	M-SHIELD, TEMPERATURE	N/A	PAL190
	06167	M-SHIELD, TEMPERATURE	N/A	PAL190
	06322	M-TOWER, 10 METER	N/A	PAL190
	06310	M-TRANSLATOR, SOLAR RAD	N/A	PAL190
000350		S-SHELTER, 8X8X10, ALUM	26012-02	PAL190
	06269	S-UPS	5B0706U14389	PAL190

Figure 2-4 Sample Site Inventory Form for NIC001, NY

CLEAN AIR STATUS AND TREND NETWORK SITE INVENTORY LIST
Sorted By EPA Bar Code Within Site
Monday, April 21, 2014

SITE ID ▲	EPA BAR CODE	CASTNet # ▲	EQUIPMENT NAME ▲	QUANTI...	TOTAL CO...
NIC001	000801		D-DATA LOGGER	1	
NIC001		06989	D-MODEM, CELLULAR	1	
NIC001	000594		F-CONTROLLER, MASS FLOW	1	
NIC001	000785		F-TOWER, FOLDING B	1	
NIC001		04943	M-SENSOR, TEMPERATURE-TRANSLATOR	1	

2.2.2.3 Sharing Site Locations in Other Networks

The same siting criteria employed for the new sites are used to judge the suitability of the existing sites being used by another sponsoring agency. In the event existing sites that are already in service with another sponsoring agency are candidate locations for CASTNET, the sites are visited to ascertain any special requirements necessary to house the additional equipment required. The local site operator and the sponsoring agency are contacted to obtain the following information:

- Availability of shelf or rack space in the existing shelter
- Adequacy of existing power and communications
- Suitability of existing sample manifold and possibilities for retrofit
- Means of access (e.g., duplicate keys and security requirements)
- Protocols for cooperation with sponsoring agency
- Comprehensive onsite evaluation and site survey

The two new sites in upstate New York (NIC001 and WFM105) are operated by DEC and NYSERDA, respectively. The new site in Vermont (UND002) is operated by EPA on a NADP site. Underhill is sponsored by VT DEC (in-kind operations). It is collocated with NTN, AIRMoN, NCore, and IMPROVE.

Figure 2-5 Example Site Information Form

SITE INFORMATION

amec

Site Name/Number	Calibrator	Start Date	Start Time	End Date	End Time	Met Manufacturer
PAL 190	TYLER WARD	11/19/2013	09:40	11/20/2013		R.M. Young

Site Equipment Replaced

Parameter	Device	Manufacturer	Model	ID #	Type
Wind AQ	Anemometer	R.M. Young	5305	004354	

Site Equipment as Found

Parameter	Device	Manufacturer	Model	ID #	Type
Signal Input/Output	Datalogger	Campbell Scientific	3000	000347	
Temperature	10-m Thermistor	R.M. Young	43347	006303	
	2-m Thermistor	R.M. Young	43347	006302	
	10-m Signal Translator	R.M. Young			
Relative Humidity	Sensor	Vaisala	102425	006223	
Wind AQ	Vane	R.M. Young			
	Anemometer	R.M. Young	5305	004405	
	Translator	R.M. Young			
Flow	Controller	Apex		000604	
	MFC Display				
Precipitation	Tipping Bucket Gauge	Texas Electronics	TR-5251	006307	
Wetness	Sensor	R.M. Young	58101	006288	
Ozone	Analyzer				
Solar Radiation	Pyranometer	LiCor	Li-200	004009	
	Translator	R.M. Young		004063	

Calibration Equipment Used

Parameter	Device	Manufacturer	Model	ID #	Last Certification Date
Signal Input/Output	Mulitmeter	Fluke		4622	3/26/2013
	Voltage Source	Datel	C-350A	4624	10/22/2013
Temperature	RTD	Eutechnics	4600	4643	8/12/2013
Relative Humidity	Hygrometer	Rotronics	GTL	6834	8/2/2013
	Humidity Chamber	VaporPak		537	
Solar Radiation	Pyranometer	LiCor	Li-200	6533	11/8/2013
	Transfer - Translator			6321	
Flow	Transfer MFM	BIOS	Dry Cal Lite	768	6/21/2013
	Data Module				
Ozone	Transfer - Analyzer				
Wind	Transit	Brunton	F-5006	6554	5/16/2013
	Synchronous Motor	R.M. Young	18802	4631	4/3/2013
Wetness	Mulitmeter	Fluke		4622	3/26/2013
	Decade Box				

Remarks	iForms Version
	1.5.1

Figure 2-6 Example Site Information Form for NIC001, NY

SITE INFORMATION

amec

Site Name/Number	Calibrator	Start Date	Start Time	End Date	End Time	Met Manufacturer
NIC001	MIKE SMITH	04/05/2014	13:20	04/05/2014	15:05	

Site Equipment as Found

Parameter	Device	Manufacturer	Model	ID #	Type
Signal Input/Output	Datalogger	Campbell Scientific	3000	000801	
Temperature	10-m Thermistor		43347	004943	
	2-m Thermistor				
	10-m Signal Translator				
Relative Humidity	Sensor				
Wind Direction	Vane				
	Anemometer				
	Translator				
Flow	Controller	Apex		000594	
	MFC Display				
Precipitation	Tipping Bucket Gauge				
Wetness	Sensor	R.M. Young	58101		
Ozone	Analyzer				
Solar Radiation	Pyranometer				
	Translator				

Calibration Equipment Used

Parameter	Device	Manufacturer	Model	ID #	Last Certification Date
Signal Input/Output	Mulitmeter				
	Voltage Source	Datel	C-350A		
Temperature	RTD	Eutechnics	4600	4643	1/20/2014
Relative Humidity	Hygrometer	Rotronics			
	Humidity Chamber	VaporPak			
Solar Radiation	Pyranometer				
	Transfer - Translator				
Flow	Transfer MFM	BIOS	Dry Cal Lite	812	7/19/2013
	Data Module				
Ozone	Transfer - Analyzer				
Wind	Transit	Brunton			
	Synchronous Motor	R.M. Young			
Wetness	Mulitmeter				
	Decade Box				

Remarks	iForms Version
	1.5.1

2.2.2.4 Determination of Favorable Sites for Comprehensive Evaluation

Amec Foster Wheeler expects future sites will be proposed by government agencies, universities, or tribes. Consequently, site evaluation will be preformed primarily on a local basis and not regionally. A new regional site will be based on review of available documentation, emission inventories, and local land-use maps, Amec Foster Wheeler prepares lists of candidate sites along with recommendations for the EPA Project Officer and EPA Technical Monitors to review. On the other hand, candidate sites are often proposed by participating agencies. In these situations Amec Foster Wheeler's role will be to gauge site acceptability. The candidate site list includes information regarding site location, status (e.g., proposed site, existing NADP/NTN site, other network site), land ownership, host agency, operator availability, proximity to emission sources (SO_2 and NO_x) and population centers, land-use patterns, maps, and wind rose data (where available). Following review and discussion of the candidate sites with the EPA Project Officer, favorable sites are identified for comprehensive on-site evaluations.

2.2.2.5 Comprehensive On-Site Evaluation

Again, Amec Foster Wheeler anticipates future site selection activities will focus on a local area rather than candidate sites spread over a wide region. Following receipt of approval from the EPA Project Officer, a schedule of site visits will be prepared, if needed. A schedule is designed to minimize travel by organizing candidate sites in logical geographic groups (if appropriate). Advance arrangements are made with agency personnel and landowners; and background information on CASTNET is sent to them for review, prior to the arrival of Amec Foster Wheeler personnel.

Amec Foster Wheeler personnel conduct on-site evaluations of all prospective EPA-sponsored CASTNET sites. The objective of each trip is to accomplish the following activities:

- Meet with the site manager or landowner to discuss monitoring objectives
- Evaluate the site with respect to site-specific siting criteria (Tables 2-1 through 2-3)
- Obtain documentation of current site characteristics
- Investigate availability of candidate site operators

All site evaluation data files include information regarding site ownership, site management, local conditions, regional conditions, long-term availability, and on-site activities.

During the on-site evaluation, Amec Foster Wheeler personnel interview the prospective site operators. Amec Foster Wheeler assembles information for further consideration regarding the prospective site operator’s experience, education, intent to remain in the area, and ability to assume additional duties.

Following completion of the candidate site evaluation trip, all forms, data, and maps collected are assembled into the physical site summary file. Within two weeks of the site survey, an evaluation report is submitted to the EPA Project Officer. The site evaluation report contains a narrative summary, recommendations, and a site documentation package that includes:

- Site identification and administration,
- Site representativeness (including regional and local influences),
- Site suitability and logistics,
- Topographic maps and aerial and satellite photographs,
- Maps of pollutant emissions, and
- Site photographs in at least four cardinal directions.

After reviewing the site evaluation report, the EPA Project Officer will make the final selection of the site(s).

2.2.2.6 Contractual Arrangements

Following approval of a location for site installation, contractual arrangements are initiated if necessary. Such activities vary from site to site because numerous agencies, organizations, offices, and individuals might have to be contacted and agreements reached prior to actual site installation. Arrangements include contracts, cooperative agreements, consulting agreements, leases, special-use permits, and state business licenses. Since securing final agreement from all parties prior to installation is potentially the single most time-consuming activity, it is essential that negotiation of such arrangements be initiated immediately upon receipt of EPA approval for site installation.

2.3 Site Operators

In general, training for EPA, NPS and BLM site operators includes an overview of CASTNET and the project objectives. Emphasis is placed on explaining how the data gathered at the field sites are used to accomplish project goals. The basic theory of operation of each sensor/instrument, the type of data gathered by each sensor, and general meteorological principles are explained, as necessary. Field SOP and checklists are distributed, and trainees are required to familiarize themselves with the contents. Documentation procedures, such as filling out SSRF, are reviewed and practiced.

Before training is concluded, trainees must perform successfully all site operator duties while observed by the trainer. Site operator duties are discussed later in Section 2.4 and are summarized in Table 2-5. Note that only four EPA sites operate the meteorological instruments listed in Table 2-5. Since the most critical aspect of site operator duties involves the weekly filter pack change-out, performance of these procedures is stressed during this part of the training. If the site includes O_3 measurements and/or trace gas measurements, operation of the continuous analyzers is also emphasized. Site operators also fill out the SSRF and electronic iForms while demonstrating their duties. A record of the training is established in the site logbook. Certifications and acknowledgements of training proficiency are archived electronically at each site and at the Amec Foster Wheeler Gainesville office using a secure SharePoint CASTNET team site. If needed, refresher training is given during the biannual calibration and maintenance visits.

Site operators received additional support and training during the Tuesday call to the FOM, during each biannual calibration visit, and any site visits.

2.3.1 Training and Management: EPA-Sponsored Sites

Potential site operators are required to attend and successfully complete a training seminar provided on-site. The training is performed by the FOM or a designated field coordinator or field technician. Operation of the Campbell Scientific CR3000 or CR850 data loggers and the field sampling instruments particular to that site is presented in detail. The on-site training includes all site operator duties, and before training is concluded, the trainees must successfully perform all operator duties and complete all required hard copy and electronic forms required for a weekly site visit while observed by the trainer. The field technician will answer all of the site operator's questions and will verify that the site operator is familiar with the contents and location of Field SOP, checklists, and other documentation and forms. Additionally, following the completion of all scheduled calibration and maintenance visits to the site, the field technician will spend as much time as required with the site operator to verify that the operator has a complete working knowledge of his/her required duties. The overall quality of the network operators directly translates to the quality of network data. The field technician will observe and/or check the site operator's performance of his/her duties as follows:

- Observe the operator perform a routine weekly station check, including zero checks, precision checks, and sample line integrity checks (SLIC)
- Observe and assist the site operator with a multipoint check
- Review operator log notes and other forms including station checklists, electronic calibration forms, other data documentation, and overall station documentation
- Review a completed CASTNET SSRF
- Train the site operator on any aspect of weekly station checks, multipoint calibrations, zero checks, precision checks, SLIC, filter replacements, data reporting, data transmittal, or other operational requirements where deficiencies are observed
- Verify that the current versions of all SOP are available on-site and update, if necessary, the SOP to reflect any changes in instrumentation, procedures, or protocols
- Thoroughly review any changes in instrumentation, procedures, or protocols with the site operator
- Verify that the operator has an adequate inventory of consumable supplies
- Update the operator on the monitoring program goals and objectives
- Instill in each operator a sense of purpose to stimulate self-interest and responsibility and encourage and fully answer any questions and note any operator comments and suggestions.

2.3.2 Training and Management: NPS- and BLM-Sponsored Sites

Onsite training for NPS and BLM site operators is provided by ARS field specialists during the 6-month calibration visit as discussed in Section 4.2.8 of the ARS SOP "Procedures for Semiannual Maintenance Visits to a NPS Ambient Air Monitoring Station." Also, focused communication and network documentation promotes effective remote site operator training. Following the completion of all scheduled calibrations and maintenance, the ARS field specialist will spend time with site operator to ensure the operator has a complete and working knowledge of their required duties. The overall quality of operator performance translates directly to the quality of the network measurements. The ARS specialist will:

- ✓ **Observe operator performance** - Observe the operator perform a complete station check and review procedures for ZPS checks and multipoint calibrations.

- ✓ **Review log notes** - Review operator log notes, station checklists, calibration forms, other data documentation, and overall station organization.
- ✓ **Train** - Further train the station operator on any aspect of multipoint calibrations, precision checks, data reporting, data transmittal, or other operational requirement where deficiencies are observed.
- ✓ **Review changes** - Thoroughly review any changes in SOPs or operations with the station operator.
- ✓ **Verify on-site SOPs** - Verify that the current versions of all SOPs are available on-site, and update if necessary to reflect any changes in instrumentation, procedures, or protocols.
- ✓ **Verify inventory** - Verify that the operator has an adequate inventory of all required forms and consumable supplies, including desiccant, particulate filters, gloves, printer ink, and similar items.
- ✓ **Encourage/answer questions** - Encourage station operator comments and fully answer any questions the operator may have. Note any operator comments or suggestions.
- ✓ **Inform** - Update the operator on the monitoring program goals and objectives. Instill in each operator a sense of purpose to stimulate self-interest and responsibility.

The field specialist will document any corrective action. The training record is not complete until the site operator signs and dates the form, acknowledging the training was received.

2.4 Field Sampling Methods

Field sampling procedures are very important in achieving and maintaining DQI criteria. How these procedures are performed can have a major impact on every project task or operation and, ultimately, the quality of the final data.

The accuracy of field measurements is determined by challenging instruments with standards that are traceable to NIST. Continuing accuracy is verified through semiannual calibrations by Amec Foster Wheeler personnel. Accuracy objectives for field measurements are listed in Table 2-6.

Meteorological instruments (Table 1-1) are operated at four EPA, five BLM, the St. Johns River Water Management District (SJRWMD) site at IRL141, FL and all NPS sites. In addition, BLM operates meteorological instruments at the EPA PND 165, WY site.

In practice, separate measurement criteria are used for field calibrations and for data validation. Table 2-7 provides acceptance criteria for field calibrations. The table also lists the calibration methods, e.g., dry piston meter for filter pack flow rate. For example, the filter pack flow rate is adjusted if its calibration result is outside of the ± 2 percent criterion, while flow rate data are considered valid if results are within ± 5 percent.

To evaluate precision of the CASTNET measurements, two sites in the network operate collocated sampling systems. Amec Foster Wheeler has operated two sampling systems at the EPA-sponsored site at MCK131/231, KY since December 1992. Although located at the same site in Rocky Mountain National Park, ROM206, CO and ROM406, CO are serviced by different operators and calibrators. ROM206 is an EPA-sponsored site initiated in July 2001 and is operated by Amec Foster Wheeler, while ROM406 is an NPS-sponsored site and is operated by ARS. Instruments are installed in identical configurations. Sensors are located so that they will not interfere with each other's operation or response. The overall precision of continuous data except gas analyzers is assessed quarterly and annually by calculating MARPD or MAD between simultaneous hourly averages and weekly filter pack concentrations from collocated sites. Precision for gas analyzers, including O_3, is calculated as described in Table 4-12.

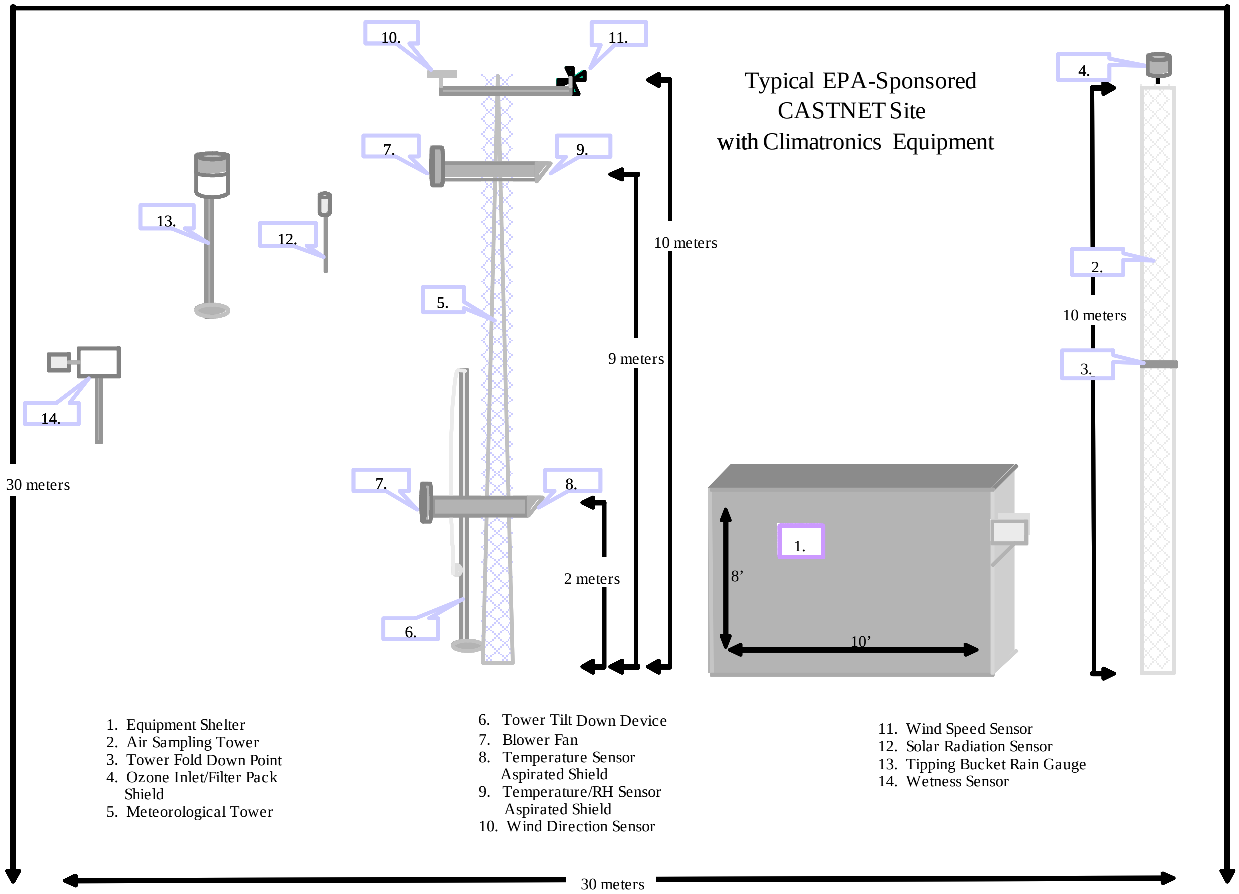
Collocated continuous data are analyzed on a quarterly basis, and quarterly MARPD or MAD that deviate substantially from the established measurement criteria are investigated. Corrective actions depend on the diagnosis and may consist of instrument/sensor replacement or adjustment. When a problem is identified, it is not to be corrected until a network-wide solution is created or until regularly scheduled maintenance is performed, as appropriate, to preserve collocated results as an indicator of network operation.

Table 2-8 lists the measurements and instruments used by EPA (Amec Foster Wheeler) and NPS/BLM (ARS) throughout the network. Figure 2-7 provides schematics of standard EPA-sponsored CASTNET sites with Climatronics and RM Young meteorological equipment. Photographs of many of the components used at the sites are shown in Figure 2-8. The meteorological instruments (Table 2-9) used by EPA and NPS are generally the same with some minor procedural differences that do not affect the resulting measurements.

Table 2-10 summarizes the instrument specifications for the O_3 analyzers used by Amec Foster Wheeler at the EPA-sponsored sites. ARS operates Thermo Scientific analyzers at the NPS-sponsored sites and utilizes an in-station transfer standard to verify the ozone levels generated for the precision and span checks. Seventy-nine of 80 O_3 sites conform to EPA requirements described in 40 CFR Part 58, Appendix A (EPA, 2015).

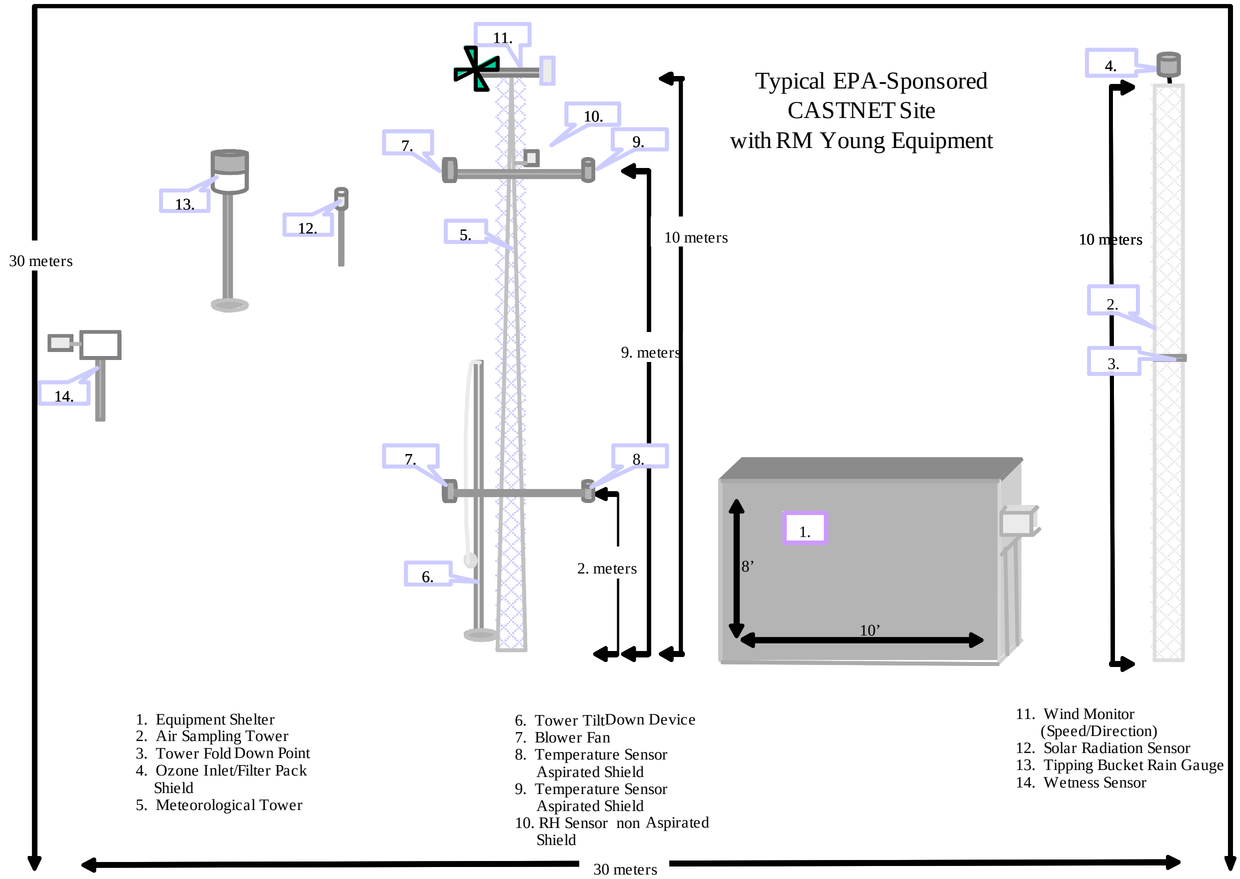
The following sections describe procedures that are implemented at each sampling site to ensure the collection of data that are of the highest quality. The discussions apply to both EPA and NPS field instruments unless noted otherwise.

Figure 2-7 Schematic of an EPA-Sponsored CASTNET Site with a Full Instrument Suite (1 of 3)



Notes: Climatronics Meteorological Instruments
RH = relative humidity

Figure 2-7 Schematic of an EPA-Sponsored CASTNET with a Full Instrument Suite (2 of 3)



Notes: RM Young Meteorological Instruments
RH = relative humidity

Figure 2-7 Schematic of an EPA-Sponsored CASTNET Site with a Full Instrument Suite (3 of 3)

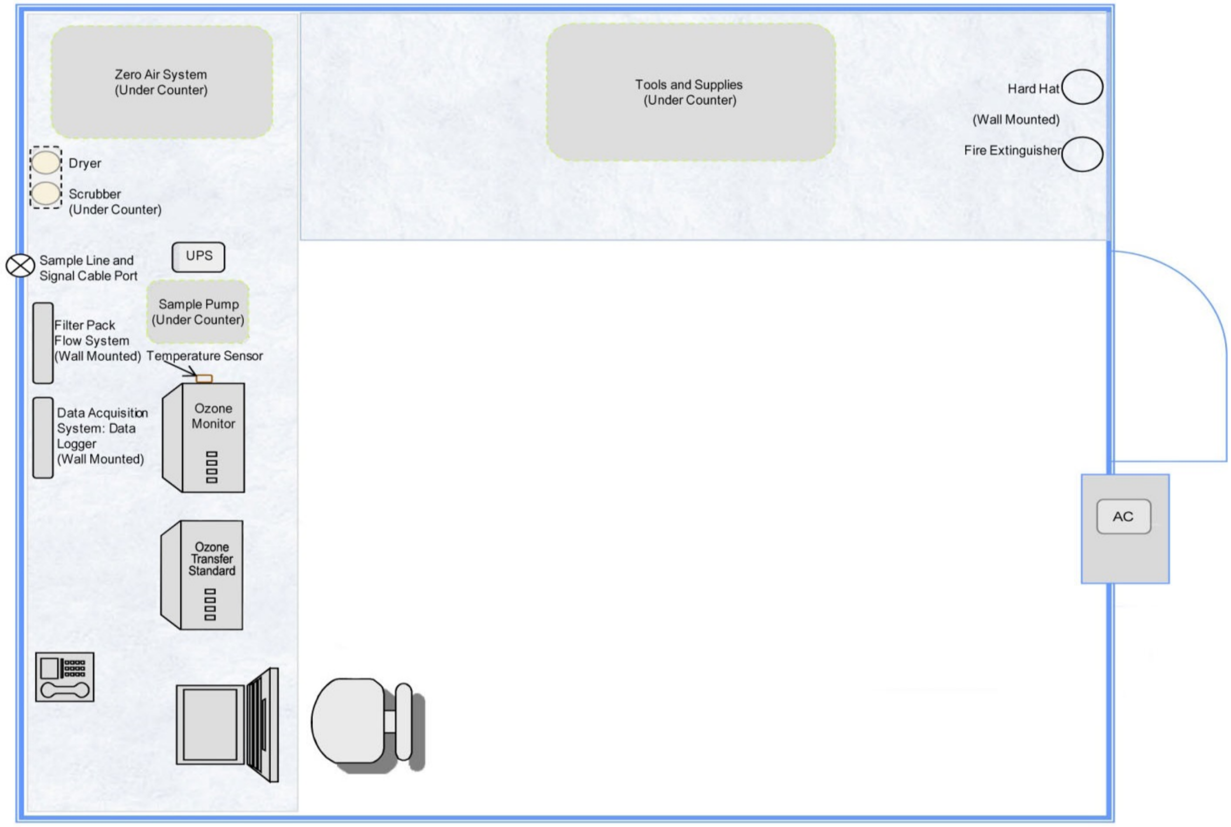


Figure 2-8 EPA-Sponsored CASTNET Site Components (1 of 4)

Three-Stage Filter Pack

Mass Flow Controller

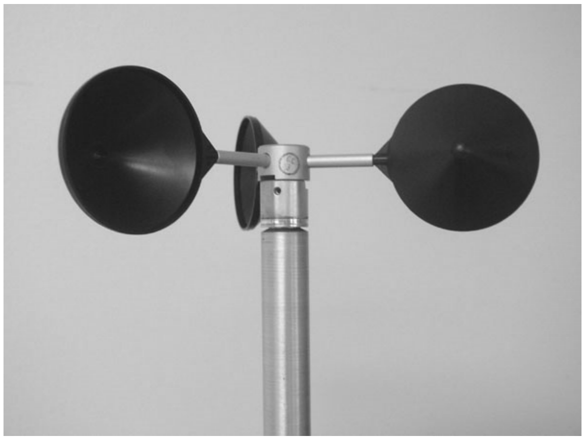
Ozone Inlet / Filter Pack Shield

Ozone Filter Cartridge

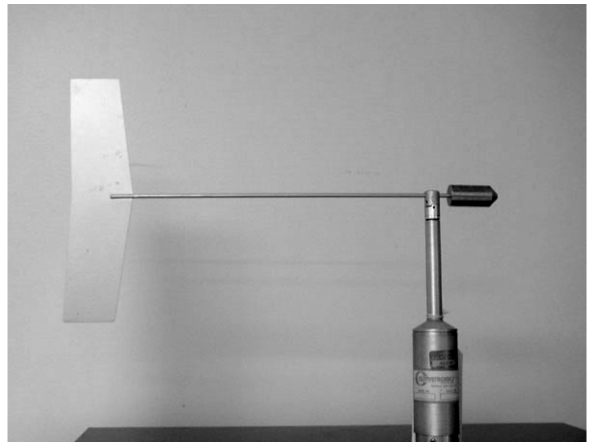
49i Ozone Analyzer

Wind Sensor (Speed / Direction) RM Young

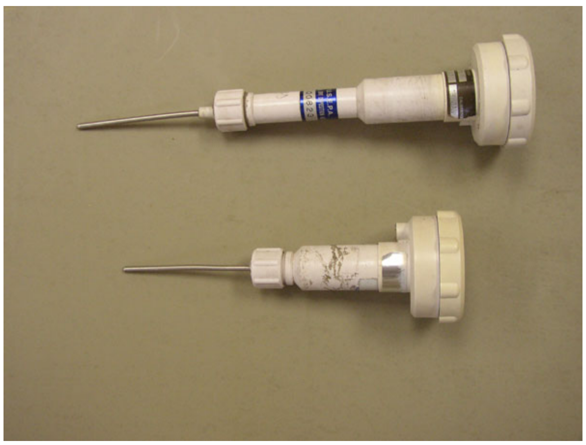
Figure 2-8 EPA-Sponsored CASTNET Site Components (2 of 4)



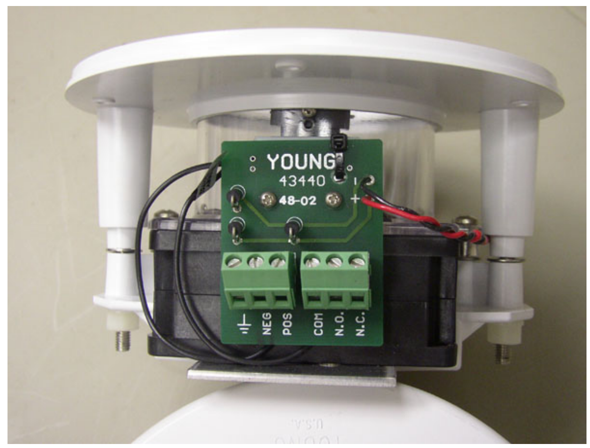
Wind Speed Sensor – Climatronics



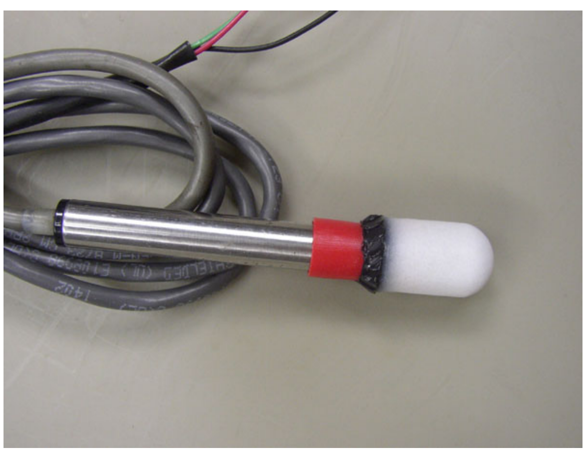
Wind Direction Sensor – Climatronics



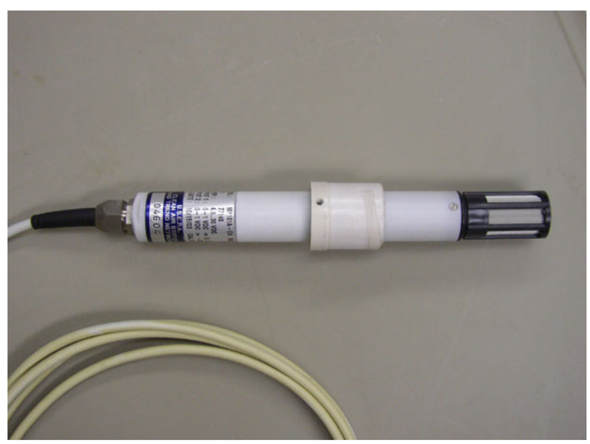
Temperature (longer) / Delta Temperature Sensors



Blower Fan for Aspirated Temperature and Relative Humidity Sensor



Aspirated Relative Humidity Sensor (Climatronics)



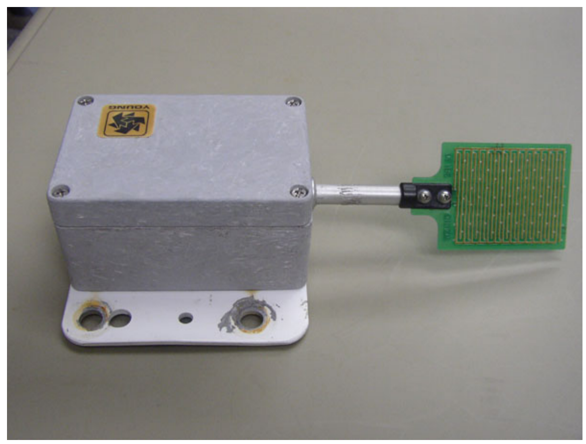
Non-Aspirated Relative Humidity Sensor (Rotronic)

Figure 2-8 EPA-Sponsored CASTNET Site Components (3 of 4)

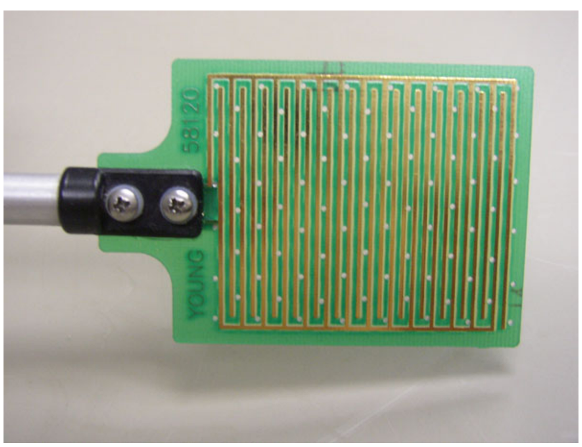
Non-Aspirated Relative Humidity Sensor Shield

Tipping Bucket Rain Gauge

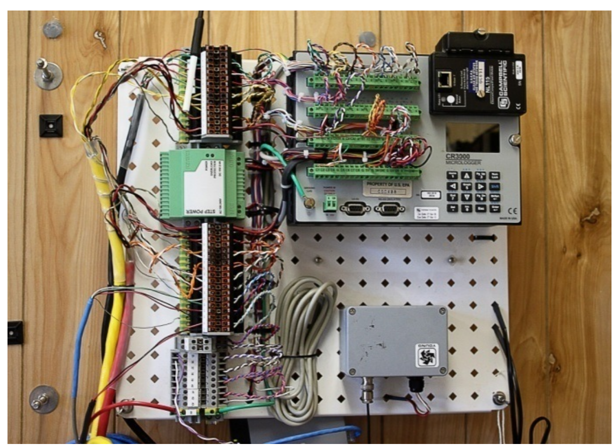
Solar Radiation Sensor



Wetness Sensor

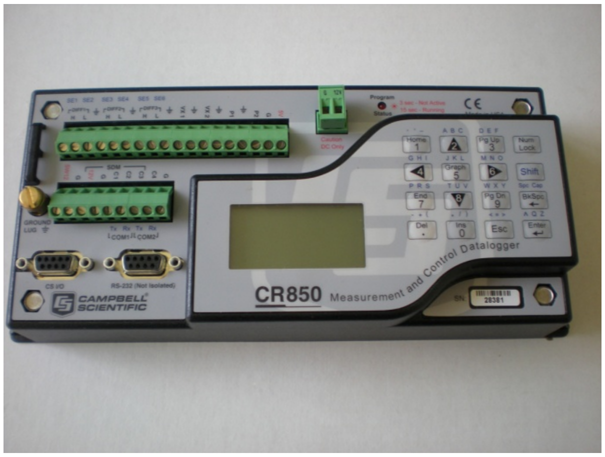


Wetness Sensor Grid



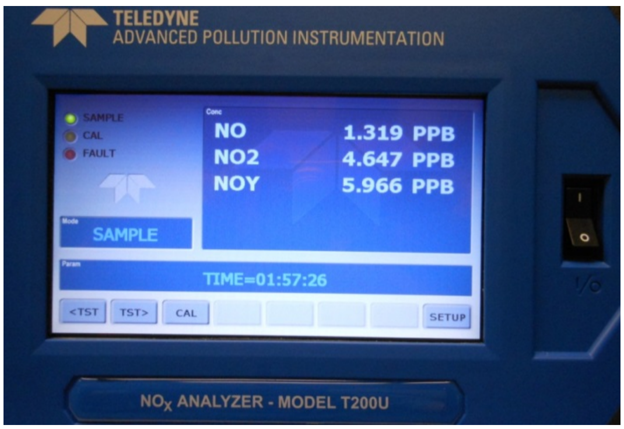
Campbell Scientific CR3000 Data Logger
with wired back plane

Figure 2-8 EPA-Sponsored CASTNET Site Components (4 of 4)

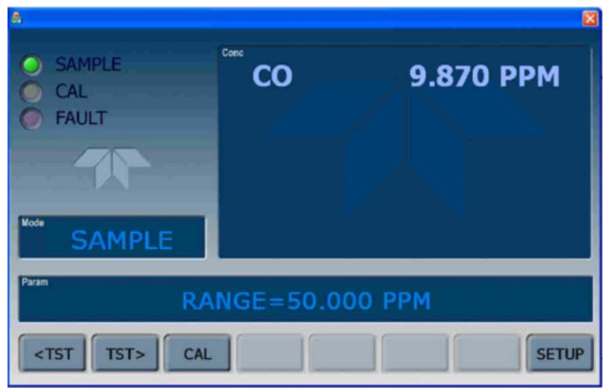


Campbell Scientific CR850 Micrologger

T100U Instrument Display Screen



T200U Instrument Display Screen



T300U Instrument Display Screen

T700U Instrument Display Screen

701H Instrument Display Screen

Site operators visit CASTNET sites each Tuesday and as directed by the FOM or field coordinator (e.g., for equipment repair). Detailed procedures for equipment checks, preventive and corrective maintenance, sample media collection, data logger operation, filter pack change-outs, documentation, and shipment of samples are described in the CASTNET Field SOP in Appendix 1. Table 2-5 summarizes the site operator's responsibilities for routine site visits.

Site operator activities are documented on various forms, such as the Site Narrative Log (Figure 2-9) and SSRF. All original field documentation is sent monthly to the Amec Foster Wheeler, Gainesville, FL DMC and stored. Copies are also filed at the CASTNET site.

Field technicians perform preventative maintenance every six months according to the schedule listed in Table 2-11. Table 2-12 summarizes possible QC failures for all field instruments and the respective corrective actions.

Figure 2-9 Sample Site Narrative Log

AMEC 042

PROJECT NUMBER 606404800 PARAMETER O_3 Met Dry

PROJECT NAME CASTNet PROJECT LOCATION SAN 189

NARRATIVE LOG

DATE		COMMENTS
9/08/2015	SIGNATURE	Arrival time 7:43 Temp 16.77 Shelter temp 20.28 MFC Display flow 3.049 Ozone flow zero 0.09 Proc. -1.37% span -1.65% Data flow 2.98
	SIGNATURE	Rotometer 3.50 Desiccant 95 % Downed channels @ 7:54 Removed filter 1536001-69 Installed filter 1537001-69 Upped channels @ 8:13
	SIGNATURE	Departure time 8:30 Matt Malinad

WHITE COPY: AMEC PINK COPY: STATION LOG

2.4.1 Equipment Calibration and Frequency

Field calibrations are critical to achieving and maintaining DQI criteria. Therefore, training field technicians and developing calibration criteria (Table 2-7) with stricter limits than project DQI (Table 2-6) are essential. Calibration procedures are also under constant review. With EPA approval, calibration procedures are modified to improve sensor/instrument operation based on the experience gained from operating the network. Calibration results provide crucial information for the validation of the continuous data. Table 2-7 summarizes the calibration methods and acceptance criteria for all of the CASTNET field equipment, including the O_3 analyzer.

Every six months (Table 2-13), Amec Foster Wheeler or subcontractor technicians visit each site to perform routine calibration and maintenance of all sensors and instruments. The results of the individual sensor calibration data are summarized on the electronic Calibration Summary Form (Figure 2-10). The information on this form is then entered into the calibration summary database, which is maintained by the Amec Foster Wheeler DMC in the Gainesville, FL office. Any condition that might require attention during the next scheduled calibration visit is also noted on this form. All data manually entered into the database are validated for accuracy through double entry. All maintenance is performed on-site. Both routine and supplemental maintenance are recorded in the remarks section of each calibration form. These are in turn automatically imported into the Calibration Summary Form (Figure 2-10). The sites are calibrated every six months (Table 2-13) in geographic groups. Each block of sites is calibrated within one month. The calibrations are performed in two 5-month blocks: January through May and July through November. The Calibration Summary Forms are reviewed by the FOM and/or field coordinator. The calibration summary database entry is also checked. The results from the 6-month calibrations are used to estimate DQI measures as described in Section 1.5, Subsection 1.5.2, Data Quality Indicators, and in Appendix 1.

Figure 2-10 Calibration Summary Form

Calibration Summary

amec

Site Name	Calibrator	Calibration Date	Data Logger
PAL 190	TYLER WARD	11/19/2013 - 11/20/2013	Campbell 3000 ID:347

Remarks

	As Found				As Left				Remarks
Temperature	Zero °C	Ambient °C	Max Error °C	diff °C	Zero °C	Ambient °C	Max Error °C	diff °C	
Transfer	0.05	30.29							
Temperature	-0.04	30.24	-0.04	-0.09					
Temperature 2/Delta	0.06	30.23	30.23	-0.06					
Shelter Temperature	-0.13	30.07	48.98	-0.36					
Relative Humidity	> 85 %	< 50 %	Other %	%	> 85 %	< 50 %	Other %	%	
Transfer	94.5	17.2	62.9						
Site Sensor	95.8	16.4	62.2						
Solar Radiation	Mean watt/m²	Max watt/m²	Total watt/m²	watt/m²	Mean watt/m²	Max watt/m²	Total watt/m²	watt/m²	Prior to as left check, a new cable was run from the met tower box to the sensor. Previously this new cable had been run from the datalogger to the met tower box. So now the new cable runs from
Transfer	513	620	15120		455	687	13424		
Site Sensor	474	576	14221		445	665	13345		
Wind Direction	North deg	East deg	South deg	West deg	North deg	East deg	South deg	West deg	
Transfer	3	90	180	270	360	90	180	270	
Site Sensor	1.5	92.6	178.7	266.1	0.8	89.3	179.3	268.6	
Windspeed	< 5 m/s	> 5 m/s	Max Error m/s	m/s	< 5 m/s	> 5 m/s	Max Error m/s	m/s	
Transfer	4.096	8.192	4.096		4.096	8.192	4.096		
Site Sensor	4.100	8.190	4.100		4.100	8.190	4.100		
Precipitation	inches	inches	inches	inches	inches	inches	inches	inches	Could not check heater because freeze-it nozzle was missing.
Transfer	0.50								
Site Sensor	0.49								
Wetness	Dry		Wet		Dry		Wet		
Transfer	0.000		1.000		0.000		1.000		
Site Sensor	0.008		1.015		0.008		1.007		
Flow	Nominal lpm	Low lpm	High lpm	lpm	Nominal lpm	Low lpm	High lpm	lpm	Set point was changed prior to as left point.
Transfer	2.964	2.496	3.450						
Site Sensor	3.007	2.507	3.512						
Ozone	Max Error %	Slope	Intercept ppb	r²	Max Error %	Slope	Intercept ppb	r²	L2 leack check = 175mmHg. Prior to ZSP the L3 lamp setting was adjusted from 30.7% to 35.5% and the site analyzers lamp adjusted from 42.3% to 44%. The resulting intensities are recorded in the as
Transfer									
Site Sensor				#DIV/0!					

Site Remarks	DAS Remarks
REVIEWED AK: 12/23/13	[illegible signature]

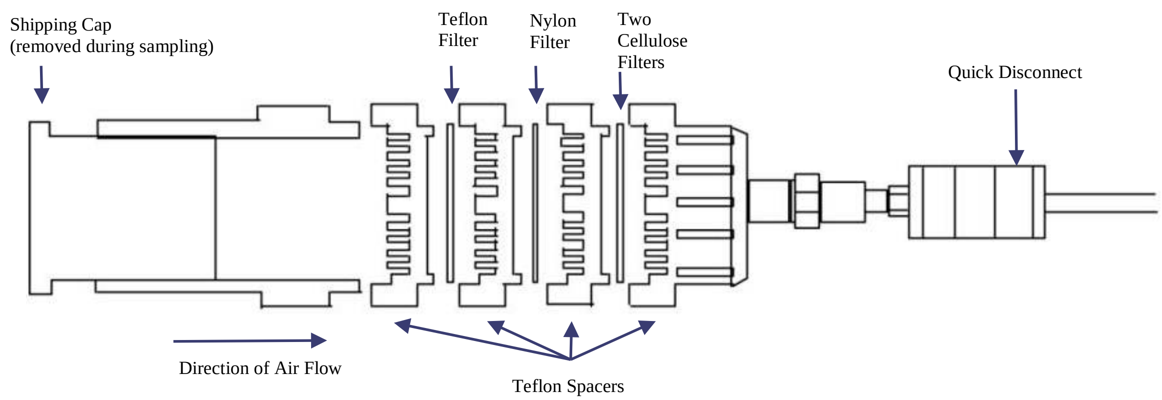
MD: 652

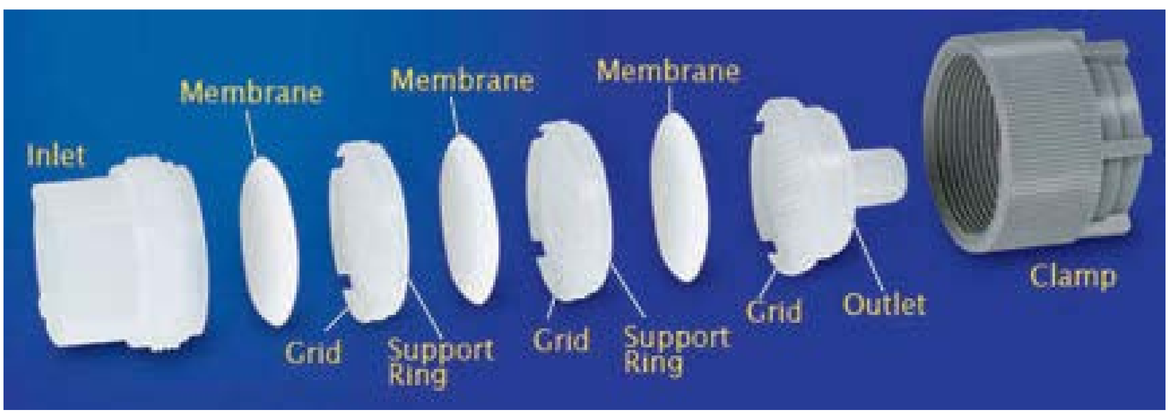
2.4.2 Dry Deposition Filter Pack and Flow

2.4.2.1 Method Description

Ambient measurements of SO_2, SO_4^{2-}, NO_3^-, HNO_3, NH_4^+, Cl^-, Na^+, K^+, Mg^{2+}, and Ca^{2+} are performed at each CASTNET site. Atmospheric sampling is integrated over weekly collection periods using a three-stage filter pack (Figure 2-11). Section 1.3.1 summarizes the basic network tasks.

Figure 2-11 Filter Pack Assembly





Filter pack sampling is performed at 10 m using a tilt-down aluminum tower manufactured by Aluma Tower, Inc. Filter pack flow is maintained at 1.50 Lpm at eastern sites and 3.00 Lpm at western sites, for standard conditions of 25°C and 760 mm Hg, with an MFC.

Environment Canada collects daily filter pack samples at the Egbert, Ontario CAPMoN site, which is collocated with a standard-protocol CASTNET site (EGB181, ON). Previously, a composite sample (weekly filter pack) and day/night samples were collected on a weekly schedule at the CASTNET site.

2.4.2.2 Equipment

The MFC generally used at CASTNET sites are Apex model AX-MC or equivalent, serially connected to the site data logger allowing remote telemetry of internal instrument system data and remote control of system parameters including flow rates. The MFC is paired with a Thomas 107CA18 flow pump.

2.4.2.3 Quality Control

Amec Foster Wheeler staff reviews filter pack flow data from each site daily. The MFC is calibrated semiannually using a mass flow meter. Because flow is so important in determining filter concentrations, the calibration acceptance criterion is two percent (Table 2-7). In other words, the MFC is adjusted if the calibration results are outside the two percent tolerance. Figure 2-12 provides an example of completed electronic Flow Calibration Data Form. The DQI measurement criterion for flow is five percent (Table 2-6).

Amec Foster Wheeler scientists, as part of the Level 3 validation process (Section 4.3.5.4), review the filter concentrations. In particular, the concentrations are reviewed for consistency among analytes from the three filter types for a specific week and also from week-to-week for a specific site. Concentration values are compared to regional and historical data for reasonableness. On/off dates and times and comment codes are reviewed to help ascertain the validity of the concentration values.

Another QC check on the operation of the filter pack sampling system is the shipment of quarterly field blanks to each site. Field blanks are used to assess the sample integrity during the packing, shipping, receiving, and unpacking phases of the operation. Laboratory blanks are used to assess the integrity of analytical operations.

Figure 2-12 Example Flow Calibration Form

Flow amec

Site Name	Calibrator	Calibration Date	Data Logger	iForms Ver.
PAL 190	TYLER WARD	11/19/2013 - 11/20/2013	Campbell 3000 ID:347	1.5.1

	Mass Flow Controller		MFC Display	
	As Found	As Left	As Found	As Left
ID #	000604			
Description	MFC			
Manufacturer	Apex			
Model				
Serial #				
Full Scale	0.951			
Zero	-0.054			
Set Point	3.04	3.073		
Rotameter	3.5 lpm	3.6 lpm		
Pump Max Flow	4.400 lpm			

Transfer Mass Flow Meter	
ID #	000768
Manufacturer	BIOS
Model	Dry Cal Lite
Date of Last Cert.	6/21/2013
Data Module	
ID #	
Manufacturer	
Model	
Date of Last Cert.	

		Transfer Flow		Site MFC Display	Voltage	Flow lpm	% Diff
		Display	STP				
Pump Off (Zero Value)			0.000	0.00	0.026	-0.028	
Leak Check				0.02	0.036	-0.018	
Exisiting Flow			2.964	3.04	3.046	3.007	1.5%
Adjusted Zero Value			0.000				
Adjusted Leak Check							
Set Point	2.543		2.496	2.54	2.548	2.507	0.4%
Set Point	3.543		3.450	3.54	3.548	3.512	1.8%
Set Point							
Flow As Left (Unadj.)			3.000	3.07	3.076	3.037	1.2%

Remarks
Set point was changed prior to as left point.

Reviewed By: [signature] Date: 12/23/13

2.4.3 Ozone

2.4.3.1 Method Description

O_3 is measured via UV absorbance. The principle of operation is based on the Beers Law technique of UV absorption. EPA-sponsored sites primarily use Thermo Scientific Model 49i analyzers operating on the 0 to 250 parts per billion (ppb) ranges. Thermo Scientific 49C and 49i analyzers are used as primary (i.e., Level 2) standards in the Amec Foster Wheeler ozone calibration laboratory. Ambient air is drawn from the inlet on the 10-m air monitoring tower through 1/4-inch tetrafluoroethylene (TFE) Teflon tubing. EPA-sponsored sites use Savillex 47-mm filter holders to house 5-µm Teflon filters located at the tower inlet to help prevent particle deposition within the system. Sites are also equipped with Campbell Scientific model 107 temperature probes located inside near the analyzer for continuous monitoring and recording of shelter temperatures to ascertain compliance with Part 58 instrument environmental criteria. Table 2-10 lists the Thermo Scientific O_3 analyzers' operating specifications.

ARS operates Thermo Scientific O_3 analyzers, which measure O_3 via UV absorbance. See Table 2-8 and the ARS SOP in Appendix 3 for more information.

2.4.3.2 Quality Control

Every six months, a multipoint calibration is performed to verify the response of the on-site instrument via comparison with the output of an O_3 transfer standard. Each EPA-sponsored site utilizes a second in-station photometer with Level 3 transfer standard authority. This on-site transfer standard contains an internal ozone generation system that is used to generate the calibration gas during the semiannual calibration. Six points are checked from zero to 90 percent of the full-scale output of the ozone analyzer using the detector in a traveling transfer standard with Level 2 authority. The internal ozone generator is then set to perform automatic daily z/s/p checks of the ozone measurement system. The O_3 calibration results are recorded on an electronic Ozone Calibration Form (see Figure 2-13).

The traveling transfer standards used for the multipoint calibrations of EPA-sponsored sites are verified annually by NIST reference photometer and audited at least twice per calendar quarter against a primary standard maintained in the Amec Foster Wheeler field instrumentation laboratory, which is discussed in Section 2.6. The primary standard is verified annually against the standard reference photometer at the EPA Region 7 laboratory, known as the Kansas City Science & Technology Center (KCSTC). Please refer to Figure 2-14. Copies of the certification documentation are filed at each site and at Amec Foster Wheeler along with the calibration results for each site.

Automatic z/s/p checks are performed using the second in-station photometer to verify ozone levels used for the z/s/p checks. The results of the z/s/p checks are recorded by the Campbell CR3000 data logger and uploaded to the Amec Foster Wheeler CASTNET DMC server through routine hourly polls. The daily z/s/p checks are displayed (Figure 2-15) and reviewed by a data analyst and a field coordinator. The z/s/p binary files are named and managed similarly to the binary data files.

Figure 2-13 Example Ozone Calibration Form

Ozone

amec

Site Name	Calibrator	Calibration Date	Data Logger	iForms Ver.
PAL 190	TYLER WARD	11/19/2013 - 11/20/2013	Campbell 3000 ID:347	1.5.1

	Site Analyzer		Level 3 Transfer Standard		Level 2 Transfer Std.
	As Found	As Left	As Found	As Left	
Manufacturer	Thermo		Thermo		Thermo
Model	49i		49i		49i
ID #	000733		000214		000679
Background	0.1		0		0
Coefficient	1.005		1		1
Pressure (mmHg)	648 mmHg		748 mmHg		732 mmHg
Cell Temperature (°C	31.3 °C		32.3 °C		31.0 °C

	Site Analyzer As Found A	Site Analyzer As Found B	Site Analyzer As Left A	Site Analyzer As Left B	Level 3 As Found A	Level 3 As Found B	Level 3 As Left A	Level 3 As Left B	Level 2 A	Level 2 B
Cell Freq. (kHz)	91	97	96	102	84	81	114	110	99	97
Cell Noise	0.6 Hz	0.6 Hz			1.0 Hz	0.9 Hz			1.4 Hz	1.5 Hz
Cell Flow (lpm)	0.66	0.661			0.66	0.702			0.752	0.753

Date of Last Certification: 8/28/2013

AutoCal Results	As Found	As Left
Zero	-0.79	
Span	0.3	
Precision	0.11	

Sample Line Loss Check	As Found	As Left
Inlet		
Analyzer		
Corrected		

Sample Leak Check	As Found	As Left
Pressure	182	

		Level 2 Transfer		Level 3 Transfer		Site Analyzer	
Target	Lamp	Conc.	Corrected	Conc.	% Diff	Conc.	% Diff
450	49.4%	451.4	451.7	445.25	-1.42%	449.5	-0.48%
300	37.4%	298.4	298.6	293.99	-1.55%	297.5	-0.37%
200	29.6%	198	198.2	194.8	-1.70%	197.2	-0.49%
90	20.9%	87.4	87.5	85.7	-2.07%	87	-0.59%
60	18.6%	60.95	61.1	59.64	-2.31%	60.28	-1.26%
0	0.0%	0.08	0.2	-0.44	-0.59 ppb	0.008	-0.15 ppb

Level 3 Verification History	Date	m	I
1	5/17/11	0.9974	-0.58
2	11/1/11	0.9847	-0.478
3	11/2/11	0.9835	-0.58
4	5/15/12	0.9829	-0.59
5	11/20/12	0.9988	-0.34
6	5/28/13	0.9842	-0.46
Update	11/19/13	0.987	-0.66

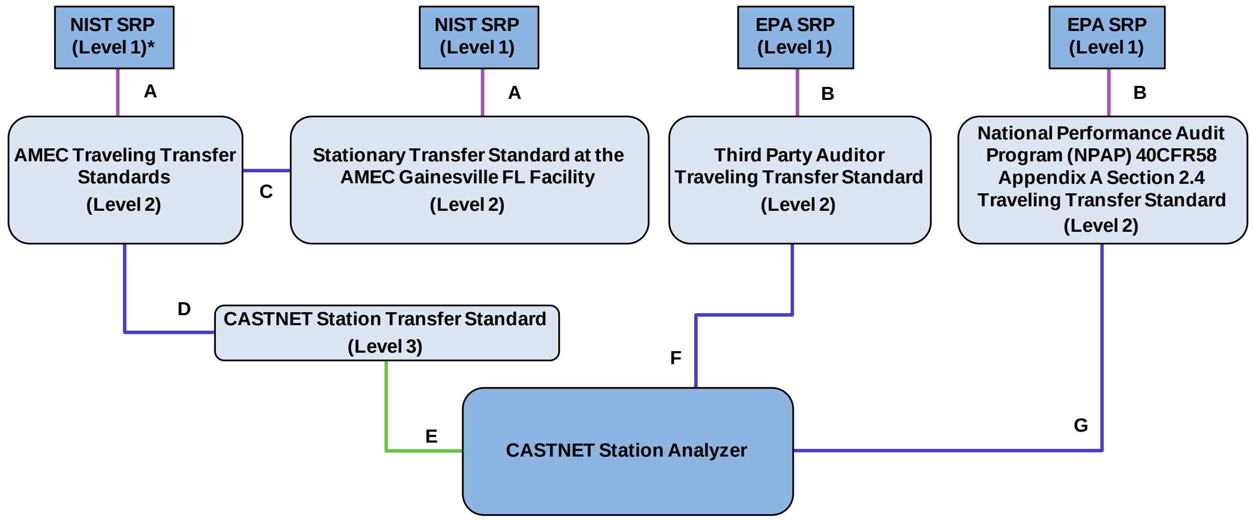
	Level 2 Transfer	As Found			As Left		
		Site Analyzer	Level 3 Verification	Level 3 Update	Site Analyzer	Level 3 Verification	Level 3 Update
m	0.99955	0.9961	0.989	0.9869			
I	-0.07305	-0.23	-0.51	-0.52			
S_m	0.1%		0.75%	0.61%			
S_I	0.03733		0.098	0.115			

Remarks

L2 leack check = 175mmHg. Prior to ZSP the L3 lamp setting was adjusted from 30.7% to 35.5% and the site analyzers lamp adjusted from 42.3% to 44%. The resulting intensities are recorded in the as left column.

Reviewed By: ________ Date: 12/23/13

Figure 2-14 Ozone Standard Verification



Legend

A = Annual Reverification
B = Quarterly Reverification
C = Audited ˜1/6 weeks
D = Reverification 1/6 months
E = Zero, Span and single Point QC check daily
F = Audited Annually
G = Audited 1/5 years

***Traceability**

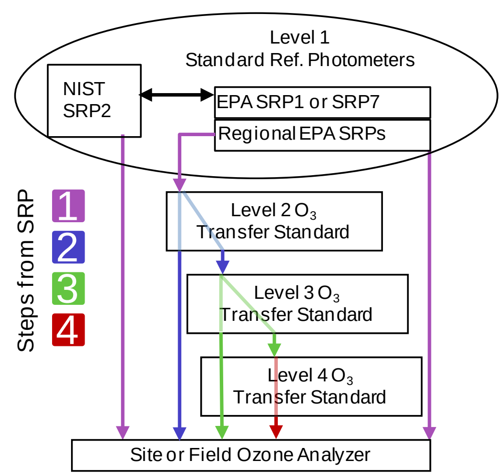
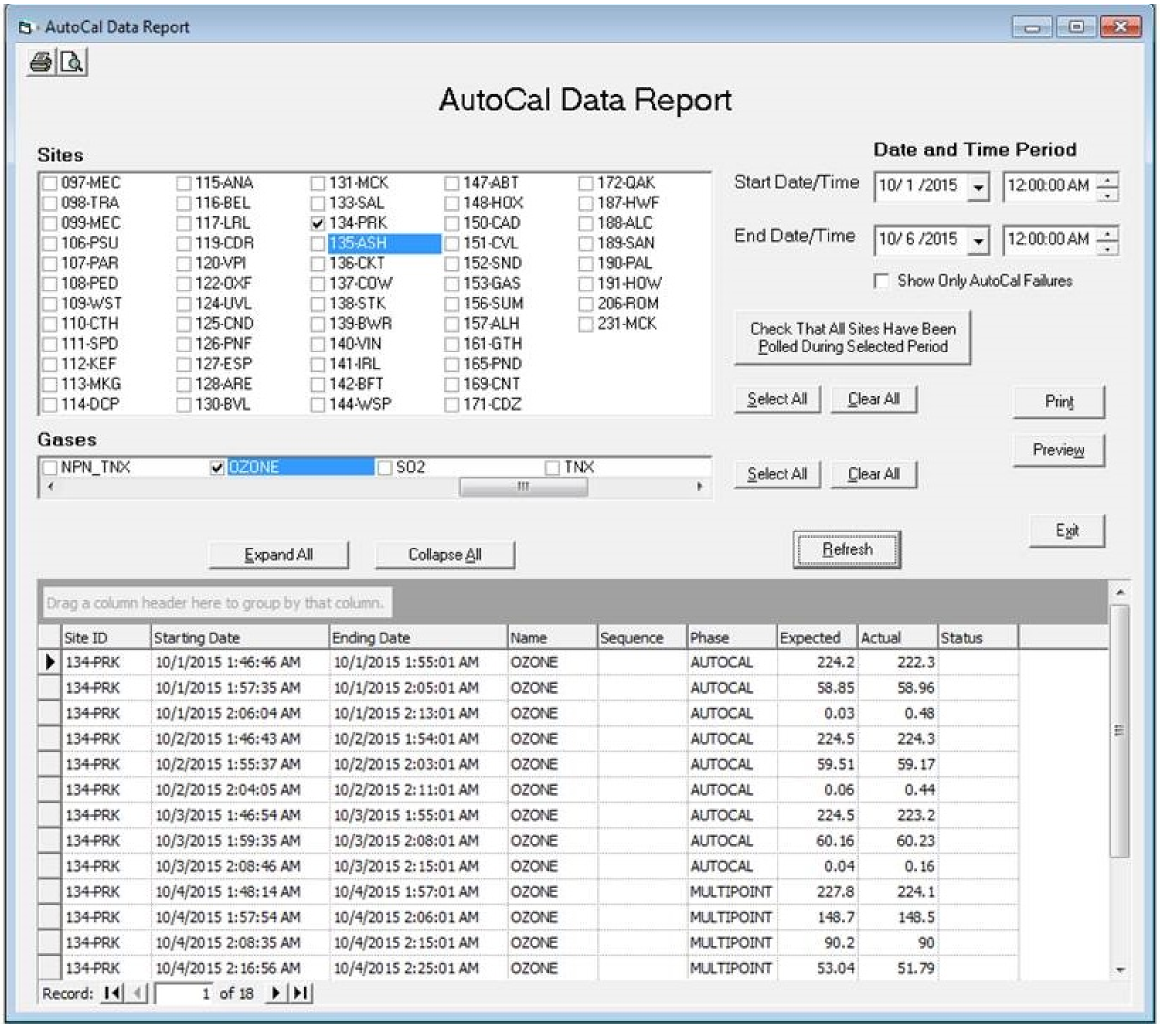


Figure 2-15 Example Daily O_3 Precision and Span Checks



Site ID	Starting Date	Ending Date	Name	Sequence	Phase	Expected	Actual	Status
134-PRK	10/1/2015 1:46:46 AM	10/1/2015 1:55:01 AM	OZONE		AUTOCAL	224.2	222.3	
134-PRK	10/1/2015 1:57:35 AM	10/1/2015 2:05:01 AM	OZONE		AUTOCAL	58.85	58.96	
134-PRK	10/1/2015 2:06:04 AM	10/1/2015 2:13:01 AM	OZONE		AUTOCAL	0.03	0.48	
134-PRK	10/2/2015 1:46:43 AM	10/2/2015 1:54:01 AM	OZONE		AUTOCAL	224.5	224.3	
134-PRK	10/2/2015 1:55:37 AM	10/2/2015 2:03:01 AM	OZONE		AUTOCAL	59.51	59.17	
134-PRK	10/2/2015 2:04:05 AM	10/2/2015 2:11:01 AM	OZONE		AUTOCAL	0.06	0.44	
134-PRK	10/3/2015 1:46:54 AM	10/3/2015 1:55:01 AM	OZONE		AUTOCAL	224.5	223.2	
134-PRK	10/3/2015 1:59:35 AM	10/3/2015 2:08:01 AM	OZONE		AUTOCAL	60.16	60.23	
134-PRK	10/3/2015 2:08:46 AM	10/3/2015 2:15:01 AM	OZONE		AUTOCAL	0.04	0.16	
134-PRK	10/4/2015 1:48:14 AM	10/4/2015 1:57:01 AM	OZONE		MULTIPOINT	227.8	224.1	
134-PRK	10/4/2015 1:57:54 AM	10/4/2015 2:06:01 AM	OZONE		MULTIPOINT	148.7	148.5	
134-PRK	10/4/2015 2:08:35 AM	10/4/2015 2:15:01 AM	OZONE		MULTIPOINT	90.2	90	
134-PRK	10/4/2015 2:16:56 AM	10/4/2015 2:25:01 AM	OZONE		MULTIPOINT	53.04	51.79	

If the z/s/p results indicate responses greater than ± 7 percent for the span (225 ppb) and precision (60 ppb) checks, or greater than 1.5 ppb or less than -1.5 ppb for the zero check, the site operator is instructed to perform a manual test during the Tuesday site visit. Those results are then included in the polled database. If the manual results still indicate a problem, corrective action is initiated by the FOM or field coordinator. The corrective actions include checking for the proper volume of test gas [15 pounds per square inch (psi) of zero air pressure], ensuring that there are no leaks in the test gas supply or O_3 sample train, confirming the set points, and activating the ozone generator.

The current z/s/p test and corrective action procedures incorporate the semiannual calibrations and independent audit results as confirmation of data accuracy and validity. The stability of the internal O_3 generators is acceptable, but not always reliable. All corrective actions are performed to obtain the most cost effective and efficient results, maximizing valid data capture.

Specific O_3 procedures are described in the CASTNET Field SOP (Appendix 1). The SOP includes instructions for manual operation of the z/s/p checks. Documentation of all z/s/p check activities is recorded on the SSRF and the Site Narrative Log (Figure 2-9).

2.4.4 Measurements of Trace-Level Gaseous Pollutants

Appendix 11, entitled QAP for Procuring, Installing, and Operating NCore Monitoring Equipment at CASTNET Sites, provides detailed information on the methods for measuring CO, SO_2, and NO/NO_y; a discussion of the specific API analyzers used for the measurements; and the approach to quality control of the trace-level gaseous measurements.

2.4.5 Meteorological Measurements

This section describes individual components chosen for meteorological monitoring. Currently, four EPA-sponsored sites include meteorological measurements. Climatronics system translators require zero and span checks; RM Young systems do not. The procedural difference is noted, as appropriate, throughout the following subsections. The ARS equipment and procedures (Appendix 3) are virtually identical to Amec Foster Wheeler's and are not discussed separately in the remainder of this section. Please see ARS SOP in Appendix 3 for specific details.

Sites configured with Campbell Scientific CR3000 data loggers do not require separate signal conditioning translators for any parameter except solar radiation.

2.4.5.1 Wind Speed

2.4.5.1.1 Method Description

2.4.5.1.1.1 Climatronics F460

The Climatronics wind speed sensor monitors the wind speed with a 3-cup anemometer assembly. A frequency output, which is proportional to wind speed, is produced by a 30-hole chopper wheel that is turned by the cup assembly. The chopper wheel breaks a beam of light generated by a light-emitting diode (LED). The frequency is converted to direct current (DC) voltage by circuits located in the translator assembly and is recorded by the data logger.

2.4.5.1.1.2 RM Young Wind Monitor-AQ

The propeller rotation on the RM Young wind monitor produces an alternating current (AC) sine wave signal with a frequency proportional to wind speed.

2.4.5.1.2 Quality Control

The wind speed sensors are calibrated every six months. An anemometer is adjusted if any calibration result (any point) is outside the ± 0.2 m/sec criterion for wind speeds less than 5 m/sec or outside the ± 5 percent criterion for wind speeds greater than or equal to 5 m/s. Site operators review wind measurements every Tuesday as part of their weekly visit. Amec Foster Wheeler data analysts review wind measurements daily. Figure 2-16 illustrates a completed electronic calibration form for wind speed and direction.

Figure 2-16 Example Wind Calibration Form

Wind

amec

Site Name	Calibrator	Calibration Date	Data Logger	iForms Ver.
PAL 190	TYLER WARD	11/19/2013 - 11/20/2013	Campbell 3000 ID:347	1.5.1

		Wind Direction		Windspeed	
		As Found	As Left	As Found	As Left
ID #		04405	04354	04405	04354
Description		Wind AQ	Wind AQ	Wind AQ	Wind AQ
Manufacturer		R.M. Young	R.M. Young	R.M. Young	R.M. Young
Model		5305	5305	5305	5305
Torque		< 10 g/cm	< 10 g/cm	< 0.2 g/cm	< 0.1 g/cm
Vane/Prop ID #				68264	68264
Translator ID #					
Translator	Manufacturer				
	Type				
	Zero				
	540°				
	Span				

Transit	
ID #	06554
Manufacturer	Brunton
Model	F-5006
Date of Last Cert.	5/16/2013
Synchronous Motor	
ID #	04631
Manufacturer	R.M. Young
Model	18802
Date of Last Cert.	4/3/2013
Wind System Mfg.	R.M. Young
Magnetic Declination	
Degrees	7.0°
Direction	East

					Wind Direction					
					As Found			As Left		
		Crossarm Alignment			0.0° True			0.0° True		
		Wheel Indication			180.0°			180.0°		
		Alignment Ring			180°			180°		
Crossarm	Wheel	Target Direction	True Bearing	Wheel Indication	Datalogger Output Degrees	Sensor Diff	True Diff	True Bearing	Datalogger Output Degrees	Diff
☐	☑	South	180.0°	180.0°	178.70	-1.3°	-1.3°	180.0°	179.30	-0.7°
☐	☑	East	90.0°	90.0°	92.60	2.6°	2.6°	90.0°	89.30	-0.7°
☐	☑	West	270.0°	270.0°	266.10	-3.9°	-3.9°	270.0°	268.60	-1.4°
☐	☑	Crossover Entry	357.0°	357.0°	354.40	-2.6°	-2.6°	355.0°	352.60	-2.4°
☐	☑	Crossover Exit	3.0°	3.0°	1.52	-1.5°	-1.5°	3.0°	0.80	-2.2°

	Windspeed							
	As Found				As Left			
	Prop Correction Factor				Prop Correction Factor			
	0.00512				0.00512			
RPM	Frequency	m/s	Datalogger Output m/s	Diff	Frequency	m/s	Datalogger Output m/s	Diff
0		0.00	0.00	0.00		0.00	0.00	0.00
100		0.51	0.51	0.00		0.51	0.51	0.00
200		1.02	1.02	0.00		1.02	1.02	0.00
400		2.05	2.05	0.00		2.05	2.05	0.00
800		4.10	4.10	0.00		4.10	4.10	0.00
1600		8.19	8.19	0.00		8.19	8.19	0.00
3600		18.43	18.43	0.00		18.43	18.43	0.00
8600		44.03	44.03	0.00		44.03	44.03	0.00

Remarks

Reviewed By: [signature] Date: 12/23/13

2.4.5.2 Wind Direction

2.4.5.2.1 Method Description

2.4.5.2.1.1 Climatronics F460

The Climatronics wind direction sensor consists of a balanced, lightweight vane and a precision, low-torque potentiometer to yield a voltage output proportional to wind direction. The data logger converts the potentiometer signal into 0° to 360° wind direction units for storage and retrieval.

2.4.5.2.1.2 RM Young Wind Monitor-AQ

The RM Young wind direction vane position is determined by a 10-kilo Ohm (kΩ) precision conductive potentiometer, which requires a regulated excitation voltage. With constant voltage applied to the potentiometer, the output signal is converted to 0° to 360° wind direction by the data logger.

2.4.5.2.2 Quality Control

The wind direction sensors are calibrated every six months by aligning the vanes with a compass sighted target. See Figure 2-16. Site operators review wind measurements every Tuesday as part of their weekly visit. Amec Foster Wheeler data analysts review wind measurements daily.

2.4.5.3 Temperature

2.4.5.3.1 Method Description

The RM Young temperature sensors are platinum resistance temperature devices (RTD). The sensors are housed in motorized or naturally-aspirated radiation shields (located at heights of 9 and 2 m) that protect them from heating from direct sunlight. Replacement and/or repair of the sensor are not required under normal use.

Delta temperature was calculated previously by subtracting the 2 m temperature from the 9 m temperature. The 2 m temperature is no longer measured. Campbell Scientific Model 107 temperature probes are used to measure temperature inside the shelters.

2.4.5.3.2 Quality Control

Temperature sensors are calibrated every six months using a NIST-traceable certified RTD in an isothermal bath at three temperature values from 0 to 50°C. An example of an electronic temperature sensor calibration form is shown in Figure 2-17. Site operators review temperature values during the Tuesday site visit. Data analysts review temperature data on a daily basis.

Figure 2-17 Example Temperature Calibration Form

Temperature

amec

Site Name	Calibrator	Calibration Date	Data Logger	iForms Ver.
PAL 190	TYLER WARD	11/19/2013 - 11/20/2013	Campbell 3000 ID:347	1.5.1

	9 Meter (T1)		2 Meter (T2)	
	As Found	As Left	As Found	As Left
ID #	06303		06302	
Description	RTD		RTD	
Manufacturer	R.M. Young		R.M. Young	
Model	43347		43347	
R_o	1000.56		1000.04	
Alpha	0.003743		0.003738	
Translator Type				

Transfer Standard					
ID #	04643				
Manufacturer	Eutechnics				
Model	4600				
Date of Last Cert.	8/12/2013				
Correction Factors					
0°	10°	20°	30°	40°	50°
-0.01	-0.01	0.00	0.00	0.01	0.01

As Found RTD (°C)			Temperature Data Logger Output: Temperature (9m) Output				Temperature 2 (2m) Output				Delta T.	Shelter Temperature	
Uncorrected Temp. (°C)	Correction Factor	Corrected Temp. (°C)	Raw Temp. (°C)	Corrected Temp. (°C)	Raw Diff (°C)	Corrected Diff (°C)	Raw Temp. (°C)	Corrected Temp. (°C)	Raw Diff (°C)	Corrected Diff (°C)	Diff (°C)	Temp. (°C)	Diff (°C)
0.06	-0.01	0.05	0.11	-0.04	0.06	-0.09	0.07	0.06	0.02	0.01	-0.10	-0.13	-0.18
30.29	0.00	30.29	30.35	30.24	0.06	-0.05	30.15	30.23	-0.14	-0.06	0.01	30.07	-0.22
49.33	0.01	49.34	49.42	49.34	0.08	0.00	49.22	49.37	-0.12	0.03	-0.03	48.98	-0.36
44.99	0.01	45.00										44.70	-0.30

Remarks

Reviewed By: [signature] Date: 12/23/13

2.4.5.4 Relative Humidity

2.4.5.4.1 Method Description

Relative humidity is measured using the Vaisala Model 102425 relative humidity sensor or the Rotronic MP-series humidity-temperature probe.

The Vaisala Model 102425 relative humidity sensor measures atmospheric moisture via a capacitive thin-filter sensor. The dielectric properties of the thin polymer film changes as moisture is absorbed from or released to the atmosphere. The capacitance of the sensor is connected to humidity readings. The Vaisala relative humidity sensor is mounted at 9 m above ground and is housed in either a motor-aspirated or naturally aspirated radiation shield.

The Rotronic MP-series relative humidity sensor is a combination of a C-80 hygrometer sensor and capacitive bridge. The output of the bridge is conditioned by an amplification and linearization circuit contained in the probe housing. The Rotronic relative humidity sensor is mounted at 9 m above ground and is housed in a RM Young naturally-aspirated, gill, multi-plate radiation shield.

2.4.5.4.2 Quality Control

The relative humidity sensors are calibrated every six months using a certified Vaporpak Model H-31 or Rense Instruments Model S-503 (Figure 2-18). The sensors are tested at three relative humidity values. Site operators review relative humidity values during the Tuesday site visit. Data analysts review relative humidity data on a daily basis.

2.4.5.5 Precipitation

2.4.5.5.1 Method Description

The tipping bucket rain gauge consists of a 6-inch-diameter funnel-shaped collection basin and a measuring apparatus. Precipitation enters the collection basin and is funneled through a small hole in the center to the measuring apparatus. The collection basin is equipped with a thermostatically controlled heater to melt snow for collection purposes. The liquid precipitation is directed into one of two identical compartments on either side of a “bucket” balanced on the measuring apparatus. As one compartment fills, the weight of the liquid causes it to tip and bring the other compartment into place for collection of additional precipitation. The gauge is calibrated so that the weight of 0.01 inch (0.25 mm) of collected liquid causes the apparatus to tip. The tipping motion empties the measured liquid out of the bucket into a drain tube. When the apparatus tips, the swinging motion passes a magnet across a frictionless reed, or proximity switch, causing a momentary closure of the switch. This contact closure sends a signal to the data logger, which records the closure as a precipitation event. The amount of precipitation measured by the tipping bucket rain gauge directly corresponds to the number of tips the bucket makes. The rate of precipitation correlates to the number of tips per unit of time.

A clear and unobstructed mounting location is necessary to obtain accurate precipitation data. Normally, mast mounting is the simplest method. The gauge is mounted in a level position and in a location free from vibration. The funnel and tipping mechanism must be checked weekly and cleaned if necessary. An accumulation of dirt and bugs on the tipping bucket will adversely affect the performance and calibration.

2.4.5.5.2 Quality Control

The tipping bucket rain gauge is calibrated every six months by adding known volumes of water to the instrument and comparing the output to the known values. An example of a completed electronic precipitation calibration form is included as Figure 2-19. Site operators check the reasonableness of the precipitation data during Tuesday site visits and verify operation through manual tips. Data analysts evaluate the precipitation measurements daily.

Figure 2-18 Example Relative Humidity Calibration Form

Relative Humidity amec

Site Name	Calibrator	Calibration Date	Data Logger	iForms Ver.
PAL 190	TYLER WARD	11/19/2013 - 11/20/2013	Campbell 3000 ID:347	1.5.1

	RH Sensor	
	As Found	As Left
ID #	06223	
Description	RH	
Manufacturer	Vaisala	
Model	102425	
Translator ID #		
Manufacturer		
Zero		
Span		

Humidity Chamber	
ID #	00537
Manufacturer	VaporPak
Model	
Date of Last Cert.	

Transfer Standard					
ID #	06834				
Manufacturer	Rotronics				
Model	GTL				
Date of Last Cert.	8/2/2013				
Correction Factors					
10%	30%	50%	70%	85%	95%
-1.90	-2.70	-2.60	-3.10	-3.30	-2.80

As Found	Relative Humidity Datalogger Output			
Portable Hygrometer	Correction Factor	Equivalent Relative Humidity	Datalogger Output % Relative Humidity	Datalogger Output Diff
19.1%	-1.9%	17.20%	16.40%	-0.8%
66.0%	-3.1%	62.90%	62.17%	-0.7%
97.3%	-2.8%	94.50%	95.80%	1.3%

Remarks

Reviewed By: [signature] Date: 12/23/13

2.4.5.6 Solar Radiation

2.4.5.6.1 Method Description

The LI-COR LI-200S pyranometer is used to measure solar radiation. It consists of a silicon photovoltaic cell that gives a reproducible spectral response in the range of 280 to 2,800 nm. The pyranometer is mounted on a 1-m mast in an area free from any obstruction that might direct or diffuse radiation. The mast is located to the south of all other monitoring equipment to minimize shading. The sensor is checked weekly and cleaned, if necessary, to maintain the accuracy of its calibration.

Figure 2-19 Example Precipitation Calibration Form

Precipitation

amec

Site Name	Calibrator	Calibration Date	Data Logger
PAL 190	TYLER WARD	11/19/2013 - 11/20/2013	Campbell 3000 ID:347

iForms Ver.	1.5.1

Tipping Bucket Gauge	As Found	As Left
Manufacturer	Texas Electronics	
Model	TR-5251	
ID #	06307	

Wetness Sensor	As Found	As Left
Manufacturer	R.M. Young	
Model	58101	
ID #	06288	

Tipping Bucket Rain Gauge							
Volume H_2O		Time/Tip	Datalogger Output			As Found	As Left
mL	inches	Seconds	As Found	As Left			
231.5	0.50	14.0	0.49		Clean	Yes	
231.5	0.50				Level	Yes	
231.5	0.50				Heater OK		
231.5	0.50				Screen In	Yes	

Wetness			Dry		Wet	
Sensitivity			As Found	As Left	As Found	As Left
On (kΩ)	Off (kΩ)	Output Volts DC	0.008	0.008	1.015	1.007
235	245	Sensitivity	319 kΩ	245 kΩ	313 kΩ	235 kΩ

Remarks

Could not check heater because freeze-it nozzle was missing.

Reviewed By: [illegible signature] **Date:** 12/13/13

2.4.5.6.2 Quality Control

The LI-COR pyranometer is calibrated every six months using a NIST-traceable transfer standard (Figure 2-20). The site operator checks the reasonable of the solar radiation measurements weekly and, if necessary, cleans the sensor during the Tuesday site visit. Data analysts review solar radiation measurements daily.

2.4.5.7 Surface Wetness

2.4.5.7.1 Method Description

The CASTNET sites are equipped with a RM Young Model 58101 wetness sensor. The operation of the sensor is based on a detection of a predetermined change in capacitance. Surface wetness is indicated when water droplets cover approximately 0.2 square centimeter (cm^2) of the sensor grid. The grid is designed from low-density fiber to represent a leaf surface. The grid is mounted at least 2 inches away from the sensor housing which contains the circuitry to convert the signal to voltage. When the sensor is wet, it registers 1.00 V, and when dry, it registers 0.00 V. The wetness sensor is mounted at the height of the natural ground-level vegetation.

2.4.5.7.2 Quality Control

The wetness sensor is calibrated every six months by testing sensor output with known resistances. The site operator tests the wetness sensor every Tuesday by wetting the sensor and checking output. CASTNET data analysts review surface wetness data daily.

2.5 Field Data Acquisition and Management

Field data, or continuous data, are handled by the DMC. Amec Foster Wheeler utilizes an automated Data Acquisition System (DAS) for collection of data from the sites. All EPA-sponsored sites, except for CHE185, OK, use a Campbell Scientific CR3000 or CR850 Micrologger data logger for on-site data collection. The CHE185, OK site uses an Environmental Systems Corporation (ESC) data logger. Measured data are collected hourly from a centralized server and automatically uploaded into the Amec Foster Wheeler database using Campbell Scientific's LoggerNet polling software. CASTNET IP -enabled sites use a Sierra Wireless AirLink Raven X modem to access the Internet through a cellular service packet-switched data network that provides a public static IP address. A network address translation (NAT) router allows multiple Ethernet-enabled devices at the site to share the Internet connection, as well as communicate locally. All sites capable of receiving cellular service are enabled for IP communication. The other three sites, including CHE185, OK, are served by telephone modems.

The data logger program, which was developed by Amec Foster Wheeler, allows site operators and site calibrators access to CR3000 data. The program acquires data in seven tables and also flags the data according to their status.

Figure 2-20 Example Solar Radiation Calibration Form

Solar Radiation

amec

Site Name	Calibrator	Calibration Date	Data Logger
PAL 190	TYLER WARD	11/19/2013 - 11/20/2013	Campbell 3000 ID:347

	Sensor As Found	Sensor As Left
ID #	04009	04009
Description	Pyronometer	Pyronometer
Manufacturer	LiCor	LiCor
Model	Li-200	Li-200
Translator ID #	04063	04063
Manufacturer	R.M. Young	R.M. Young
Zero		
Span		

iForms Ver.	1.5.1
Transfer Standard	
ID #	06533
Manufacturer	LiCor
Model	Li-200
Date of Last Cert.	11/8/2013
Slope	0.97800
Intercept	2.49110
Translator ID #	06321

As Found

Time	Transfer W/m²	Sensor W/m²	Time	Transfer W/m²	Sensor W/m²	Time	Transfer W/m²	Sensor W/m²
9:50	375	332	10:55	532	512	12:05	569	557
9:55	388	343	11:00	553	533	12:10	551	522
10:00	400	355	11:05	567	558	12:15	593	570
10:05	411	367	11:10	467	447	12:20	609	576
10:10	423	379	11:20	573	549			
10:15	435	391	11:25	568	528			
10:20	446	403	11:30	578	560			
10:25	461	415	11:35	569	558			
10:30	473	433	11:40	584	573			
10:35	482	439	11:45	558	520			
10:40	495	458	11:50	503	466			
10:45	507	488	11:55	475	439			
10:50	517	501	12:00	458	449			

As Found Transfer		As Found Sensor		As Found % Diff	As Left Transfer		As Left Sensor		As Left % Diff
Total	15120	Total	14221	-5.9%	Total	13424	Total	13345	-0.6%
Adj. Max.	620	Max	576	-7.1%	Adj. Max.	687	Max	665	-3.1%
Adj. Average	512.8	Average	474.0	-7.6%	Adj. Average	455.0	Average	444.8	-2.2%

As Left

Time	Transfer W/m²	Sensor W/m²	Time	Transfer W/m²	Sensor W/m²	Time	Transfer W/m²	Sensor W/m²
9:20	312	312	10:25	468	467	11:30	578	570
9:25	329	329	10:30	429	427	11:35	591	582
9:30	354	354	10:35	477	474	11:40	622	613
9:35	370	371	10:40	551	548	11:45	674	665
9:40	464	464	10:45	623	617			
9:45	412	413	10:50	500	497			
9:50	377	376	10:55	536	532			
9:55	335	334	11:00	524	521			
10:00	292	292	11:05	543	538			
10:05	415	413	11:10	381	379			
10:10	405	403	11:15	284	283			
10:15	203	205	11:20	389	386			
10:20	385	386	11:25	601	594			

Remarks

Prior to as left check, a new cable was run from the met tower box to the sensor. Previously this new cable had been run from the datalogger to the met tower box. So now the new cable runs from the datalogger to the sensor. A new barrel connector was installed and the barrel connector connection was taped with electrical tape and zip tied snuggly to a piece of cardboard seperating the connector from the mètal railing. This change was performed on 11/19/13. The sensor read a consistant .4

Reviewed By: [signature] Date: 12/23/13

The LoggerNet polling software enables recovery of hourly data and status files, power failure logs, and automated calibration results. LoggerNet also maintains synchronization of the network by checking the clock within each DAS and correcting the time if necessary. If daily polling results in incomplete data capture from any site, the missing data are recovered by subsequent polls.

2.5.1 Data Acquisition and Storage

The flow of field data for Amec Foster Wheeler operated CASTNET sites from acquisition to delivery uses the following sequence of data management events.

1. Data acquisition and recording begin on-site with the field measurements from each instrument electronically recorded by the DAS and stored in the internal memory of the DAS at each site. Data status, consisting of a status code for each datum produced, is generated and recorded by the DAS. Supporting data such as site conditions and operational checks are manually recorded by the site operator on the SSRF and the Site Narrative Log Sheets.
2. Data and data status codes/flags from the DAS are transmitted via IP communication or telephone modem connection to the polling computer. Hard copy SSRF and Site Narrative Log Sheets are mailed to the DMC monthly.
3. Raw data, collected as a result of Steps 1 and 2, are processed through Levels 1, 2 and 3 validation and maintained in the CASTNET database.
4. Final data are delivered to the EPA Project Officer as described in Table 1-6.

Figure 2-21 depicts the data traceability of a datum for a continuously recorded parameter. It also illustrates data validation and submittal and shows the project personnel involved.

2.5.2 Equipment

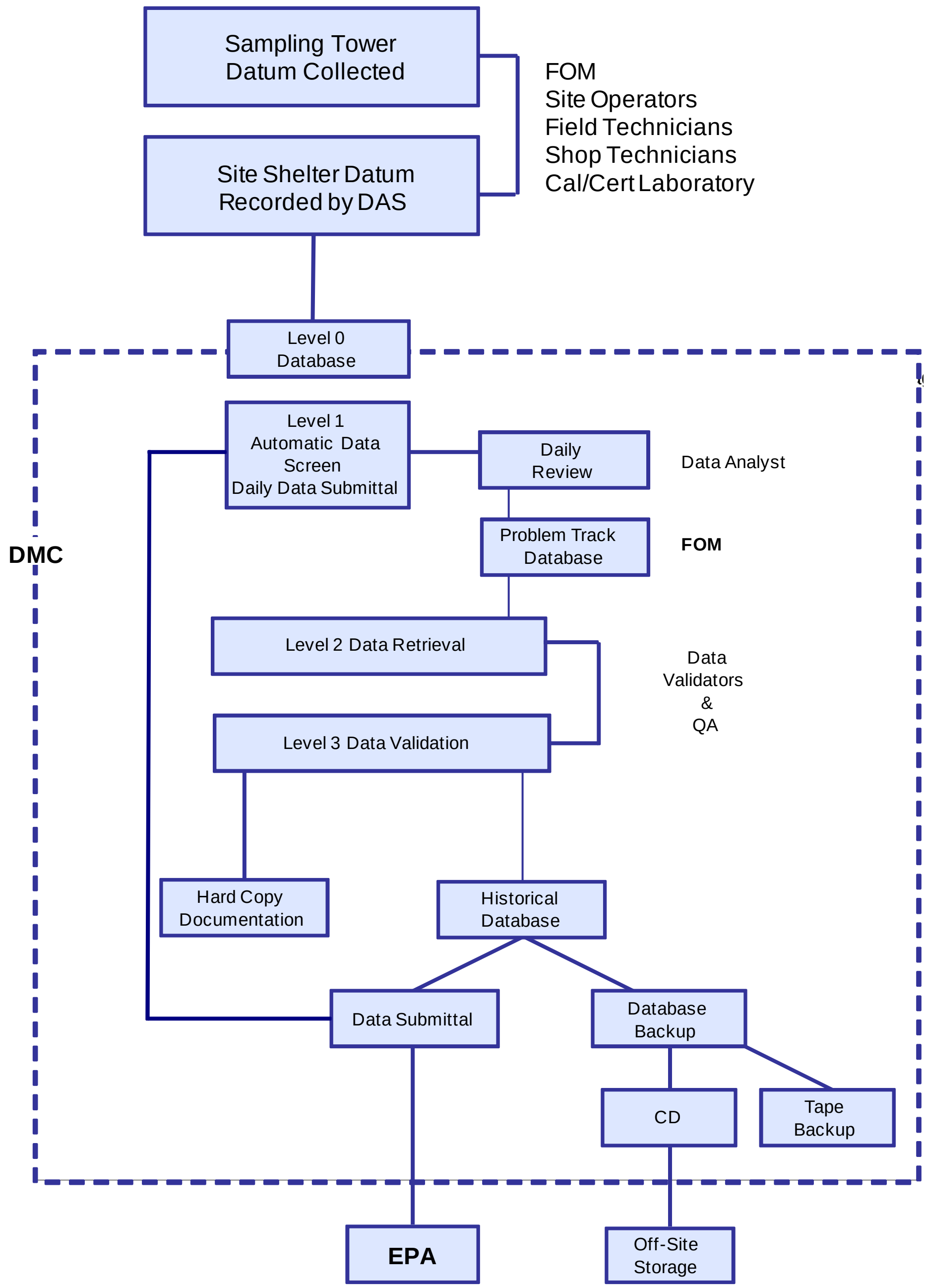
All of the continuous measurements described in the previous sections are recorded by the Campbell Scientific CR3000, CR850, or ESC 8816 data loggers. The overall accuracy of the recorded data is dependent on two factors:

1. The accuracy of the measurement instrumentation; and
2. The accuracy of the DAS.

The DAS accuracy and resolution is superior to the accuracy of the measurement instrumentation. The DAS provides a means of receiving, converting, and storing the input data without losing the accuracy of data. The DAS independently converts each analog input using a 16-bit analog to digital converter.

Each instrument's analog voltage output is stored as a 5-minute average in the on-site DAS compact flash module. The LoggerNet or H2NS DataLink (ESC8816 only) polling system is used for all sites to retrieve the values stored on the compact flash module and store the values in engineering units in the CASTNET database. Each CASTNET site is polled hourly to retrieve hourly averages and status files. O_3, meteorological, and flow data are reviewed daily by data operations personnel as part of the data validation process (Section 4.0). For sites with EPA-supplied CR3000 data logger and 49i ozone analyzers, data are polled hourly with Campbell's LoggerNet and uploaded to the EPA AIRNow Web site. (ftp:/upload.epa.gov/incoming/CASTNET/data). For any site supplying its own data logger (i.e., Cherokee Nation, OK for the CHE185 site), an ESC 8816 data logger collecting hourly averages is used, and sites are polled hourly using DataLink. Hourly data are uploaded to AIRNow.

Figure 2-21 Data Traceability of a Datum for a Continuously Recorded Parameter



2.5.3 Maintenance

Each site operator verifies the operation of the DAS during the weekly site visit. CASTNET data analysts monitor the operation of each DAS during daily polling of each site. If any problems are noted, the FOM or field coordinator will work with the site operator via telephone to investigate and correct the problem. Replacement equipment and/or a field technician will be dispatched to correct the problem, if necessary.

2.5.4 Equipment Calibration and Frequency

The analog to digital conversion circuitry of the DAS is checked semiannually with a certified voltage supply. The range of input voltages is from 0.000 to 1.000 volt direct current (VDC). Figure 2-22 is an example of a completed CR3000 Calibration Form.

2.5.5 Data Quality Indicators

No DQI has been prepared for the DAS voltage. However, an acceptance criterion of 3 millivolts (mV) is applied. If the DAS voltage is not within 3 mV of the actual, the DAS is adjusted.

2.5.6 Sample Handling and Record Keeping

Three-stage filter packs are prepared and shipped to site operators weekly for dry deposition sampling. Field blanks are shipped quarterly. The three-stage filter packs are shipped to the field in rigid polyvinyl chloride (PVC) tubes packed inside rectangular boxes. The PVC tube contains a filter pack, SSRF, and an Element-generated return label. Site operators open the shipment and verify that the filter pack lot number on the filter pack matches the same number on the SSRF chain-of-custody label. The site operator signs and dates the chain-of-custody label and installs the filter pack on the tower. After sampling, the site operator will complete the SSRF and place the filter pack and corresponding SSRF back into the capped PVC tube, place the tube in the shipping box, seal it, and attach the Element-generated return shipping label addressed to the CASTNET laboratory in Gainesville, FL. The sealed shipping box is then transferred to the courier by one person (the site operator). A field shipping log is used to document shipments (e.g., FedEx Government) of filter packs to and from each site.

Ninety-five percent of the exposed filter pack samples from EPA-sponsored sites must be received by the CASTNET laboratory within two weeks of removal from the sampling tower.

2.6 Field Equipment Calibration and Certification

Amec Foster Wheeler maintains a field instrumentation laboratory to repair, rebuild, calibrate, and certify field sensors and transfer standards. Field systems are repaired and calibrated in accordance with manufacturer specifications and CASTNET Field SOP (Appendix 1). Systems that are rebuilt and tested are available with documentation to send to field sites when needed for the repair of field monitoring equipment. The routine schedule for calibration of equipment at CASTNET monitoring sites is listed in Table 2-13.

Transfer standards required for field parameters are certified in the equipment laboratory before and after each field calibration trip, or a minimum of every six weeks. Copies of the certification documentation are filed at each site and at Amec Foster Wheeler with the calibration results of each site.

Primary standards that are used to certify the transfer standards are also maintained in accordance with CASTNET Field SOP (Appendix 1) in the instrumentation laboratory. Table 2-12 summarizes the procedures and frequency of the primary standard certifications.

Figure 2-22 Example Data Logger Calibration Form

Data Logger Calibration

amec

Site Name	Calibrator	Calibration Date	iForms Ver.
PAL 190	TYLER WARD	11/19/2013 - 11/20/2013	1.5.1

Datalogger	As Found	As Left
ID #	000347	
Mfg./Model	Campbell 3000	

MultiMeter	
ID #	04622
Mfg.	Fluke
Cert. Date	3/26/2013

Voltage Source	
ID #	04624
Model	Datel DVC-350A
Cert. Date	10/22/2013

Data Logger Signal Accuracy

Voltage Source Output	Digital MultiMeter Reading	Datalogger Reading As Found Voltage	Diff	Max Channel	Diff	As Left Voltage	Max Channel
0.0000	0.0000	0.0000	0.0000	SR			
0.1000	0.1000	0.0998	-0.0002	F			
0.2000	0.1999	0.1997	-0.0002	WD			
0.3000	0.3000	0.2996	-0.0004	WD			
0.4000	0.4000	0.3997	-0.0003	WD			
0.5000	0.5000	0.4997	-0.0003	WD			
0.6000	0.6000	0.5996	-0.0004	WD			
0.7000	0.7000	0.6997	-0.0003	WD			
0.8000	0.8000	0.7996	-0.0004	WD			
0.9000	0.9000	0.8996	-0.0004	F			
1.0000	0.9999	0.9997	-0.0002	F			
2.0000	1.9980	1.9989	0.0009	F			
3.0000	2.9980	2.9991	0.0011	F			
4.0000	3.9980	3.9987	0.0007	F			
5.0000	4.9980	4.9988	0.0008	F			

	With Charger	Without Charger
Backup Battery Volatge	12.7	11.8
	(+)	(-)
Climatronics Mainframe Power Supply Voltage		
	As Found	As Left
Status Switches		
Channels Changed		

Remarks:

Reviewed By: [signature] Date: 12/23/13

Table 2-1 Siting Criteria for CASTNET Traditional Monitoring

Traditional* CASTNET Monitoring Sites	
Potential Interferant	**Minimum Distance from Measurement Apparatus**
Large point source of SO_2 or NO_x	20 to 40 km
Major industrial complex	10 to 20 km
City, > 50,000 population	40 km
City, 10,000 to 50,000 population	10 km
City, 1,000 to 10,000 population	5 km
Major highway, airport, or rail yard	2 km
Secondary road, heavily traveled (> 100 ADT**)	500 m
Secondary road, lightly traveled (≤ 100 ADT)	200 m
Feedlot operations	500 m
Intensive agricultural operations (including aerial spraying)	500 m
Limited agricultural operations	200 m
Large parking lot	200 m
Small parking lot	100 m
Tree line	50 m
Obstacles to wind	10 times obstacle height

* Sites with a full suite of meteorological measurements along with a weekly filter pack.
** Measured or modeled traffic volumes and mixes or approximations based on nearby similar roads.

Table 2-2 Siting Criteria for CASTNET Filter Pack Only Monitoring Sites

Potential Interferant	**Minimum Distance from Measurement Apparatus**
Large point source of SO_2 or NO_x	20 to 40 km
Major industrial complex	10 to 20 km
City, > 50,000 population	40 km
City, 10,000 to 50,000 population	10 km
City, 1,000 to 10,000 population	5 km
Major highway, airport, or rail yard	2 km
Secondary road, heavily traveled (> 100 ADT**)	500 m
Secondary road, lightly traveled (≤ 100 ADT)	200 m
Feedlot operations	500 m
Intensive agricultural operations (including aerial spraying)	500 m
Limited agricultural operations	200 m
Large parking lot	200 m
Small parking lot	100 m
Tree line	10 m
Obstacles	10 m from sampling tower plus distance equal to 2 times any obstacle height above the sampling inlet*

* For example: An object 15 m tall must be 20 m from the sampling tower (10 m plus 2 times the 5 m measured above the sampling inlet).

** Measured or modeled traffic volumes and mixes or approximations based on nearby similar roads.

Table 2-3 CASTNET Siting Criteria for Gas Monitoring

Height from Ground to Inlet (meters)	**Distance from Trees to Inlet (meters)**	**Obstacles**	**Inlet Clearance**
2 – 15	10 m from dripline	10 m from sampling tower plus distance equal to 2 times any obstacle height above the sampling inlet*	Unrestricted airflow in an arc of 180 degrees
Roadway Average Daily Traffic (vehicles/day)**	**Minimum Distance O_3 and NO_y (meters)**	**Minimum Distance* O_3 and NO_y (meters)**	**Minimum Distance CO (meters)**
≤ 1,000	10	10	10
10, 000	10	20	10
15,000	20	30	25
20,000	30	40	45
30,000			80
40,000	50	60	115
50,000			135
60,000			150 (maximum required)
70,000	100	100	
≥110,000	250	250	

* Applicable for ozone monitors whose placement had not been approved as of December 18, 2006.
** Measured or modeled traffic volumes and mixes or approximations based on nearby similar roads.

Table 2-4 Summary of Site Installation and Initiation Activities

Task	Activities
Preinstallation	• Finalize land leases, permits, contracts • Establish electricity/telephone/internet accounts including installation schedule • Hire local site operator • Schedule drop-shipments of equipment • Begin site preparation
Station Installation/Initiation	• Deliver all equipment/support materials to location • Finalize electricity and communications service • Install and interface all equipment • Perform equipment calibrations and verify proper operation of the complete system • Train site operator on operation and maintenance of all pertinent instrumentation, sample collection/shipping, and documentation of site activities

Table 2-5 Summary of Site Operator Responsibilities (1 of 2)

Operation[1, 2, 3]	**Frequency**
Site Inspections • Check station integrity (e.g., shelter, towers, guy wires, fence, etc.)	Every Tuesday
Dry Deposition Sampling System • Change/ship filter pack • Inspect sample tower • Leak check flow system	Every Tuesday
Ozone Analyzer	
• Review automated z/s/p checks at 0, 225, 60 ppb	Every Tuesday
• Perform manual z/s/p checks	As requested by FOM or field coordinator
• Check internal diagnostics	Every Tuesday
• Check sample tubing integrity	Every Tuesday
• Check 5-micron Teflon filters, replace if needed	Outside filter – every other week Inside filter – first of month
Trace Gas Samplers	
• Review automated z/s/p checks with span and precision checks at 10% of full scale and zero checks at 1.5 ppb for SO_2 and NO_y and 30 ppb for CO; see QAPP Appendix 11	Every Tuesday
• Perform manual z/s/p checks	As requested by FOM or field coordinator
• Check internal diagnostics	Every Tuesday
• Check sample tubing integrity	Every Tuesday
Wind Speed/Wind Direction • Check reasonableness of data • Check integrity of cups/vane/prop	Every Tuesday
Ambient/Delta Temperature • Check reasonableness of data • Check aspirated shield motor operation	Every Tuesday
Relative Humidity • Check reasonableness of data • Check aspirated shield motor operation, if applicable	Every Tuesday
Tipping Bucket Rain Gauge • Check reasonableness of data • Verify operation-manual tips • Level gauge • Clean debris from collection basin	Every Tuesday
Solar Radiation • Check for sensor obstructions • Clean sensor • Check reasonableness of data	Every Tuesday

Table 2-5 Summary of Site Operator Responsibilities (2 of 2)

Operation[1, 2, 3]	**Frequency**
Surface Wetness	
• Check instrument response	Every Tuesday
• Clean sensor	Monthly
• Check sensor height is 6" to 12" above natural vegetation	Monthly
Data Acquisition System	Every Tuesday
• Verify data/instrument readings	
• Verify internal clock	
• Verify communications	
Communication	Every Tuesday
• Place call to FOM	
Data Transfer	
• Ship site documentation	Monthly
• Ship sample and SSRF	Every Tuesday

Note: [1] See the CASTNET Field SOP (Appendix 1) for details
[2] Meteorological instrument checks are only performed at sites officially monitoring those parameters. See Table 1-1
[3] See Appendix 11 for details on trace-gas analyzers

Table 2-6 Data Quality Indicators for CASTNET Field Measurements

Measurement Parameter	Method	Criteria[1]	
		Precision	Accuracy
Filter Pack Flow	Mass flow controller	± 10%	± 5%
Ozone	UV absorbance	90% CL CV ≤ 7% *[90% confidence limit of co-efficient of variation.* ***40 CFR Part 58 App A Sec 4.1.2****]*	All points on calibration curve within ± 2% of full scale as compared to the best fit straight line linearity error < 5%
Wind Speed	Anemometer	± 0.5 m/s	The greater of ± 0.5 m/s for winds < 5 m/s or ± 5% for winds ≥ 5 m/s
Wind Direction	Wind vane	± 5°	± 5°
Sigma Theta	Wind vane	Undefined	Undefined
Ambient Temperature	Platinum RTD	± 1.0°C	± 0.5°C
Delta Temperature	Platinum RTD	± 0.5°C	± 0.5°C
Relative Humidity	Thin film capacitor	± 10% (of full scale)	± 10%
Precipitation	Tipping bucket rain gauge	± 10% (of reading)	± 0.05 inch†
Solar Radiation	Pyranometer	± 10% (of reading taken at local noon)	± 10%
Surface Wetness	Conductivity bridge	Undefined	Undefined

Notes: °C = degrees Celsius
m/s = meters per second
RTD = resistance-temperature device
UV = ultraviolet

[1] Mean absolute difference (MAD) is the precision measure for difference criteria such as wind speed and temperature. Mean absolute relative percent difference (MARPD) is the precision measure for percentage criteria.
† For target value of 0.50 inch.

Table 2-7 Acceptance Criteria for CASTNET Field Calibrations

Measurement Parameter	Measurement Method	Calibration Method	Acceptance Criteria
Filter Pack Flow	Mass flow controller	Mass flow meter or dry piston meter	± 2% of actual flow rate
Ozone	UV absorbance (photometric analyzer)	Certified transfer photometer	All points on calibration curve within ± 2% of full scale as compared to the best fit straight line linearity error < 5%
Wind Speed	Anemometer	Adjustable synchronous motor	± 0.2 m/sec < 5 m/s ± 5% ≥ 5 m/s
Wind Direction	Wind vane	Vane aligned with compass sighted target	± 3°each point
Temperature	Platinum RTD	Certified platinum RTD in isothermal bath	± 0.15°C
Delta Temperature	Platinum RTD	Certified platinum RTD in isothermal bath	± 0.30°C
Relative Humidity	Thin film capacitor	Transfer sensor	± 10% of full scale
Precipitation	Tipping bucket rain gauge	Known volume addition	± 0.02 inches at 0.50 inches
Solar Radiation	Pyranometer	Transfer sensor	± 5% of average
Surface Wetness	Conductivity bridge	Test with 230-240 kΩ resistance	Full-scale response to test resistance

Notes: °C = degrees Celsius
m/s = meters per second
r^2 = correlation coefficient
RTD = resistance temperature device
UV = ultraviolet
kΩ = kilo Ohm
Calibration of trace gas instruments is discussed in QAPP Appendix 11.

Table 2-8 EPA and NPS/BLM Sites: Measurements/Methods (1 of 2)

Measurement	EPA Sensor/Device	Method	NPS Sensor/Device	Method
Filter Pack Flow	Tylan, model FC-280 or Apex, model AX-MC, or equivalent	• Controlled system maintains a pre-set flow rate • Mass flow determination via pressure or resistive temperature	Tylan, model FC-280 or equivalent	• Controlled system maintains a pre-set flow rate • Mass flow determination via resistive temperature
Ozone[1]	Analyzer: Thermo Scientific, model 49i	• Sample inlet at 10 m with 5 micron filter at tower inlet • Continuous measurements yielding hourly averages using UV absorbance method, 0-500 ppb range • Sample tubing 1/4 inch • Entire sample drawn by analyzer pump	Thermo Scientific, model 49i	• Sample inlet at 10 m with 20 micron filter at tower inlet • Continuous measurements yielding hourly averages using UV absorbance • Sample tubing 1/4 inch
Ozone[2]	Transfer Standard: Thermo Scientific, model 49i	• Zero air supply and ozone generator set for automated daily zero, span, and precision level checks • Independent verification of test atmosphere with second in-station photometer	Transfer Standard: Thermo Scientific, models 49-103, 49C, and 49i	• Zero air supply and ozone generator set for daily zero, span, and precision level checks • Independent verification of test atmosphere with second in-station photometer
SO_2	API T100U	• UV Fluorescence measured at 10 m	Thermo Scientific 43i-TLE	UV Pulsed Fluorescence measured at 10 m
NO/NO_y	API T200U/NO_y	• Chemiluminescence measured at 10 m	Thermo Scientific 42i-Y	Chemiluminescence measured at 10 m
CO	API T300U	• Gas Filter Correlation measured at 10 m	Thermo Scientific 48i-TLE	Gas Filter Correlation measured at 10 m
Wind Speed	Climatronics, model F460	• Sensor at 10 m • Anemometer chopper wheel/LED proportional to wind speed	Climatronics, model F460	• Sensor at 10 m • Anemometer chopper wheel/LED proportional to wind speed
	RM Young Wind Monitor-AQ	• Sensor at 10 m • Magnetic/sine wave frequency proportional to wind speed	RM Young Wind Monitor-AQ	• Sensor at 10 m • Magnetic/sine wave frequency proportional to wind speed
Wind Direction	• Climatronics, model F460 • RM Young Wind Monitor-AQ	• Sensor at 10 m • Vane and translator	• Climatronics, model F460 • RM Young Wind Monitor-AQ	• Sensor at 10 m • Vane and translator

Table 2-8 EPA and NPS/BLM Sites: Measurements/Methods (2 of 2)

Measurement	EPA Sensor/Device	Method	NPS Sensor/Device	Method
Temperature/ Delta Temperature	RM Young RTD in motorized and naturally aspirated shields	• Temperature measured at 9 m, delta temperature at 9 m and 2 m • Resistance temperature device	Climatronics in motorized aspirated shields	• Temperature measured at 9 m or 2 m. Delta temperature is measured at 9 m and 2 m at a few sites. • Thermistor in motorized aspirated shield
			RM Young in motorized aspirated shields	• Temperature measured at 9 m, delta temperature at 9 m and 2 m • Resistance temperature device
Relative Humidity	• Vaisala, model 102425 • Rotronic MP-Series	• Sensor at 9 m • Capacitor sensor in motorized or naturally aspirated shield	• Rotronic, model MP-601 or MP-101 • Vaisala, model HMP 45C	• Sensor at 9 m • Capacitor sensor in motorized or naturally-aspirated shield
Precipitation	Texas Electronics, model TR-525I	• Measured between 1 m and 2 m • Heated tipping bucket rain gauge	Texas Electronics or equivalent	• Measured between 1 m and 2 m • Heated tipping bucket rain gauge
Solar Radiation	LI-COR pyranometer with RM Young translator	• Measured between 1 m and 4 m • Silicon photovoltaic sensor	LI-COR pyranometer	• Measured between 1 m and 4 m • Silicon photovoltaic sensor
Surface Wetness	RM Young	• Measured near height of ground-level vegetation • Resistive grid	RM Young	• Measured near height of ground-level vegetation • Resistive grid
Station/Shelter Temperature	Campbell Scientific	• Mounted near or on instrument rack. • Thermistor	ARS – Shelter Temp 100	• Mounted near or on instrument rack. • Thermistor
Data Recording	Campbell Scientific[2], Model CR3000 or CR350	• Digital data logger	ESC, model 8816 or 8832	• Digital data logger
Site Information	Dell laptop computers	• Data access with instrument control • PC 200W data forms	Various laptop and desk top computers	• Data access with instrument control • Digital Data View

Notes: [1] Monitor Labs model 9811 analyzer is used at CHE185, OK.
[2] An ESC model 8816 data logger is used at CHE185, OK.

Table 2-9 Meteorological Instrument Specifications

Parameter	Manufacturer	Manufacturer's Specifications	
Wind Speed	Climatronics	Accuracy:	± 0.07 m/sec < 5 m/sec; ± 1% otherwise
		Threshold:	0.22 m/sec
	RM Young	Accuracy:	± 2%
		Threshold:	0.4 m/sec up to 1.0 g/cm torque
Wind Direction	Climatronics	Accuracy:	± 2 degrees
		Threshold:	0.22 m/sec
	RM Young	Accuracy:	± 5 degrees
		Threshold:	0.5 m/sec up to 11 g/cm torque
Temperature	RM Young	Accuracy:	± 0.3°C
		Range:	-50 to 50°C
Temperature Difference	RM Young	Accuracy:	± 0.10°C
Relative Humidity	Vaisala 102425	Accuracy:	± 5.0%
	RM Young (Rotronic)	Accuracy:	± 3.0%
Precipitation	Climatronics (Texas Electronics)	Accuracy:	± 4.0% up to 76 mm/hr
Solar Radiation	LI-COR/RM Young translator	Accuracy:	± 5.0%
		Linearity:	± 2.0%
Surface Wetness	RM Young	Accuracy:	Undefined

Table 2-10 Thermo Scientific Ozone Analyzer Models Instrument Specifications

Analyzer Operation	Specification
Range	0 - 500 ppb
Noise	± 1 ppb
Minimum Detectable Concentration	2 ppb
Zero Drift	< 0.5%/month
Span Drift	< 1%/month
Lag Time	10 seconds
Response time at 2 Lpm (0 - 95%)	20 seconds
Precision	± 2 ppb
Linearity	± 1 ppb
Flow Rate	1 - 3 Lpm
Operating Temperature Range	0 - 50°C
Designated Equivalence Method Number	EQOA-0880-047
EPA Designation Date	August 27, 1980

Source: Thermo Scientific

Table 2-11 CASTNET Field Maintenance Schedule (1 of 2)

Parameter	Site Visit	
	January–June	July–December
Zero Air Compressor – Ozone		
Charcoal	1	1
Silica Gel	3	3
Canister O-rings	3	3
Drain Compressor	4	4
Ozone Site Transfer		
Balston Filter with SS Ferrule Set	1	2
Cooling Fan Filter	2	3
Ozone Site Analyzer		
Cooling Fan Filter	2	2
Sample Pump	3	3
Mass Flow System		
Pump Diaphragm	1	1
Balston Filter with Ferrule Set	1	1
Quick Connect	2	2
Rotameter	3	3
Climatronics		
WSP Sensor	1	1
WDR Sensor	1	2
RH Filter	1	2
WDR Vane	2	2
WSP Cups	2	2
Heater Assembly	2	2
Temp Blowers	2	2
Temp Shields	2	2
RM Young		
Nose Cone	1	1
Wind Monitor AQ	1	2
RH Filter	1	2
WDR Vane	2	2
WSP Prop	2	2
Temp Blowers	2	2
Temp Shields	2	2
RH Shield	2	2
Tipping Bucket		
Bucket and Tipper	2	2
Drain Hole Filter	2	2
Heater	3	3
Miscellaneous		
A/C and Heater Relays	3	3

Notes: 1. Replace with new or rebuilt, or rebuild on-site.
2. Clean and inspect/ Replace as needed.
3. Inspect and replace as needed.
4. Drain water.

Table 2-11 CASTNET Field Maintenance Schedule (2 of 2)

Parameter	Site Visit July–December
RM Young	
Temp Blowers	2
Temp Shields	2
Zero Air System - Trace Gas	
Charcoal	1
Purafil	1
NO_y Analyzer / Bypass Box	
Rebuild Bypass Box Pump	1
Bypass Box Orifice Filters (3)	3
NO/NO_y Sample Pump	1
Ozone Dryer Filter-DFU	1
External Scrubber	1
Ozone Filter Chemical	1
Vacuum Manifold Filters (1)	3
Vacuum Manifold O-rings	3
Reaction Cell Orifice Filters (2)	3
Reaction Cell Orifice O-rings	3
FP Only Site	
Pump	1

Notes: 1. Replace with new or rebuilt, or rebuild on-site.
2. Clean and inspect.
3. Inspect and replace as needed.

Table 2-12 Summary of Possible QC Failures

QC Check	QC Failure	Corrective Action
Filter Pack Sampling System Operational Check	• Flow rate greater than ± 2 percent of target value • Indication of a system leak or otherwise suspect operation	• FOM or field coordinator provides instructions to the site operator to perform detailed checks. • If the problem is not resolved, the appropriate replacement equipment is sent to the site.
Ozone Analyzer Zero/Span/ Precision Check	• Automated span and precision greater than ±7 percent of target value • Zero outside ± 1.5 ppb	• Site operator notifies FOM or field coordinator if analyzer is out of criteria. • Site operator may be instructed to perform a manual check. • If problem persists, instrument response is corrected by field technician during semiannual calibration.
Meteorological Sensors Reasonability Check	• Instrument operation suspect	• FOM or field coordinator provides instructions to the site operator to perform detailed checks. • If problem is not resolved, a replacement instrument or replacement part is sent to the site. • Otherwise, problem is corrected during semiannual calibration.
Site Documentation	• Documentation missing, incomplete, or unreasonable	• List of missing, incomplete, and or unreasonable documentation is generated by the laboratory filter pack receiving personnel or DMC and submitted to FOM or field coordinator for verification with site operators during Tuesday call.

Table 2-13 Field Calibration Schedule

Calibration Group	Months Calibrated	Sites Calibrated			
Eastern Sites (23 Total)					
E-1 (8 Sites)	February/August	BEL116, MD BWR139, MD	WSP144, NJ CTH110, NY	ARE 128, PA PSU106, PA	PED108, VA VPI120, VA
E-2 (11 Sites)	April/October	ABT147, CT ASH135, ME HOW191, ME	WST109, NH CAT175, NY HWF187, NY	WFM105, NY NIC001, NY EGB181 ON	UND002, VT WFM007, NY
E-3 (5 Sites)	May/November	KEF112, PA MKG113, PA	LRL117, PA PAR107, WV	CDR119, WV	
Southeastern Sites (10 Total)					
SE-4 (7 Sites)	January/July	SND152, AL GAS153, GA	BFT142, NC CND125, NC	COW137, NC COW005, NC	SPD111, TN
SE-5 (4 Sites)	February/August	CAD150, AR CVL151, MS	IRL141, FL SUM156, FL		
Midwestern Sites (18 Total)					
MW-6 (6 Sites)	January/July	CDZ171, KY CKT136, KY	MCK131, KY MCK231, KY	ESP127, TN PNF126, NC	
MW-7 (9 Sites)	March/September	ALH157, IL BVL130, IL RED004, MN	STK138, IL VIN140, IN	DCP114, OH OXF122, OH	QAK172, OH PRK134, WI
MW-8 (4 Sites)	April/October	SAL133, IN HOX148, MI	ANA115, MI UVL124, MI		
Western Sites (11 Total)					
W-9 (5 Sites)	March/September	KNZ184, KS KIC003, KS	CHE185, OK SAN189, NE	ALC188, TX	
W-10 (6 Sites)	May/November	GTH161, CO ROM206, CO	CNT169, WY PND165, WY	PAL190, TX NPT006, ID	

Table 2-14 Calibration Standards, Certification Procedures, and Frequency

Measurement Device	Calibration Procedure	Calibration Frequency
Mass Flow Meter: Bios Model DC-1 Bios Model Definer 220 Mass Flow Controller: Gillian Model 5100	Certified with NIST-traceable Phillips Universal Counter/Timer and a Mitutoyo Master Gauge Block	The NIST-traceable mass flow standards are calibrated annually by the vendor.
Ozone Analyzer: Thermo Scientific Model 49C-PS and 49i-PS	Multi-point comparison to the NIST reference photometer maintained by KCSTC or another EPA region	Primary standard is certified annually against the NIST reference at KCSTC or another EPA region
Ozone Analyzer: Thermo Scientific Model 49i (when used as a Level 2 traveling transfer standard)	Multi-point comparison to the NIST reference photometer maintained by NIST or an EPA regional laboratory.	Certified annually against the NIST reference.
Ozone Analyzer: Thermo Scientific Model 49i (when used as an onsite Level 3 transfer standard)	Multi-point comparison to a Level 2 standard.	Initial certification then 1/6 months.
Wind Speed Sensor: RM Young Model 18802 Synchronous motor	Multi-point comparison to a NIST-traceable frequency meter	The NIST traceable synchronous motor is calibrated annually by the vendor.
Wind Speed Torque: RM Young Model 18310 Torque Disc	Fixed test disc, no calibration needed	This is a fixed test fixture; if the validity is in question, it is replaced.
Wind Direction Sensor: RM Young Model 18212 Test fixture	Fixed test fixture, no calibration needed	This is a fixed test fixture; if the validity is in question, it is replaced.
Wind Direction Sensor: Climatronics Model 101984 Test fixture	Fixed test fixture, no calibration needed	This is a fixed test fixture; if the validity is in question, it is replaced.
Wind Direction Torque: RM Young Model 18331 Torque Gauge	Fixed test gauge, no calibration needed	This is a fixed test fixture; if the validity is in question, it is replaced.
Temperature: Dostmann Precision RTD Measuring Instrument Model P600	A four-point comparison to NIST standards	The NIST-traceable digital thermometers are calibrated annually by the vendor.
Relative Humidity Calibrator: Vaportron Model H-100L	Calibrated with a NIST-traceable humidity generator based on the “two-pressure” principle	The NIST-traceable humidity calibrator is calibrated annually by the vendor.
Precipitation: Water measurement using a laboratory grade graduated cylinder	Fixed test cylinder, no calibration needed	This is a fixed test cylinder; if the validity is in question, it is replaced.
Solar Radiation Sensor: Eppley Model PSP100 Hukseflux Model LP02	Comparison calibration with Standard Precision Spectral Pyranometer Serial No. 21231f3 at radiation intensities of approximately 700 W/m^2	The NIST solar radiation standard is calibrated annually by the vendor.
Multimeter: Fluke Model 8060A	Tested under varying conditions, NIST-traceable measurement standards	The NIST-traceable multimeter is calibrated annually by the vendor.

Notes: KCSTC = Kansas City Science and Technology Center
W/m^2 = watts per square meter

3.0 Laboratory Operations

3.1 Sample Handling and Custody

A proper sample custody system ensures that data quality is not compromised due to faulty or inadequate documentation, shipping errors, and/or contamination during the sample transfer stage. Specifically, sample custody must be maintained to:

- Create an accurate record that traces sample handling from preparation of sample kits through computer storage of the data, and
- Ensure the maintenance of sample integrity through traceability of the materials that contact the sample.

3.1.1 Sample Custody

A sample is defined as being in someone's custody if:

- It is in one's physical possession;
- It is in one's view, after being in one's physical possession;
- It is in one's physical possession and then locked or otherwise sealed, so that tampering will be evident; or
- It is kept in a secure area, restricted to authorized personnel, only.

3.1.2 Sample Handling for Dry Deposition Filter Packs

An open-face, three-stage filter pack is used to collect sulfur and nitrogen species and trace ions. Figure 1-6 shows the filter pack assembly. The measurement method is discussed in Section 2.4.2. Figure 3-1 illustrates the laboratory operations process for filter packs and shows the flow of information from project set up to delivery of data to EPA.

Sample handling procedures are designed to minimize handling and transfers (i.e., opportunities for contamination and misdirection). Laboratory personnel follow the SOP in Appendix 4. The QA Manager ensures distribution of updated SOPs and checklists to the Amec Foster Wheeler laboratory. The QA Manager also ensures the removal of obsolete documents from the laboratory. The filter pack custody system begins with setting up the weekly field sampling groups in Element, the LIMS. Element generates the filter pack site and laboratory identification (ID) label for each of the three filter fractions. Once the filter pack is loaded and capped, a filter pack ID label is attached to the outer ring. This label contains the filter pack ID number and site number. A corresponding chain-of-custody label bearing the same filter pack ID number and site number, plus the employee number (e.g., 3578) of the person who assembled the filter pack is attached to the SSRF which accompanies the filter pack to and from the sampling site (Figure 3-2).

The prepared filter pack and labeled SSRF are placed in a PVC tube, which in turn is placed in a shipping box for shipment to the designated site operator. The shipping label on the outside of the box includes the site number and filter pack ID number. The same person who assembled the filter pack and packed it in the shipping tube completes the CASTNET Filter Pack Preparation Form for the filter preparation log. This form identifies the ID numbers of the filters used in the filter pack and the date the tube was given to the shipping clerk. The laboratory technician changes the sample designation in Element to “Active Out” when the filter pack is shipped.

Figure 3-1 Laboratory Operations for Filter Packs

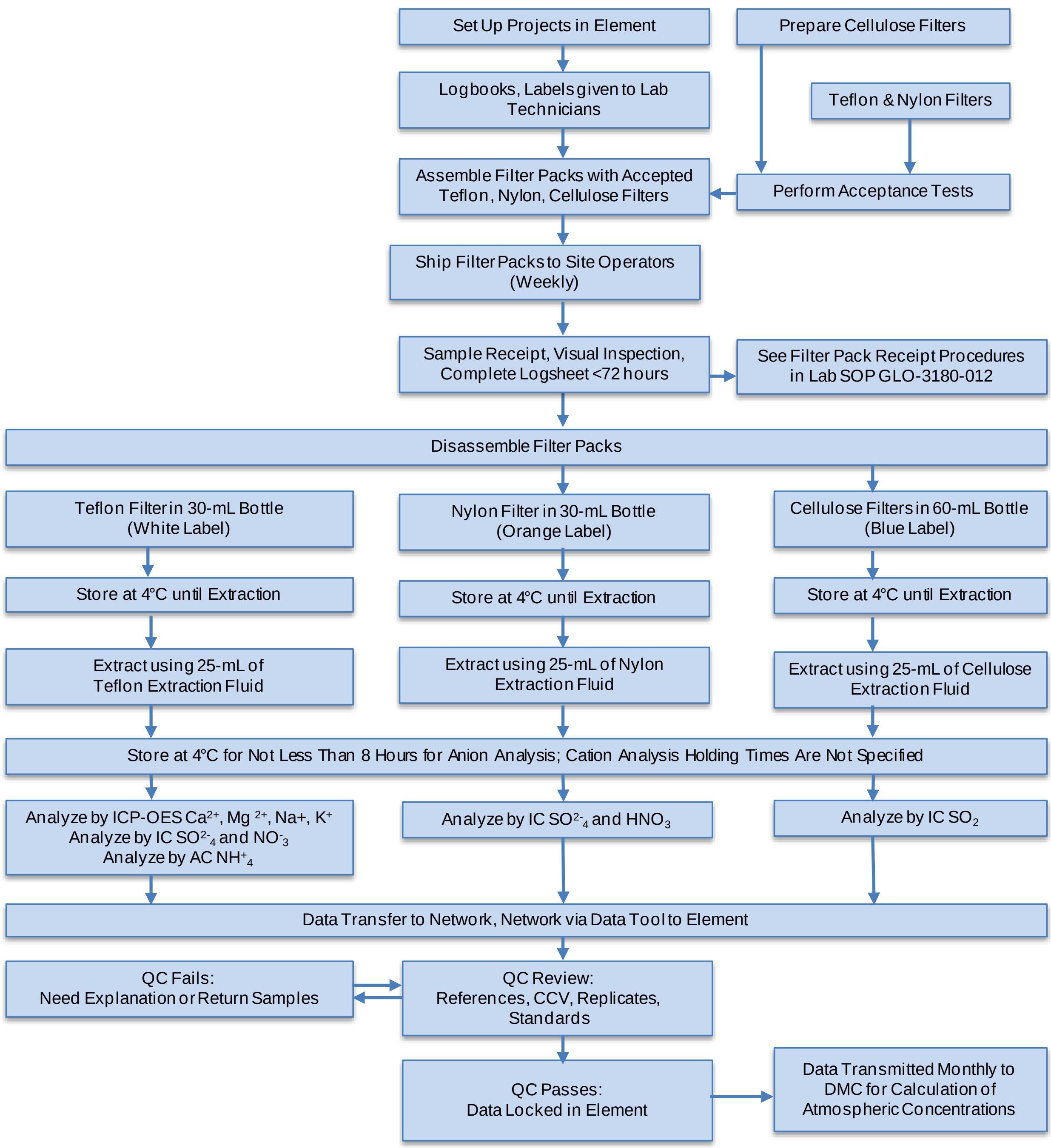


Figure 3-2 Sample Site Status Report Form

The filter pack is then shipped using FedEx or UPS to the site operator who will open the shipment and verify that the filter pack ID label on the filter pack matches the same number on the SSRF chain-of-custody label. The site operator signs and dates the chain-of-custody label and installs the filter pack on the tower. After sampling, the site operator will complete the SSRF and place the filter pack and corresponding SSRF back into the PVC tube, place the tube in the shipping box, seal it, and attach the prepaid first class US Postal Service (USPS) shipping label addressed to the CASTNET laboratory in Gainesville, FL. The sealed shipping box is then conveyed to USPS by the site operator. Ninety-five percent of exposed filter pack samples from EPA-sponsored sites must be received by the CASTNET laboratory within 14 days of removal from the sampling tower.

The Amec Foster Wheeler receiving clerk delivers the sealed shipping container to the sample custodian. The sample custodian inspects the integrity of the container and seal, opens the container, and checks the integrity of the contents. The sample custodian verifies that the filter pack ID label and site number match the numbers on the SSRF chain-of-custody label and then signs the chain-of-custody label on the SSRF and notes any damage or unusual findings on the SSRF. The “Laboratory Use Only” section of the SSRF is provided to document the samples received, the date received, and the signature of the person processing the samples. The sample custodian also verifies that the site operator completed the on and off sampling dates and checks the SSRF for comments or needed supplies.

Samples are unpacked and recorded daily. As part of the unpacking process, the filter pack ID label is matched to its corresponding, bar-coded, Element generated, laboratory fraction (S) label and to the SSRF label. The S label is bar-coded to scan the sample in the system. The sample number is then logged into the Element system for continued tracking. Filters are removed from the filter pack, placed in labeled extraction bottles, and stored in a secure cold room until extracted. There is no established maximum holding time between sampling and extraction as long as the filters are stored in a cold (approximately 4ºC) and contaminant-free environment. Data identifying the samples received, the date received, and the person who processes the samples then enters them into Element. The filter pack ID label and corresponding S label are turned into the laboratory technician who performs the peer review of the logins and stores/enters SSRF data into the CASTNET CDMSA.

3.1.3 Sample Integrity

Sample integrity is maintained by ensuring that materials in contact with samples do not affect the analytes of interest in a way that could bias results. These materials must be traceable to a point to enable documentation of their contact with the sample. Sample integrity is maintained by incorporating filter acceptance tests, laboratory blanks, and field (trip) blanks for the dry deposition samples. Section 3.2 discusses the acceptance tests.

Field blanks are prepared once each quarter for each sampling site. The laboratory follows the SOP (Appendix 4) for preparing the three-stage filter pack. The filter packs used for the field blanks contain a nonstandard quick connect that cannot be installed on the tower. The field blanks are clearly identified with labels informing the site operator not to remove the filter pack from the resealable plastic bag. When the field blank is received back from the site, it is unpacked and extracted following the standard procedures described in Section 3.1.6.

Laboratory blanks are prepared during the same time the filter packs are being prepared for the field. Two sets of separate laboratory blank samples are prepared each week. Each blank contains a filter from the same lots of Teflon, nylon, and cellulose filters used in preparation of the field filter packs. The filters selected for the laboratory blanks are placed directly into the extraction bottles.

The field and laboratory blank results are reviewed quarterly for outliers and for any trends or bias. The analytical results are summarized quarterly and presented in CASTNET Quarterly QA Reports (e.g., Amec Foster Wheeler, 2014). Electronic data files for all of the blank samples are submitted to the DMC quarterly.

Reagents used in laboratory analyses are analytical reagent grade, traceable to a commercial supplier. The date of container opening and, if applicable, expiration are recorded on each container. Method blanks, containing each reagent used in the analysis, are run with each analytical batch to assess reagent integrity. Method blanks containing detectable levels of analytes of interest and/or interfering analytes indicate possible contamination of the reagent or contamination from other sources (i.e., glassware, carryover). These occurrences are investigated, and the source of the contamination is eliminated or reduced to an acceptable level.

3.1.4 Preparation, Serialization, and Shipment of Dry Deposition Filter Packs

Three-stage filter packs are prepared and shipped to site operators weekly for dry deposition sampling. Field blanks are shipped quarterly. Custody tracking begins with preparation of the filter pack as described in Section 3.1.2.1. All handling of filters and filter packs during preparation and packing for shipment is done with powder-free gloves in a limited-access room dedicated for this purpose.

Prior to loading, each three-stage filter pack assembly is cleaned with deionized (DI) water, oven-dried, and inspected for damage that could permit air leaks. Damaged parts are rejected and removed for repair or disposal. Each three-stage filter pack (Figure 1-6) is loaded with one Teflon filter as the (first stage) in the air flow stream, one nylon filter as the second stage, and two potassium carbonate (K_2CO_3)-impregnated cellulose filters as the third stage or last stage in air flow stream. First, the two cellulose filters are placed directly together on the bottom filter support grid. Two cellulose filters are used to ensure that all the SO_2 in the air stream is captured. Next, the nylon filter is placed on a filter support ring and grid above the cellulose filters. Finally, the Teflon filter is installed on a filter support grid above the nylon filter. The Teflon filter has a backing attached to the filter. Orientation of the Teflon filter in the filter pack is verified so the Teflon side is facing the air stream. The support ring without a grid is placed atop the Teflon filter to hold it securely in place.

Sample handling procedures are designed to minimize handling and transfers. After assembly, the filter pack is sealed and capped, and a filter pack ID label is attached to the filter pack clamp. This label contains the filter pack ID number, site number, and on date. A corresponding chain-of-custody label bearing the same filter pack ID label and site number is attached to the SSRF. The same person who assembled the filter pack and packed it in the shipping tube completes the CASTNET Filter Pack Preparation Form for the filter preparation logbook.

At the same time, two sets of laboratory blanks are prepared with each batch of filter packs by placing a selected filter from each filter type into extraction bottles. Two separate sets of laboratory blank samples are prepared for each field sampling week. The laboratory blanks are prepared from the same lots of filters used in preparing the weekly filter packs. Two Teflon and two nylon filters are selected. Each is placed in an individual extraction bottle labeled with the corresponding filter lot number. A total of four cellulose filters are selected, and two filters are placed in each labeled extraction bottle. The laboratory blanks and samples for a given week are extracted and analyzed together.

The three-stage filter packs are shipped to the field in rigid capped PVC tubes packed inside rectangular cardboard boxes. The shipping package includes a filter pack, SSRF, and a prepaid first class USPS return mailing label. Site operators complete the SSRF after sampling and return the exposed filter packs to the CASTNET laboratory. The dry deposition network returns the entire filter pack to the laboratory for unloading. A field shipping log is used to document shipments of filter packs to each site.

When the exposed filter packs arrive at the CASTNET laboratory, the shipment is inspected and unpacked by following the CASTNET Laboratory SOP for Receiving, Unpacking, and Log in of Three-Stage Filter Packs (GLO3180-012) in Appendix 4. Filter packs are numbered according to the following sequences:

XXYY001-Z

XX	=	calendar year (last two digits)
YY	=	week number (1-52)
Z	=	site sequence number

For example, the third week of sampling during 2009 at CKT136, KY (site sequence number 20) was 0903001-20. The 001 designated the Element project number.

3.1.5 Receipt and Log in of Sample Media

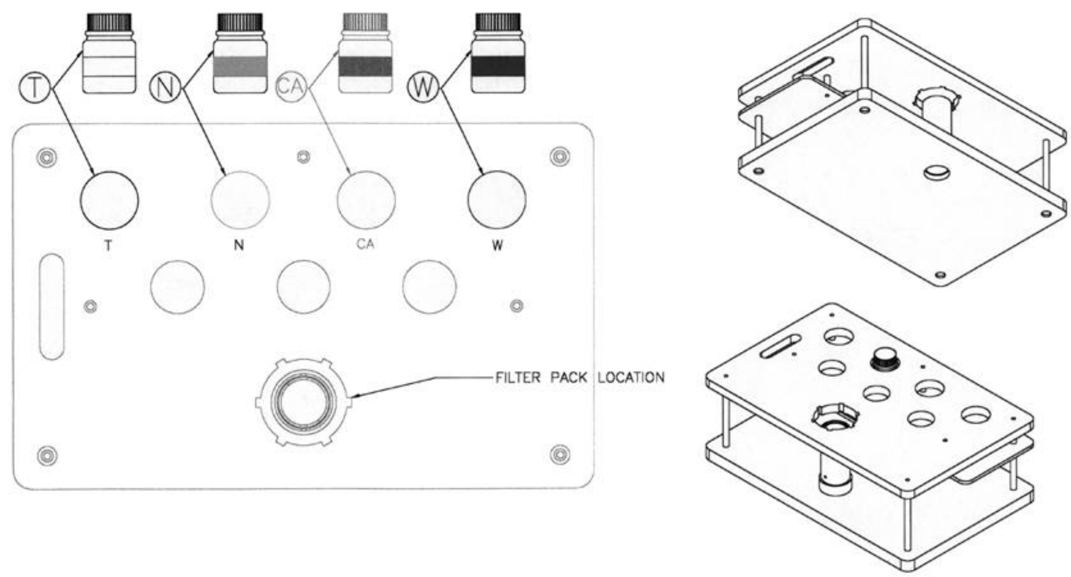
Filter packs are received from the sites at the Amec Foster Wheeler receiving area. Ninety-five percent of exposed filter pack samples from EPA sponsored sites must be received by the CASTNET laboratory within 14 days of removal from the sampling tower. The receiving clerk checks the receiving area daily and transfers the samples to the sample custodian. The sample custodian examines each shipping container for damage and verifies that the filter pack ID number and site number match the numbers on the SSRF chain-of-custody label. The sample custodian also verifies that the site operator completed the on and off sampling dates and checks the SSRF for comments or needed supplies. The filter pack label is removed and placed beside the corresponding S label on a label comparison page. The unpacking processor records the date received and any of the pertinent comment codes. Individual sample bottles are labeled with the appropriate sample fraction label, and the corresponding filter types are placed in the bottles. The sample number is then activated and logged into the Element system, and tracking of the sample continues. Samples are stored for subsequent extraction and analyses.

3.1.6 Sample Preparation Prior to Analysis

During the unpacking process, gloves are worn at all times, and forceps are used to handle the filters. The filter pack ID label is removed from the filter pack and placed next to its matching laboratory S label. Any problems identified with the internal filters are documented with comment codes on the log sheet next to the matched labels.

Once in the laboratory, filter packs are unloaded individually using a disassembly stand (Figure 3-3) that supports the filter pack base and three extraction bottles. A color-coded label is affixed to each extraction bottle to differentiate the three filters: a white label for the Teflon, orange for the nylon, and blue for the impregnated cellulose. Filter packs are unloaded by removing the top retaining ring and then carefully lifting the Teflon filter off the support grid. The Teflon filter is inspected for holes, tears, evidence of leakage, or unusual appearance and is placed in the appropriately labeled bottle. The Teflon filter support grid is removed, and the nylon filter is carefully lifted off its support grid. As with the Teflon filter, the nylon filter is inspected before being placed in the designated extraction bottle. Once the nylon filter support grid is removed, both cellulose filters are carefully lifted off the bottom support grid. The cellulose filters are inspected and then both filters are placed in one correctly labeled bottle. After disassembly, the extraction bottles are capped and refrigerated (in weekly groups) according to filter type until extraction. The analyst is notified that samples are ready for extraction. The Teflon, nylon, and cellulose filters are extracted according to the procedures described in the CASTNET Laboratory SOP (GLO3180-001 in Appendix 4).

Figure 3-3 Filter Pack Assembly/Disassembly Apparatus



Sample Slot	Label Color	Description
T	White	Teflon Filter
N	Orange	Nylon Filter
W	Blue	Cellulose Filter
CA*	Yellow	Citric Acid

Note: * Not used on CASTNET Project

3.2 Inspection and Acceptance of Supplies and Consumables

3.2.1 Teflon, Nylon, and Cellulose Filters

3.2.1.1 Teflon and Nylon Filters

Teflon and nylon filters require no preparation for use in filter packs. Prior to being loaded into the filter packs, each lot of Teflon and nylon filters is analyzed to ensure that background contamination from the manufacturing process is within acceptable limits. Acceptance testing is done on each box of Teflon and nylon filters prior to preparation of the filter packs. In the filter acceptance testing process, four percent of Teflon and nylon filters are selected from each new box of filters, extracted, analyzed following standard procedures, and tested for background contamination. If results exceed nominal reporting limits (Table 3-1), the box of filters is rejected for use in field sampling. Statistical analysis has demonstrated that four percent of Teflon and nylon filters (or four filters from a box of 100) must be analyzed and found to be less than the reporting limit for 95 percent confidence to be established that all filters in the box have blank contamination less than twice the reporting limit. Acceptance test results are stored in Element. The manufacturers' lot numbers from each box of Teflon and nylon filters are recorded in the filter pack preparation logbook. An Element database table is maintained to facilitate cross-referencing Amec Foster Wheeler sample numbers with the Teflon and nylon manufacturers' lot numbers. Figure 3-4 is an example of quarterly acceptance testing on Teflon filters. All acceptance testing is performed by a laboratory analyst and approved by the LOM, or designee, before the filters are released for use in the filter packs.

3.2.1.2 Cellulose Filters

Cellulose filters must be impregnated with K_2CO_3 to collect SO_2 quantitatively from the atmosphere. Refer to CASTNET Laboratory SOP GLO3180-010 in Appendix 4. Cellulose filters are acceptance tested after the impregnation procedure. Between 400 and 800 filters are prepared at one time. The filters are assigned to an impregnation group of 400 filters that is uniquely associated both with the impregnation date and a group of acceptance test samples. Each impregnation group is isolated throughout the entire impregnation procedure and is stored separately before use. Acceptance testing is performed on four percent of the filters contained in each impregnation group. The acceptance test samples are prepared with two cellulose filters per sample and are extracted and analyzed according to normal procedures. To date, statistical analysis has not been applied to impregnated cellulose filter types. If any of the filters show contamination above the reporting limit (Table 3-1), the group is rejected and not used in filter packing. Acceptance test results for an impregnation group are considered satisfactory if no more than one sample in the group shows sulfate contamination above 3.83 micrograms (µg), which is equivalent to an approximate ambient concentration of 0.17 µg per cubic meter ($\mu g/m^3$) as SO_2. All cellulose filter acceptance test results are stored in Element. The impregnation group used for each filter pack is referenced in the filter pack preparation logbook. All acceptance testing is performed by a laboratory analyst and approved by the LOM, or designee, before filters are released for use in the filter packs.

Figure 3-4 Sample Acceptance Test Results for Teflon Filters

LAB_KEY	STORET_KEY	BATCH	QC	SITE_ID	METHOD	PARAMETER	CONCENTRAT	UNITS	DETECTION_	EXTRACTION	ANALYSIS_D	COMMENT
1012006-01	97553	L004036	FAT	TAT10	6010B Mod	CALCIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-01	97359	L004038	FAT	TAT10	300.0 Mod	CHLORIDE,TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-01	97554	L004036	FAT	TAT10	6010B Mod	MAGNESIUM, TEFLON	<0.07500	µg (total)	0.075	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-01	97550	L004032	FAT	TAT10	350.1 Mod	NH3+NH4 as N, TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-01	97280	L004038	FAT	TAT10	300.0 Mod	NO3 AS N, TEFLON	<0.2000	µg (total)	0.2	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-01	97556	L004036	FAT	TAT10	6010B Mod	POTASSIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-01	97277	L004038	FAT	TAT10	300.0 Mod	SO4-TEF	<1.000	µg (total)	1	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-01	97555	L004036	FAT	TAT10	6010B Mod	SODIUM, TEFLON	<0.1250	µg (total)	0.125	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-02	97553	L004036	FAT	TAT10	6010B Mod	CALCIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-02	97359	L004038	FAT	TAT10	300.0 Mod	CHLORIDE,TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-02	97554	L004036	FAT	TAT10	6010B Mod	MAGNESIUM, TEFLON	<0.07500	µg (total)	0.075	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-02	97550	L004032	FAT	TAT10	350.1 Mod	NH3+NH4 as N, TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-02	97280	L004038	FAT	TAT10	300.0 Mod	NO3 AS N, TEFLON	<0.2000	µg (total)	0.2	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-02	97556	L004036	FAT	TAT10	6010B Mod	POTASSIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-02	97277	L004038	FAT	TAT10	300.0 Mod	SO4-TEF	<1.000	µg (total)	1	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-02	97555	L004036	FAT	TAT10	6010B Mod	SODIUM, TEFLON	<0.1250	µg (total)	0.125	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-03	97553	L004036	FAT	TAT10	6010B Mod	CALCIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-03	97359	L004038	FAT	TAT10	300.0 Mod	CHLORIDE,TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-03	97554	L004036	FAT	TAT10	6010B Mod	MAGNESIUM, TEFLON	<0.07500	µg (total)	0.075	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-03	97550	L004032	FAT	TAT10	350.1 Mod	NH3+NH4 as N, TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-03	97280	L004038	FAT	TAT10	300.0 Mod	NO3 AS N, TEFLON	<0.2000	µg (total)	0.2	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-03	97556	L004036	FAT	TAT10	6010B Mod	POTASSIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-03	97277	L004038	FAT	TAT10	300.0 Mod	SO4-TEF	<1.000	µg (total)	1	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-03	97555	L004036	FAT	TAT10	6010B Mod	SODIUM, TEFLON	<0.1250	µg (total)	0.125	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-04	97550	L004032	FAT	TAT10	350.1 Mod	NH3+NH4 as N, TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-04	97280	L004038	FAT	TAT10	300.0 Mod	NO3 AS N, TEFLON	<0.2000	µg (total)	0.2	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-04	97556	L004036	FAT	TAT10	6010B Mod	POTASSIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-05	97553	L004036	FAT	TAT10	6010B Mod	CALCIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-05	97359	L004038	FAT	TAT10	300.0 Mod	CHLORIDE,TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-05	97554	L004036	FAT	TAT10	6010B Mod	MAGNESIUM, TEFLON	<0.07500	µg (total)	0.075	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-05	97277	L004038	FAT	TAT10	300.0 Mod	SO4-TEF	<1.000	µg (total)	1	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-06	97556	L004036	FAT	TAT10	6010B Mod	POTASSIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-07	97553	L004036	FAT	TAT10	6010B Mod	CALCIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-07	97359	L004038	FAT	TAT10	300.0 Mod	CHLORIDE,TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-08	97550	L004032	FAT	TAT10	350.1 Mod	NH3+NH4 as N, TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-08	97280	L004038	FAT	TAT10	300.0 Mod	NO3 AS N, TEFLON	<0.2000	µg (total)	0.2	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-08	97556	L004036	FAT	TAT10	6010B Mod	POTASSIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-04	97555	L004036	FAT	TAT10	6010B Mod	SODIUM, TEFLON	<0.1250	µg (total)	0.125	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-05	97550	L004032	FAT	TAT10	350.1 Mod	NH3+NH4 as N, TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-05	97280	L004038	FAT	TAT10	300.0 Mod	NO3 AS N, TEFLON	<0.2000	µg (total)	0.2	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-06	97554	L004036	FAT	TAT10	6010B Mod	MAGNESIUM, TEFLON	<0.07500	µg (total)	0.075	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-06	97277	L004038	FAT	TAT10	300.0 Mod	SO4-TEF	<1.000	µg (total)	1	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-06	97555	L004036	FAT	TAT10	6010B Mod	SODIUM, TEFLON	<0.1250	µg (total)	0.125	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-08	97553	L004036	FAT	TAT10	6010B Mod	CALCIUM, TEFLON	<0.1500	µg (total)	0.15	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-08	97359	L004038	FAT	TAT10	300.0 Mod	CHLORIDE,TEFLON	<0.5000	µg (total)	0.5	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-08	97554	L004036	FAT	TAT10	6010B Mod	MAGNESIUM, TEFLON	<0.07500	µg (total)	0.075	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-08	97277	L004038	FAT	TAT10	300.0 Mod	SO4-TEF	<1.000	µg (total)	1	19-Apr-10	20-Apr-10	Lot# 80317500
1012006-09	97554	L004036	FAT	TAT10	6010B Mod	MAGNESIUM, TEFLON	<0.07500	µg (total)	0.075	19-Apr-10	20-Apr-10	Lot# 80317500

3.2.2 Laboratory Reagents and Gases

Before any standard is purchased from a supplier, purity, traceability, and safety must be considered. The purity of the analyte of interest must be known at least to the accuracy requirements for its measurement. The manufacturer ensures this through certification and traceability statements. All laboratory standards (calibration standards, drift check standards, independent references, etc.) must be traceable to a NIST (or EPA equivalent) source specifying purity on their labels. Other chemicals must have a purity specification on their labels. The safety requirements are checked with the safety data sheets (SDS) supplied by the manufacturer.

The reagents and solvents purchased from a vendor must be provided with traceability and pre-screening data. The laboratory will perform the pre-screening of the reagents and solvents, if not provided by the vendor.

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

3.3 Analytical Methods

The proprietary SOP in the CASTNET Laboratory SOP (Appendix 4) describes the analytical procedures used for CASTNET. Table 3-2 summarizes the analytical methods by sample type for the CASTNET program.

To minimize the occurrence of instrument failure and other system malfunctions, routine maintenance is performed on laboratory instruments, as needed, depending on how often the instrument is used. Analysts are trained in the maintenance and repair of instrumentation. The instrument parts that require frequent replacement are evaluated during analysis and replaced as needed with parts kept in supply for that purpose. Manufacturer service contracts or agreements cover repair of the major instrumentation in the laboratory.

Laboratory operations for CASTNET include seven major tasks:

1. Acquisition and acceptance testing of sample media;
2. Preparation, serialization, and shipment of sample media to the field;
3. Receipt and log in of samples from the field;
4. Unloading and extraction of filters and denuders;
5. Analyses of:
    - Teflon filter extracts and QC samples for SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, Ca^{2+}, Mg^{2+}, Na^+, and K^+;
    - Nylon filter extracts and QC samples for SO_4^{2-} and NO_3^-;
    - Cellulose filter extracts and QC samples for SO_4^{2-};
6. Data validation and storage; and
7. Reports for project management and EPA.

Tasks 1 through 6 are summarized in Figure 3-1 for filter packs.

3.3.1 Method Performance

Method performance data, such as precision and accuracy statistics, are documented in the quarterly and annual reports provided to EPA.

3.3.2 Ion Chromatography (IC)

3.3.2.1 Method Description

An aliquot of a filter extract or an aliquot of a water sample is injected into a stream of carbonate-bicarbonate eluent and passed through a series of ion exchangers. The anions of interest are separated on the basis of their relative affinities for a low capacity and the strongly basic anion exchanger (guard and separator column). The separated anions are directed onto a strongly acidic cation exchanger (suppressor column) where they are converted to their highly conductive acid form, and the carbonate-bicarbonate eluent is converted to a weakly conductive carbonic acid. The now separated anions, each in their acid form, are measured by conductivity. They are identified on the basis of retention time compared to standards. Quantitation is performed by measurement of peak area.

The inorganic anions that are analyzed by this method are Cl^-, NO_3^-, SO_4^{2-}, and nitrate (NO_2^-). Their reporting limits are listed in Table 3-3.

3.3.2.2 Equipment

Laboratory instrumentation and methods are listed in Table 3-2.

3.3.2.3 Instrument Testing, Inspection, and Maintenance

Standard curves are compared between runs for evidence of diminishing sensitivity, resolution, or change in response, which may indicate a need to clean the cell electrode or replace columns. Valves and fittings are examined for leaks prior to each run. Guard columns and the separator column are prone to contamination from substances having a high affinity to column resins, and are cleaned or replaced as needed. The analytical pump is lubricated every 60 to 80 hours. Spare columns, packing materials, and septa are maintained on hand at all times to ensure continuous operation.

3.3.2.4 Instrument Calibration

The IC is calibrated for Cl^-, NO_3^-, NO_2^-, and SO_4^{2-} by referencing the detector response to the concentration of nine standards plus a blank run at the beginning of each sample batch. Startup sequence, instrument variables, working standard preparation, reagent preparation, calculations, and shutdown sequence are described in the CASTNET Laboratory SOP (Appendix 4). The reporting limits for the analytes are presented in Table 3-3.

3.3.2.5 Calculations

Calculations are described in Section 1.5.2, Data Quality Indicators, and Section 4.4.1, Atmospheric Concentrations.

3.3.2.6 Quality Control

Routine QC procedures are implemented for each analytical method to verify the precision and accuracy of each sample run. These QC procedures for IC analyses include the following:

- A calibration curve is generated consisting of a minimum of five standards and one blank that bracket the sample range. The correlation coefficient must be $\geq$ 0.995, and the
- Y-intercept 95 percent confidence limit must be less than the limit of quantitation.
- One method blank consisting of extraction solution without a filter is prepared and analyzed with each batch of filters extracted.
- One mid-level CCV (independent stock) is analyzed every 10 environmental samples. The response must be within 5 percent of the certified target value.
- A reference standard that is NIST-traceable is analyzed at the beginning and end of a run to assess accuracy.
- Approximately 5 percent of samples from each batch are analyzed in duplicate to monitor within-run precision. Samples are selected at random.

- An internal system monitoring spike (rubidium bromide) is used in IC analyses to assess shifts in retention time and sample injection volume.
- All sample responses are within the standard calibration range. Samples with responses above the calibration curve high standard are diluted and reanalyzed.

Tables 3-4 and 3-5 summarize the QC procedures and associated corrective actions.

Laboratory precision is estimated through the analysis of the replicate samples. About five percent of the IC samples from each batch are reanalyzed. Differences between the original and replicate concentrations are calculated. MARPD statistics (Equation 1-1) are calculated quarterly and annually and presented in reports to EPA. In addition, network precision is estimated by analyzing pairs of filter concentrations from the two collocated sampling systems. MARPD statistics are calculated quarterly and annually. The DQI precision goals are summarized in Table 3-3. These goals apply to both the replicate analysis and the analysis of the collocated concentrations.

Laboratory accuracy (Table 3-3) is determined by the analysis of reference samples and CCV. An independent reference standard that is NIST-traceable is analyzed at the beginning and end of an analytical run. One midlevel CCV, which is also produced by an independent laboratory and is NIST-traceable, is analyzed every ten IC samples. The responses relative to the CCV and reference samples must be within 5 percent (the DQI measure) of the certified target values. The responses are plotted and reported quarterly and annually.

3.3.3 Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES)

3.3.3.1 Method Description

This method measures element-emitted light by optical spectrometry. Samples are aspirated through a nebulizer, and the resulting aerosol is transported to the plasma torch. Element-specific atomic-line emission spectra are produced via radio-frequency inductively-coupled plasma. The spectra are dispersed by a grating spectrometer, and the intensities of the lines are measured simultaneously by a segmented-array charge-coupled-device detector (SCD). For this project, this instrument is usually viewed axially, which achieves much lower reporting limits than if it were operated in the traditional mode of being viewed radially.

The cations that are analyzed by this method are Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}. Their reporting limits are listed in Table 3-3.

3.3.3.2 Equipment

Laboratory instrumentation is listed in Table 3-2.

3.3.3.3 Instrument Testing, Inspection, and Maintenance

Maintenance of this instrument is covered by a service contract with the manufacturer. Routine maintenance is performed annually as per contract requirements. Pump tubing is checked daily and replaced as needed. The torch and nebulizer are cleaned every six months or as needed.

3.3.3.4 Instrument Calibration

The procedure for ICP-OES calibration uses three multi-element standards and a blank solution of DI water to determine the concentration-versus-response relationship for the instrument. The calibration correlation coefficient must be 0.995 or better and is verified by analysis of a NIST-traceable reference solution. The elemental concentrations of the samples analyzed must be within the calibration range of the instrument.

3.3.3.5 Calculations

Calculations are described in Section 1.5.2, Data Quality Indicators, and Section 4.4.1, Atmospheric Concentrations.

3.3.3.6 Quality Control

Routine QC procedures are implemented for each analytical method to verify the precision and accuracy of each sample run. These QC procedures for ICP-OES analyses are included in the following list.

- A 4-point calibration curve is generated.
- A NIST-traceable reference standard is analyzed at the beginning and end of a run to assess accuracy.
- One method blank consisting of extraction solution without a filter is prepared and analyzed with each batch of filters extracted. This is called a Teflon method blank (TMB).
- A blank spike (BS) equivalent of a laboratory control sample (LCS) is prepared and analyzed with each batch of filters extracted.
- A CCV is analyzed after every 10 environmental samples and at the end of the run to track instrument drift.
- Replicates of environmental samples are analyzed to assess within-run precision using a relative standard deviation (RSD) criterion.

See Tables 3-4 and 3-5 for a listing of QC procedures and associated corrective actions.

3.3.4 Automated Colorimetry (AC)

3.3.4.1 Method Description

This automated procedure for the determination of ammonia utilizes the Berthelot Reaction in which the formation of a blue-colored compound, believed to be closely related to indophenol, occurs when the solution of an ammonium salt is added to sodium phenoxide, followed by the addition of sodium hypochlorite. A solution of ethylenediaminetetraacetic acid (EDTA) is added to the sample stream to eliminate the precipitation of the hydroxides of calcium and magnesium. Sodium nitroprusside is added to intensify the blue color.

This method is used for analysis of NH_4^+. The reporting limit for NH_4^+ is listed in Table 3-3.

3.3.4.2 Equipment

Laboratory instrumentation is listed in Table 3-2.

3.3.4.3 Instrument Testing, Inspection, and Maintenance

Pump and air valve tubing are changed every two weeks. All other transmission tubing is changed yearly. Pump rollers are cleaned with a soft, clean cloth when the pump tubing is changed. The pump platen is replaced after every 1,000 hours of operation. The colorimeter lamp is replaced yearly. After each run, the system is flushed with DI water.

3.3.4.4 Instrument Calibration

The AutoAnalyzer 3 (AA3) for NH_3 + NH_4^+ as N is initially calibrated by adjusting the instrument response to approximately 95 percent of full scale for the highest calibration standard. After the initial calibration, precise calibration is performed at the beginning of each analytical run based on the response-versus-concentration regression produced from seven calibration standards and one blank. The preparation of calibration standards and description of stock solutions are included in the CASTNET Laboratory SOP GLM3180-004 in Appendix 4. The reporting limit for NH_3 + NH_4^+ as N is presented in Table 3-3.

3.3.4.5 Calculations

Calculations are described in Section 1.5.2, Data Quality Indicators, and Section 4.4.1, Atmospheric Concentrations.

3.3.4.6 Quality Control

Routine QC procedures are implemented for each analytical method to verify the precision and accuracy of each sample run. These QC procedures for AC using the AA3 are described in the following list.

- A calibration curve is generated consisting of a minimum of five standards and one blank, which bracket the sample range. The correlation coefficient must be $\geq$ 0.995, and the Y intercept 95 percent confidence limit must be less than the limit of quantitation.
- One method blank consisting of extraction solution without a filter is prepared and analyzed with each batch of filters extracted.
- A BS equivalent of an LCS is prepared and analyzed with each batch of filters extracted.
- One mid-level CCV (independent stock) is analyzed every 10 environmental samples. The response must be within 10 percent of certified target value.
- A reference standard that is NIST-traceable is analyzed at the beginning and end of a run to assess accuracy.

- Approximately 5 percent of samples from each batch are analyzed in duplicate to monitor within-run precision. Samples are selected at random.
- All sample responses must be within the standard calibration range. Samples with responses above the calibration curve high standard are diluted and reanalyzed.

Tables 3-4 and 3-5 summarize QC procedures and associated corrective actions.

3.4 Quality Control

All laboratory personnel have specific responsibilities and a general requirement to adhere to the QA program. The LOM coordinates closely with the QA Manager to ensure that the QA program is followed.

Amec Foster Wheeler's laboratory uses procedures and methods for analysis of environmental samples that have been approved by EPA. The methodologies used are specified in Table 3-2 and detailed in Appendix 4. The analytical QC checks utilized for all analyses are listed in Table 3-4. All laboratory standards and reference samples are NIST traceable and have certificates of analysis available for review. For IC analyses, internal injection standards are used to assess shifts in retention time and sample injection volume.

If QC results exceed criteria, a laboratory analyst may perform certain corrective actions at the laboratory bench before the data have been submitted for review, as noted in Table 3-4. These corrective actions result from:

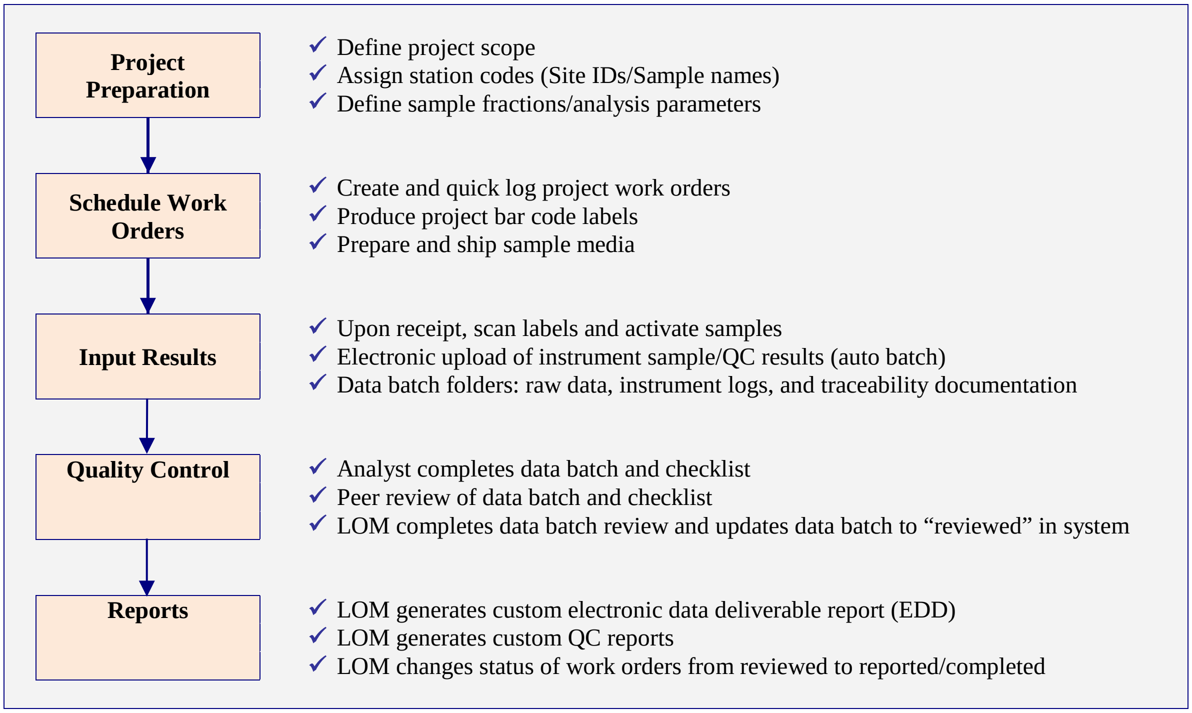
- Identification of analytical QC sample data that do not fall within the acceptance limits specified in the QAPP for project DQI, such as accuracy and precision;
- The analytical data batch that fails to meet the criteria for calibration or QC sample analysis frequency as specified in the QAPP and/or the method SOP.

Element automatically verifies fulfillment of QC requirements for each data batch. During data processing, the analyst and all peer reviewers are notified if any criterion is exceeded via color-coded flagging. The Element criteria tables include analyte-specific requirements for accuracy, precision, and QC sample analysis frequency, and sample holding and reporting times. Laboratory analysts are required to address situations that exceed the limits of acceptability as outlined in this QAPP. The analyst must perform the corrective action procedures listed in Tables 3-4 and 3-5 for QC checks that exceed acceptance criteria.

3.5 Data Processing and Submittal

Amec Foster Wheeler uses automated data acquisition, automated data transfer, and a full-featured, LIMS. Amec Foster Wheeler uses Element DataSystem (Element) to manage, control, and report sample analyses and provide feedback on project performance. The Element program is illustrated in Figure 3-5.

Figure 3-5 Flow Chart of the Element Program



Analytical data are generated using the laboratory instruments listed in Table 3-2. These instruments are operated via PC-based applications. These manufacturer-provided applications have the inherent ability to perform calibration curve statistical analyses, a wide range of QC functions, and formatted data reporting. All data flows from the laboratory instrument to the secure Amec Foster Wheeler internal network. The data are stored on the network and are uploaded using a rewritable disk or flash drive. From the network, the data are uploaded via DataTool into the Element database and then to the DMC.

The data transfer file is saved as a database file, along with its parent chromatogram file, to a server on the Gainesville, FL network for storage, retrieval, and tape backup. The formatted data file is then transferred to Element via a custom data upload program (DataTool) that creates a unique data batch sequence, assigns the appropriate analysis method codes, and populates the data batch with laboratory sample ID sequences.

The final data upload program incorporates several QC elements intended to detect errors prior to data finalization. Once the data are uploaded, the analyst initiates the Element batch finalization procedure. This automated procedure:

- Identifies the QC samples;
- Calculates the precision and accuracy data;
- Determines if the appropriate number of QC samples have been analyzed;

- Cross-references the analyte/method code combination between the data batch and the sample record to ensure the correct data are entered and reports any conflicts; and
- Prints out a copy of all electronic data in a consistent data batch report format.

The data batch report includes the following information:

- Unique data batch sequence
- Project chemist's name
- Detailed QC report
- Final data report

Copies of run log pages, calibration certificates, chromatographs, and the data batch report are included in the data batch to provide documentation of the entire analytical process. The project chemist signs the batch checklist inside the flap of the data folder to affirm the validity of the work and submits the data batch for peer review.

Data batch review is the responsibility of a senior chemist. This review includes the following checks:

- Completeness
- QC acceptance
- Appropriate signatures

Once the reviewer is satisfied with the acceptability of the data batch, he/she affirms this by signature and submits the batch to the LOM. Once the batch is reviewed, the data are locked, and the batch will require written LOM approval for any updates. Any updates performed are documented electronically in Element. The batch history may be reviewed using the Audit Trail feature in Element.

During the data reduction and transfer process, the computer programs contained in Element calculate the following:

- Relative percent differences for replicates
- Spiked recoveries (LCS)
- Reference sample concentrations (percent recoveries)
- Sample concentrations

All concentration data are calculated by instrument software and uploaded via DataTool into Element as final concentrations.

Completed batch folders are stored in a secured central location and arranged numerically by batch number. Printed chromatograms, copies of parameter notebooks, and all other pertinent documentation are stored in the batch folder.

3.6 A2LA Certification

The Amec Foster Wheeler laboratory is certified (April 2013) under the International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025:2005 accreditation by the A2LA for a scope of laboratory and field test methods that includes those utilized for exposed CASTNET filters. The current A2LA certification runs through May 31, 2017. The schedule for recertification is every two years.

Table 3-1 Teflon, Nylon, and Cellulose Filters Acceptance Criteria

Filter Media	**Acceptance Criteria (μg)**							
	SO_4^{2-}	**NO_3^--N**	**NH_4^+-N**	**Cl^-**	**Mg^{2+}**	**Ca^{2+}**	**Na^+**	**K^+**
Teflon	< 1.00	< 0.200	< 0.50	< 0.50	< 0.08	< 0.15	< 0.13	< 0.15
Nylon	< 1.00	< 0.200	N/A	N/A	N/A	N/A	N/A	N/A
Impregnated Cellulose	< 3.83*	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: * Batch is acceptable with one filter > 3.83 μg.

Table 3-2 Summary of Analytical Methods by Sample Type

Operation	Sampling Media	Analytes	Instrumentation	Reference Method
Dry Deposition				
Filter Pack System	Teflon Filter	NO_3^- (as N), SO_4^{2-}, Cl^-	IC Dionex ICS-1600, DX500/600	EPA Modified Method 300.0*
		NH_4^+	Bran+Luebbe AutoAnalyzer 3	EPA Modified Method 350.1
		Ca^{2+}, Mg^{2+}, Na^+, K^+	ICP-OES PE 7300 DV	EPA Modified Method 6010B
	Nylon Filter	NO_3^- (as N), SO_4^{2-}	IC Dionex ICS-1600, DX500/600	EPA Modified Method 300.0
	Cellulose Filter	SO_4^{2-}	IC Dionex ICS-1600, DX500/600	EPA Method 300.0

Note: * Further information on reference methods is provided in Section 6.0 – References.

Table 3-3 Data Quality Indicators for CASTNET Collocated Filter and Laboratory Replicate Measurements[1]

Analyte	Medium	Method	Acceptance Criteria			
			Precision (RPD)[2]	Accuracy (%)	Nominal Reporting Limits[3]	Method Detection Limit
Ammonium (NH_4^+)	F/W	AC	20	90 - 110	0.020 µg-N/mL	0.009 µg-N/mL
Sodium (Na^+)	F/W	ICP-OES	20	95 - 105	0.005 µg/mL	0.002 µg/mL
Potassium (K^+)	F/W	ICP-OES	20	95 - 105	0.006 µg/mL	0.002 µg/mL
Magnesium (Mg^{2+})	F/W	ICP-OES	20	95 - 105	0.003 µg/mL	0.001 µg/mL
Calcium (Ca^{2+})	F/W	ICP-OES	20	95 - 105	0.006 µg/mL	0.002 µg/mL
Chloride (Cl^-)	F/W	IC	20	95 - 105	0.020 µg/mL	0.002 µg/mL
Nitrate (NO_3^-)	F/W	IC	20	95 - 105	0.008 µg-N/mL	0.003 mg-N/L
Sulfate (SO_4^{2-})	F/W	IC	20	95 - 105	0.040 µg/mL	0.015 µg/mL
Nitrite (NO_2^-)	W	IC	20	NA	0.010 µg-N/mL	0.0005 µg-N/mL

Notes: F = filter pack samples
W = wet deposition
RPD = relative percent difference
N = nitrogen
NA = not available

[1] The precision criteria apply to the laboratory analysis of field samples and laboratory replicates.

[2] This column lists the precision goals for both network precision calculated from collocated filter samples and laboratory precision based on replicate samples.

[3] In general, the nominal reporting limits for each chemical measurement method are derived from the expected instrument sensitivity and an initial method confirmation that included adequate observed response from the low standard of the calibration curve. In the case of ICP-OES, instrument sensitivity was verified based on results of method blank and low-level standard analyses per EPA Contract Laboratory Program (CLP) protocols circa the 1988 EPA CLP Statement of Work (1988). More recently, a Method Detection Limit (MDL) study following the guidelines described in 40 CFR Part 136 Appendix B (EPA, 2001a) was performed for ion chromatography, automated colorimetry, and ICP-OES methods that supports the current nominal reporting limits.

Table 3-4 Summary of QC Procedures

Quality Control	Acceptance Criteria	Corrective Action
Calibration curve (minimum 5 points) correlation coefficient	≥ 0.995	Rerun calibration standards. If still out of control, prepare new calibration standards and recalibrate the instrument.
Calibration curve Y-intercept 95% confidence limit	± Reporting limits	Rerun calibration standards. If still out of control, prepare new calibration standards and recalibrate the instrument.
Calibration curve responses	Brackets all samples	Dilute samples to within calibration curve range and reanalyze.
CCV	± 5% of true value for IC and ICP-OES analyses ±10% of true value for AC analyses	Rerun standard. If still out of control, recalibrate the instrument and reanalyze samples run since the last acceptable calibration verification.
Sample replicate	± 20% difference as compared to initial sample run	Determine/correct the cause of the problem and reanalyze samples run since the last acceptable calibration verification.
Method blank	≤ 2x reporting limits	Determine/correct the cause of the problem and reanalyze samples, or flag the data and document why data are acceptable.
Blank spike	± 20%	Determine/correct the cause of the problem and reanalyze samples, or flag the data and document why data are acceptable.
Reference sample	± 5% of true value for IC analyses ± 10% of true value for AC (NH_4^+) and ICP-OES analyses	Rerun sample. If still out of control, terminate analysis and determine the cause of the problem.
Filter blank	≤ 2x reporting limits	Reanalyze. If still out of control, flag the data and document why data are acceptable.

Note: AC = automated colorimetry

Table 3-5 Summary of Possible Laboratory QC Failures (1 of 2)

Instrument	QC Failure	Corrective Action
Laboratory Instrumentation		
IC and AA3	• Not all samples documented in the batch • Analysis holding time not within criteria • Calibration curve correlation coefficient < 0.995 • Calibration curve Y-intercept > curve detection limit • Sample responses greater than highest standard response • Method blank not present • Method blank not within acceptance criteria • Reference standard solution not present • Reference standard solution not within acceptance criteria • Sample replicate not present • Sample replicate not within acceptance criteria • Standard matrix spike solution (CCV) not present • Standard matrix spike solution response not within acceptance criteria • Insufficient number of CCV present • Insufficient number of replicates present	Failure of any item requires the laboratory analyst to provide a written explanation. The LOM will review all documentation and accept or reject the data. If data are rejected, samples are reanalyzed.
ICP-OES	• Not all samples documented in the batch • Analysis holding time not within criteria • Method blank not present • Method blank not within acceptance criteria • Reference standard solution not present • Reference standard solution not within acceptance criteria • Sample replicate not present • Sample replicate not within acceptance criteria • Standard matrix spike solution not present • Standard matrix spike solution response not within acceptance criteria • Insufficient number of CCV present • Insufficient number of replicates present	Failure of any item requires the laboratory analyst to provide a written explanation. The LOM will review all documentation and accept or reject the data. If data are rejected, samples are reanalyzed.

Table 3-5 Summary of Possible Laboratory QC Failures (2 of 2)

Instrument	QC Failure	Corrective Action
Laboratory Documentation		
IC/AA3	Analytical documentation is missing or incomplete	If missing information is electronic, print out again. If missing information is only as hardcopy, then recopy.
	Analytical documentation is incorrect	If information is in electronic format[1], provide explanation and back up signatures. If information is not in electronic format (laboratory notebooks, extraction logs), cross out error with a single line, write correction, initial, and date.
ICP-OES	Analytical documentation is missing or incomplete	If missing information is electronic, print out again. If missing information is only as hardcopy, then recopy.
	Analytical documentation is incorrect	If information is in electronic format[1], provide explanation and back up signatures. If information is not in electronic format (laboratory notebooks, extraction logs), cross out error with a single line, write correction, initial, and date.

Note: [1] See the Laboratory Manager to report a batch update

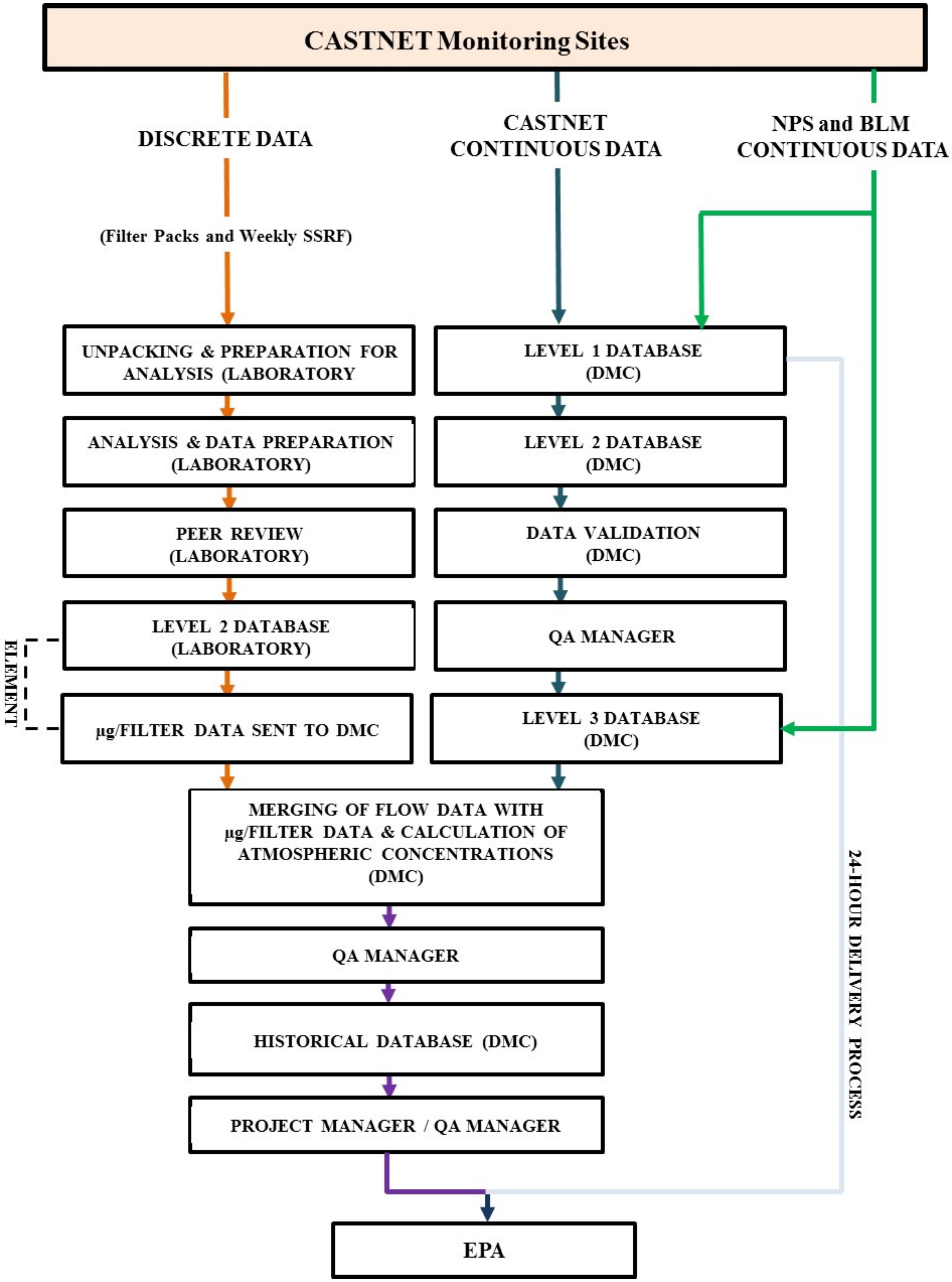
4.0 Data Operations

This section summarizes the overall system used for data management on this project. The Amec Foster Wheeler DMC is the repository for CASTNET data, including raw data that have been collected but not validated, and data that have been accepted using various validation schemes (e.g., Levels 1, 2, and 3). The Amec Foster Wheeler DMC also provides the hardware (Section 4.1), CASTNET Data Management System software (Section 4.2), data security, and the computer programming necessary to manage, maintain, and deliver the CASTNET data. The CASTNET DMC uses a client-server, Microsoft SQL server database management system for processing data. An Oracle 11g database is used for data archival and delivery of data to EPA and AIRNow. The following subsections detail the database management system used for CASTNET including the validation, verification, documentation, and version control procedures used to develop major computer programming code and a discussion of the data security procedures used to provide access and system backup for the CASTNET Database Management System. Descriptions of validation procedures for field and discrete data are provided in Section 4.3.

The flow of data processing is shown in Figure 4-1. Amec Foster Wheeler performs the following data management tasks for Amec Foster Wheeler operated CASTNET sites:

- Organizes and controls data flow from field sites and the respective analytical laboratories to the DMC;
- Inputs and validates data;
- Manages and archives the CASTNET database;
- Analyzes, evaluates, and models the CASTNET data; and
- Regularly submits data to EPA.

Figure 4-1 Flow of Data



4.1 Equipment

4.1.1 Field Data Processing Equipment

Amec Foster Wheeler utilizes an automated DAS for collection of data from the sites. All EPA-sponsored sites, except for CHE185, OK, use a Campbell Scientific CR3000 data logger for onsite data collection. The CHE185, OK site uses an ESC data logger. Measured data are collected hourly to a centralized server and automatically uploaded into the Amec Foster Wheeler database using Campbell's LoggerNet polling software (see Figure 4-2). All but two sites are enabled for IP communication. The other sites, including CHE185, OK, are served by telephone modem. CASTNET IP-enabled sites use a Sierra Wireless AirLink Raven X modem to access the Internet through a cellular service packet-switched data network that provides a public static IP address.

The data logger program, which was developed by Amec Foster Wheeler, allows site operators and site calibrators access to CR3000 data, or CR850 data from small footprint sites. The program acquires data in seven tables and also flags the data according to their status. The data logger employs three levels of security which are password protected.

The data from CHE185, OK are retrieved and processed using a custom version of H2NS DataLink software. DataLink is a communications and data transmittal package that polls the site hourly and incorporates the previous hourly averages into the raw database. Data retrieved through DataLink are entered directly into the MS SQL Server Level 0 database. The data polled by LoggerNet are entered into a separate raw database.

4.1.1.1 Preventative Maintenance Procedures

Each site operator verifies the operation of the DAS during the weekly site visit. The CASTNET data analysts monitor the operation of each DAS during polling of each site. If any problems are noted, the data analysts notify the field operations personnel who initiate a problem ticket. Problems are entered into the Field Problem Tracking System (PTS) database for tracking and resolution. Also, the FOM or field coordinator will work with the site operator via telephone to investigate and correct the problem. Replacement equipment and/or a field technician will be dispatched to correct the problem, if necessary.

4.1.2 Laboratory Data Processing Equipment

Amec Foster Wheeler uses automated data acquisition, automated data transfer, and a full-featured, LIMS. Amec Foster Wheeler uses the Promium Element LIMS (Element) to manage, control, and report sample analyses and provide feedback on lab performance. The Element program is illustrated in Figure 3-5.

Amec Foster Wheeler currently uses three commercial data acquisition/reduction programs. Chromeleon 7.2 software is used to process IC data. Amec Foster Wheeler does all IC data reduction in Element. Amec Foster Wheeler uses Automated Analyzer Control and Evaluation

(AACE) software for the AA3 system for much the same purposes as Chromeleon 7.2, with one difference. The AACE system has no provision for raw (unreduced) data reporting, so only final data are exported. The final data are in a formatted ASCII file that is uploaded into Element. Finally, the PerkinElmer ICP-AES uses the PerkinElmer WINLAB software for instrument operation, data acquisition, data reporting, and other ancillary functions. Again, a formatted ASCII file is created for upload into Element.

4.1.2.1 Preventative Maintenance and Backup Procedures

Potential data losses are controlled by a system backup protocol. The Element data management system is handled using the same server where SQL Server resides. Weekly scheduled backups of the SQL Server and Oracle 11g databases are created for all CASTNET-related data. For information that is updated several times per day, daily incremental backups are also performed. The CASTNET database system is comprised of a physical server that hosts two virtual servers, and is located in the Gainesville, FL office. After the backups are complete, the files created by the database backup process are stored locally on the servers and on three external hard drives used in rotation to permit onsite and offsite backups. Onsite backups are stored in a fire proof safe in a room equipped with an automated fire control system. Gainesville and Jacksonville office servers, used to store project related files, are backed up daily to the cloud, a process that is managed by Amec Foster Wheeler IT staff.

4.1.3 Data Processing Equipment

Amec Foster Wheeler currently uses Microsoft SQL Server and Oracle 11g to manage CASTNET data. Both RDBMS packages run on a dedicated, independent server. A Dell PowerEdge R310 server hosts the Microsoft SQL Server database, the Oracle database, and the web applications.

In addition, Amec Foster Wheeler uses a Dell PowerEdge R320 that is dedicated to supporting Campbell’s LoggerNet polling software. Finally, Amec Foster Wheeler operates separate Microsoft SQL Server and Oracle 11g test servers for use in testing software and database changes.

Each Amec Foster Wheeler office utilizes appropriate Windows-based computer systems. The current standard computer configuration is adequate to support a 64-bit operating system and includes software such as Microsoft Office and antivirus programs for computer security.

4.1.3.1 Preventive Maintenance Procedures

The primary preventive maintenance procedure used in the DMC consists of routinely defragmenting the hard drives used for data storage. This operation ensures that data files are written sequentially on the hard drive, improving access speed.

4.2 Software

4.2.1 Software Requirements

The software currently used to process CASTNET data is MS SQL Server Version 2012, which was installed in October 2014. Oracle 11g software is used for archiving and submitting data. A discussion of the approach used to perform software upgrades is provided in Section 4.2.2.1.

Three major software components are used to either manage CASTNET data or to model deposition using data managed and stored by the CASTNET DMC:

- Database management;
- Client-access; and/or
- Modeling.

4.2.1.1 Database Management Software

The current SQL database management system is comprised of nine databases. These databases are:

1. *castnet* – The *castnet* database contains all of the primary CASTNET data. These include site information, data definitions, dry chemistry data, meteorology data, data codes, and O_3 information.

2. *castnet_application* – The *castnet_application* database includes tables specifically required for the CDMSA. It includes tables that contain color codes for shading data grid cells, create the data grid cell layouts, list sites run using solar power, and provide codes for missing data replacement sources and reasons data were changed during Level 3 validation. The database also includes the equipment inventory table and tables associated with the Field Operations Problem Report.

3. *castnet_datalink* – The *castnet_datalink* database includes tables used by the Datalink polling software for storing raw polled continuous data.

4. *castnet_model* – The *castnet_model** database contains tables that hold hourly, weekly, quarterly, and annual estimates of concentrations, V_d, and fluxes.

5. *castnet_model_arch* – The *castnet_model_arch* database contains the same information as the *castnet_model* database but represents data archived from earlier runs and versions of the MLM model. As a consequence, each table also includes a field that identifies the version of the MLM model used to calculate the concentrations, velocities, and fluxes.

6. *castnet_temp* – The *castnet_temp* database provides a set of staging tables for various raw data sets. Data in these tables are held on a temporary basis until they have been processed into the *castnet_working* database.

7. *castnet_loggernet* – The *castnet_loggernet* database includes tables used by the *LoggerNet* polling software for storing raw polled continuous data.

8. *castnet_working* – The *castnet_working* database is used to perform current validation processes. Once data in the *castnet_working* database have passed all of the validation and QA procedures, they are migrated to the *castnet* database tables for permanent storage.

9. *mountain_cloud* – The *mountain_cloud* database contains all the data from the Mountain Acid Deposition Program.

   * Note: In 2015 Total Deposition (TDEP) approach for modeling dry and wet deposition became the primary EPA tool for estimating deposition.

Instead of databases, Oracle uses schema to store data and other information. The CASTNET Oracle database currently utilizes three schemas:

1. *mactecscratch*–used for the temporary loading of CASTNET data appends, i.e., new records not previously submitted.
2. *mactecupdate*–used for the temporary loading of updates, i.e., records that have been previously submitted and have changed.
3. *castnet*–permanent archive of all the primary data.

4.2.1.2 Client-access software

The DMC also uses custom designed and programmed software to provide client-side access to the database. The custom designed software is programmed using MS Visual Basic Version 6. The software (known as the CDMSA) was designed and programmed to allow various users to access data tables stored in the database management software. The software provides mechanisms for validating laboratory and meteorological data, reporting and logging problems reported by field operations personnel, and maintaining and tracking equipment inventories.

4.2.1.3 Modeling Software

The third software component is the MLM. The MLM calculates V_d and pollutant fluxes using algorithms developed by Meyers, *et al.* (1998) and Finkelstein, *et al.* (2000), coupled with concentration, meteorological, and site parameter data housed in the CASTNET database. The MLM is written in FORTRAN. Amec Foster Wheeler has established “helper” programs to assist in defining data sets and output file locations for the MLM. These “helper” programs are written in MS Visual Basic Version 6, and are primarily designed for ease of use and to avoid working directly in FORTRAN to initiate the model and to build input and output data files. When deposition velocities were unavailable due to data completeness or validity issues, historical deposition velocities [Bowker *et al*. (2011)] were used as substitutes. MLM/Bowker deposition estimates are delivered to EPA annually. A new hybrid approach (EPA, 2015), which incorporates air quality monitoring data with Community Multiscale Air Quality Modeling System (CMAQ) output, is now used for spatial analyses of total deposition.

4.2.2 Testing and Verification

4.2.2.1 Software Upgrades

Software upgrades are put into place to either:

- Improve performance;
- Increase capabilities;
- Correct bugs found in earlier versions; or
- For any combination of the above.

Software updates generally affect any one of four components:

- The operating system;
- The database management software;
- The CDMSA; or
- The MLM.

In general, software upgrades primarily affect the server, although client machines can be affected by upgrades to operating systems or by changes to the CDMSA.

Operating system upgrades are infrequent. Operating system upgrades for client machines happen rarely since the machines are normally replaced before the operating system. In those cases where the operating system is replaced on a client machine, Amec Foster Wheeler's IT staff performs the upgrade. IT staff also routinely perform a backup of the machine to tape prior to making the upgrade. In the case of the server, all information is backed up to tape prior to performing the upgrade.

Database management system upgrades are also infrequent. The procedure used to upgrade the two database management systems is similar to that for the operating system upgrades. Tape backups of the server are made prior to installing the new software.

For the CDMSA, two general approaches are used:

- If the upgrade is to add functionality, test systems are established to operate both the old method and the new method in tandem for a period of time to ensure that the new method (in the application) is performing the same functions as the old system. For example, when switching over to the meteorology data editor component of the CDMSA for Level 3 validation, parallel systems were run. For a period of two months, Amec Foster Wheeler used test tables that mimicked the CASTNET working tables. The data entered using the MS Access based system was compared to the same data entered using the new system. Had differences occurred (there were none), the systems would have been reviewed to ascertain what was causing the variability, and the CDMSA would have been corrected and modified. Additional testing would have been performed before allowing the upgraded CDMSA to be used for CASTNET data.

- If the upgrade to the CDMSA is to improve performance or to make a minor modification to an existing working module, the revised application is tested by the DMC staff against a test database to ensure that the change works correctly and does not cause unanticipated problems. Once this test is passed successfully, the software is put into general use.

Software upgrades to the MLM were instituted when the MLM was updated and improved. At that time, model runs were made using both the old and new versions to ascertain where differences occur and whether the differences were the expected results from the model's revision. If the results were unexpected, Amec Foster Wheeler determined the cause of the discrepancy, made suggestions for improvement, but did not implement the newer version until the discrepancies were fully understood and clarified, or fixed. Once the newer version was in place, the data produced from model runs using the older version were archived in the *castnet_model_arch* database.

4.2.2.2 Computer Programming Code

Computer program code is generated for use in the CDMSA and the MLM. Some minor code "snippets" are used for SQL stored procedures. The sections below discuss program code validation and verification, documentation, and version control.

4.2.2.2.1 Validation and Verification

The CASTNET DMC validation and verification program for computer code is very similar to that used for software upgrades described in Section 4.2.2.1. For computer program code developed to add new functionality to the system, a test system is established using copies of data tables and data sets. The computer code is then tested on this system to ensure that the results achieved are those anticipated. The test data sets are typically subsets of actual CASTNET data. This approach ensures that the normal operating parameters are presented to the system during testing. For calculations and programs that modify data, the results are verified by hand (primarily for calculations) or by visual inspection to ensure that the results are valid.

For program code modification updates to existing procedures, both the old method and the new method are used in tandem for a period of time to ensure that the new code is performing identically to the old system. See the discussion in Section 4.2.2.1.

Program code changes to the MLM were validated using test data subsets. Typically, at least one year of data were utilized in testing program code in the MLM. The program code was verified and validated by performing spot hand calculations and by comparing the test data subset runs to earlier versions known to work correctly. If the results of the comparison were anomalous, Amec Foster Wheeler determined what caused the discrepancy, modified the code, and then re-ran the test data set to determine if the fix corrected the problem. This iterative approach was used until Amec Foster Wheeler was sure that the model program code working correctly.

The minor SQL code "snippets" used in stored procedures are run against a test database to ensure that the correct results are being obtained. DMC personnel inspecting the resultant data typically verify these tests.

4.2.2.2.2 Documentation

Computer program code documentation is an important part of producing a high-quality, replicable product. As a consequence, Amec Foster Wheeler develops documentation for computer programmed systems (such as the CDMSA), as well as extensive comments within the program code itself. Documentation within the program code ensures that future researchers and programmers can understand the code.

Extensive documentation of the CDMSA was created during its initial development. Additional program code continues to be documented as it is developed. Documentation of the CDMSA also includes the database tables. The database tables and the data contained in them are also documented within the SQL Server database, itself. Oracle uses three tables for temporary and permanent data archiving.

Finally, significant program code changes were made to the MLM during 2000, 2001, and 2006. These program code changes were documented both in hard copy and within the code itself (via program code comments).

4.2.3 Version Control

Amec Foster Wheeler's DMC staff has implemented a version control system for all programs developed for CASTNET. The system is based on a decimal system. Major changes to programs result in a change to the number to the left of the decimal place (e.g., a major change would be from version 2.1 to 3.0). Changes that result in added capability or functionality, but do not represent a major program change, result in numeric changes to the right of the decimal place. For example, a change in capability to the CDMSA could result in a change from 3.0 to 3.1. Changes made to correct bugs or other minor glitches without a resulting functionality change (other than correcting the mistake) result in changes to the right of the decimal place either as a second decimal (e.g., a change from 3.0 to 3.01) or at the hundreds decimal place (e.g., version 2.30 to version 2.31).

4.2.4 Security

Data security is implemented using both access control and data backup procedures. The CASTNET DMC approach to these procedures is detailed below.

4.2.4.1 Access Control

Access control to the CASTNET SQL and Oracle databases is implemented in two ways. First, general access control is established across Amec Foster Wheeler's network by the Amec Foster Wheeler IT staff. All Amec Foster Wheeler staff must perform a password-protected log on to obtain access to Amec Foster Wheeler's network resources.

The second access control is established via the database management system. All users of the CDMSA must have a SQL Server account and password to access the system. When those accounts are established, the users are given access only to the tables they need to access. System administrator access to both servers is limited to only the few people who must be able to modify tables and fields.

4.2.4.2 Back-up and Restoration Procedures

Database backup strategy is detailed in the Data Operations SOP (Database Backups) in Appendix 6 of this QAPP. The SOP fully discusses all elements of current database backup procedures including off-site storage of database backup files.

Weekly scheduled backups of the SQL Server and Oracle 11g databases are created for all CASTNET-related data. For information that is updated several times per day, daily incremental backups are also performed. After the backups are complete, the files created by the backup process are archived to external hard drives located in Amec Foster Wheeler's Gainesville, FL office. Three external hard drives per server are used in rotation so that one external hard drive is in use, one is onsite and available, and the third is offsite.

Critical software and electronic documents are backed up to the Gainesville or Jacksonville office servers, which are backed up daily to the cloud in a system managed by Amec Foster Wheeler's IT staff. Should a disaster occur that renders the CASTNET server inoperable, the database management software will be rapidly re-loaded onto another server, and the data restored from the archived backup files. Amec Foster Wheeler estimates that the data management system could be redeployed within 24 hours following a server failure or catastrophic event and, depending on the age of the backups, the database could be fully repaired and in production mode within 24 hours to one week.

Other program-critical software and digital storage is and will continue to be maintained in a similar way. The CDMSA is housed on both the Jacksonville and Gainesville office servers, and the current version is backed up daily to the cloud. Therefore, server failure or a catastrophic event will have minimal effect on the CDMSA. Documents and reports prepared for CASTNET are stored on the Jacksonville or Gainesville Amec Foster Wheeler office server and are subject to the same daily backup procedure. SharePoint, an electronic document management system, is also used to electronically archive these documents (Table 1-8).

4.3 Verification and Validation Methods

The data generated by all CASTNET activities must be as precise, accurate, complete, and usable as possible in order to satisfy the project goals (Sections 1.1 and 1.5). To accomplish CASTNET objectives, Amec Foster Wheeler uses a variety of systems and procedures to collect, process, verify, validate, and archive the data produced by the project. This section describes the criteria employed to evaluate data, electronic and hard copy forms used in support of data review and validation, and steps to verify each level of validation. A principal objective of the DMC is to provide reliable data that meet end-user requirements.

The CASTNET database is maintained by the DMC in the Gainesville, FL office. Data are stored in tables using MS SQL Server Version 2012. An Oracle database is used for data archiving and delivery of data to EPA. As discussed in Section 4.2.4, access to the database is accomplished through a combination of user ID and password protection. The ability to limit user access to designated tables in the CASTNET database allows the DMAIRM to authorize the use of specific functions to each user. This access control is integral to ensuring the integrity of the final data product.

CASTNET data are accepted if they meet the measurement criteria for CASTNET DQI listed in Tables 2-6, 2-12, 3-3, 4-4 and 4-12. CASTNET DQI are discussed in Section 1.5.2. The validation process attempts to recover as much data as possible by including adjustments and/or status flags based on calibration results, audits, and other supporting information.

4.3.1 Field or Continuous Data Validation

EPA discontinued meteorological measurements at all but five EPA-sponsored CASTNET sites by December 31, 2010. As of June 2014, meteorological measurements are collected at four EPA sites: BEL116, MD; BVL130, IL; PAL190, TX; and CHE185, OK. The procedures presented in this section apply to the validation of data at those sites. The procedures also applied to meteorological data collected at all CASTNET sites operating prior to December 31, 2010.

The database of continuous measurements is composed of tables generated at each validation level beginning at Level 0 and ending at Level 3, the final validation level. Polled data (Level 0) are automatically screened (Level 1) and inserted into archive data tables after completion of validation procedures at these and each subsequent level of validation. In addition to electronic and hard copy documentation, this archival process at each stage of validation provides the means to track a data point through the entire process from data collection through Level 3 validation. The steps for validation of continuous measurements are:

- Automated processes insert placeholder records;
- Automated screened data submitted daily to EPA;
- Missing data recovered by repolling CR3000-stored measurements using LoggerNet;
- Screened, but not validated, data archived into a single processing table and all data that can be collected have been collected; and
- Final data based on results from bracketing field calibrations.

Table 4-1 illustrates the sequence of validation steps for the continuous measurements.

Other data tables containing supporting information are maintained through manual entry of field information as documented on SSRF. All data manually entered into the database are validated for accuracy through double entry.

Three options are available to the data analyst for routine corrective actions during Level 2 and 3 validation activities:

1. Corrective actions for both numerical values and data status flags include addressing incorrect numerical values recorded during data logger power failures and entry and verification of missing numerical values and data status flags resulting from problems other than power failures;
2. Automated screening, instrument drift correction, and flow rescaling for numerical values include adjustment of numerical values for flow as a result of review of semiannual calibration data validation; and
3. Corrective actions for data status flags include data revisions if actual site activities are not properly flagged during routine instrument checks, and replacement of the flags with an "I" flag if data are evaluated as invalid or with an "S" flag if data are evaluated as suspect.

4.3.1.1 Level 0 and Level 1 Data Processing

Level 0 procedures for processing the continuous measurements begin with the insertion of blank placeholder records into the appropriate, continuous data-related tables in the CASTNET database at the DMC. Placeholder records are inserted by a standalone Visual Basic application developed by Amec Foster Wheeler. The program inserts a record for every site-hour to ensure that every site has 24 records for each day. When placeholder records are inserted, they are assigned a quality assurance code of "0."

Hourly, the dedicated polling computers call and initiate an automatic polling of the continuous data from each site. The LoggerNet (or DataLink for CHE185, OK) software program inserts polled measurements and associated status flags directly into the SQL database. Data from each polling program are stored in distinct raw table structures but then follow the same data point pathway throughout the remainder of the data processing activities. When polling occurs, database triggers and stored procedures automatically update the placeholder records in the CASTNET database. The source of the data (DataLink or LoggerNet) is transparent to end-users at Amec Foster Wheeler whether they are data reviewers, data validators, field technicians, QA personnel, or management.

In addition to the support of the polling process, several forms of information are acquired and processed by the DMC during Level 0.

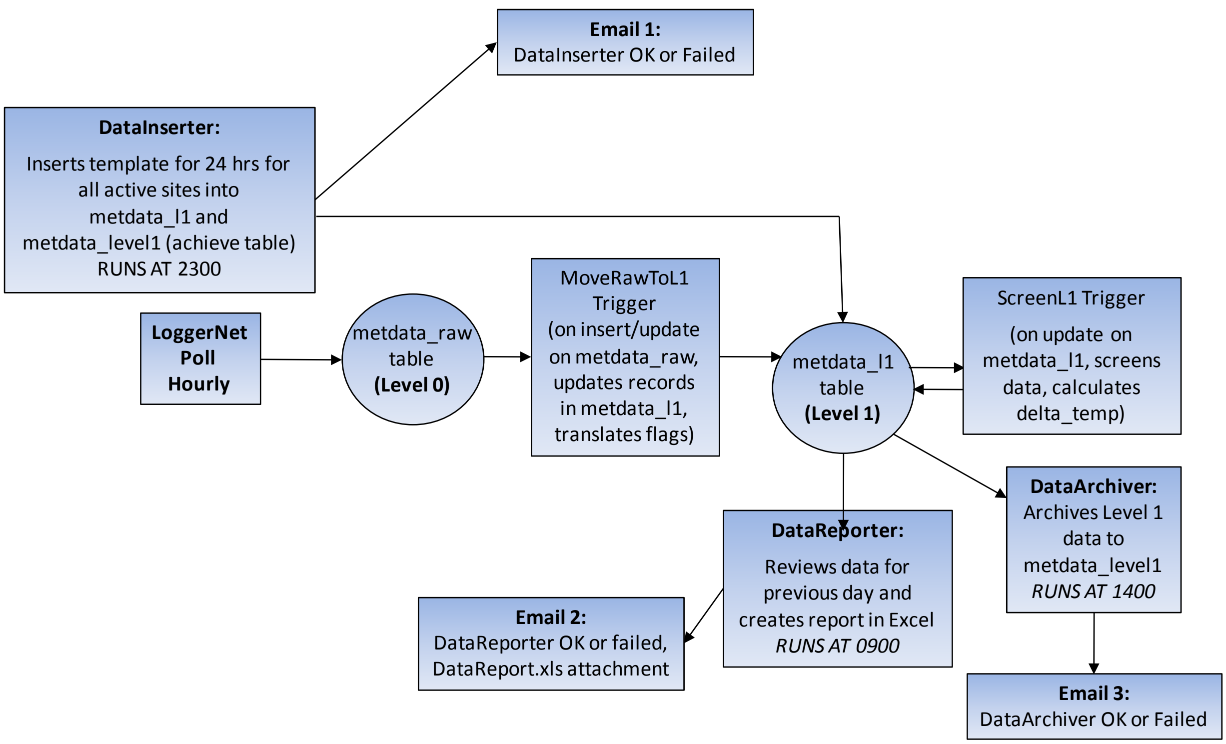
Currently, all site operators send a documentation package monthly to the DMC that contains the following:

- Narrative logs of activities;
- SSRF (yellow copy); and
- Supply requests (also conveyed during Tuesday call-in).

The packages are received at the CASTNET DMC where they are unpacked and the contents are recorded on a hard copy Continuous Data Receipt Log before filing the documentation in designated locations at the DMC. The narrative logs and yellow SSRF will be filed together in the Site History Notebooks as a backup.

After daily polling of all stations, Level 1 validation procedures are initiated. Level 1 validation consists of a set of automated screening protocols (Table 4-2). Table 4-3 displays current outlier criteria used for Level 1 screening. Figure 4-2 illustrates the automated daily screening procedure. The procedure consists of three Visual Basic executables and two database triggers. The triggers initiate the transfer of data between tables, translation of data status flags, and data screening. The executables create the data template, generate reports on the completeness of the data and the results of data screening, and archive the data. The screening program can also be triggered by data analysts making updates to the METDATA_L1 table in the *castnet_working* database using the Level 2 Editor. The screened data will be inserted in the METDATA_L1 table as depicted in Figure 4-2.

Figure 4-2 Automated Daily Screening Procedure



Daily review of polled data by a data analyst also takes place during Level 1 validation. Each morning, a data analyst reviews data for the previous day for all EPA-sponsored CASTNET sites and performs a reasonableness check of the data for all parameters. Figure 4-5 shows a daily review report. Daily review requires the data analyst to be informed of current weather conditions across the country as well as expected differences between sites based on seasonal and regional conditions. The data analyst will note any questionable values and enter all observations per site into the observations table in the PTS. The daily review process is aided by the DataReporter function, which is an automated reasonableness check program very similar to the Met Data Check program used during Level 3 validation. Any site that did not poll or only partially polled is re-polled as part of the daily review functions. In addition, scatter plots of all parameters for each site are reviewed on a monthly basis to look for problems that are not evident from review of only 24 hours of data. An example is wind direction values that do not exceed 270 degrees at a certain site for a period of time. A problem such as this one is easier to identify visually when values are plotted over time versus review of daily values.

One-minute trace gas and O_3 concentration data are used to produce time series for an entire month or any period of interest from minutes to months. Figure 4-3 shows a time series of 1-minute NO_y and NO concentrations for the period 8AM to midnight on 12/23/15. The time series are used in data evaluation and to diagnose any problems, e.g., concentration spikes and presence of moisture. The trace gas plots are used to support opening problem tickets for any instrument failures.

Field personnel use housekeeping data and 1-minute graphs to monitor status of instruments and help investigate QC failures. Housekeeping data are used to evaluate internal components of an instrument when a problem is suspected. Components such as temperature probe, pressure transducers, powers supplies, flow transducers are evaluated to ensure they are within their operational criteria and concentration data are correct. For example, hourly ozone concentrations that read almost zero for several hours combined with low or falling simultaneous flow measurements and high instrument pressure indicate failure of the sample pump.

One-minute data are also used to evaluate patterns or anomalies in a concentration measurement that may get averaged over an hourly measurement period. One-minute data are used most frequently for an investigation of failed ZSP. For example, O_3 ZSP check failed because of a measured high zero. The 1-minute concentration data (Figure 4-4) are then reviewed and graphed. Figure 4-4 reveals a saw tooth pattern with the data range from 0 to 40 ppb, which was averaged to 20 ppb in the hourly data. A graph of hourly data showed a smooth pattern, with no details of the actual 1-minute variability, suggesting interference in the O_3 measurement from (most likely) moisture.

Level 1 data validation also consists of a data analyst reviewing data at the end of a month and retrieving missing data using LoggerNet. Essentially, this step represents a double check of the daily review process. This new protocol for eliminating missing data entry is based on the implementation of the LoggerNet software and development of associated supporting programs.

Monthly, the data analyst responsible for Level 1 validation generates a missing field data report (Figure 4-6). The report, produced for all sites for which continuous data are validated, shows every hour during the month for which there is a missing value for at least one parameter. The data analyst repolls the site data using LoggerNet. In order to successfully update the database, the data analyst must document the reason the data are being updated and the origin of the data used for the update. Changes are recorded, along with the reason and source, in the TRANSACTION_LOG table in the castnet_working database, which then provides electronic documentation for all corrective actions performed during the Level 1 process.

Figure 4-3 Time series of 1-minute NO_y and NO concentrations for PNF126, NC

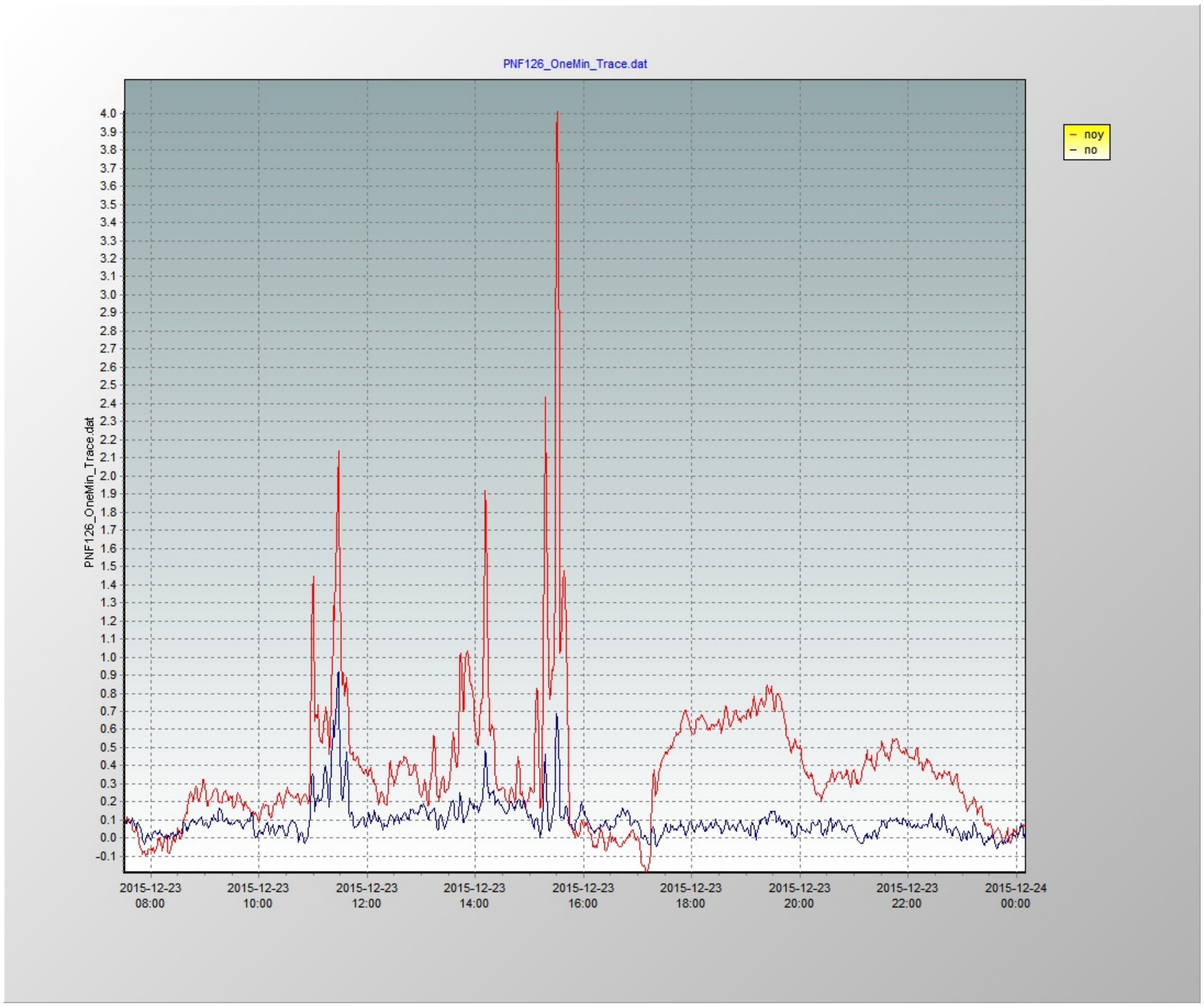


Figure 4-4 Time series of 1-minute O_3 concentrations for ALC188, TX

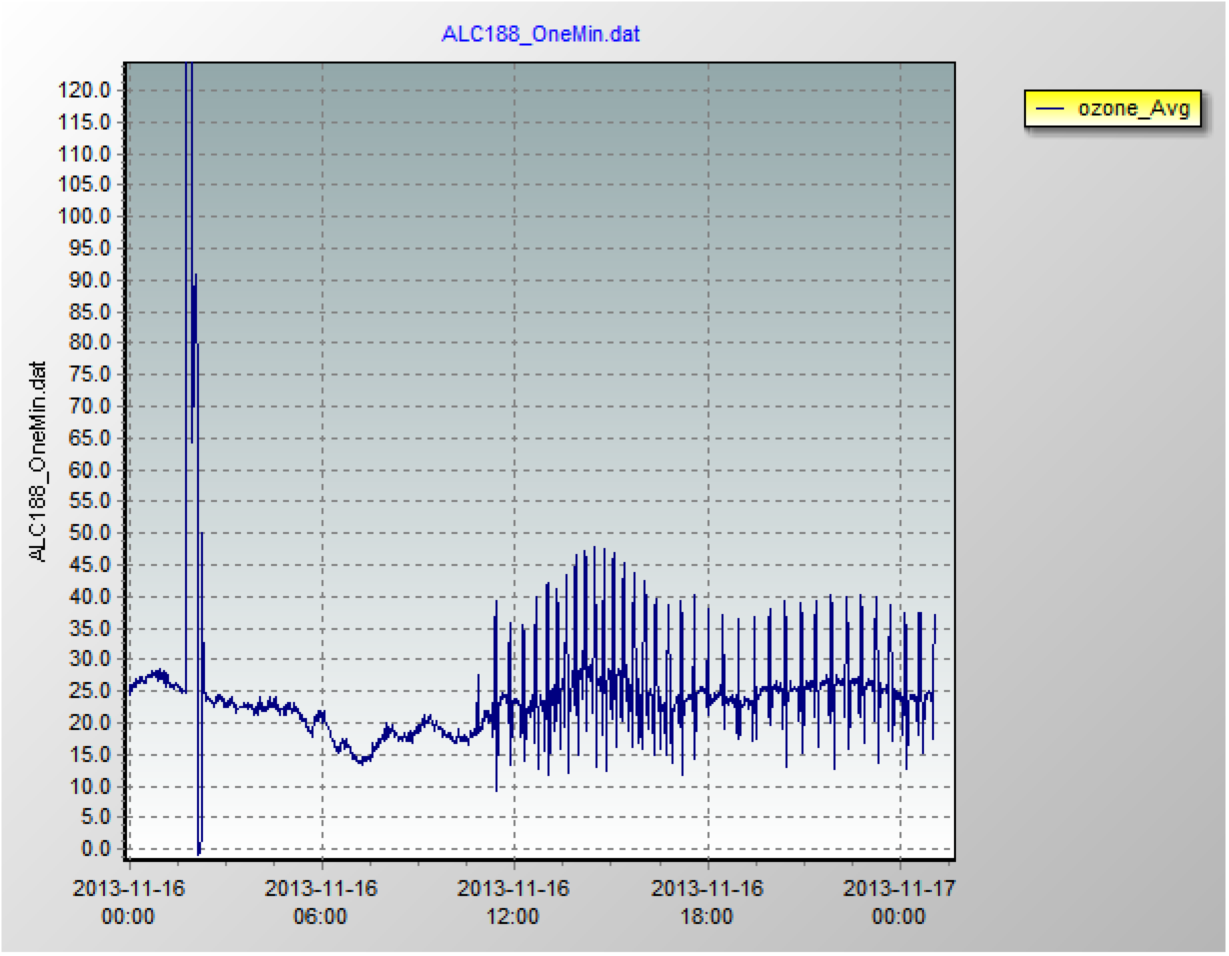


Figure 4-5 Sample Daily Report

Met Data Daily Review Report

Wednesday, October 05, 2011

STATION ID: *PAL190*

Date Time	TEMP (CENT)	DELTA or TEMP2 (CENT)	REL HUMID	SOLAR RADIATION (WATTS/M2)	OZONE (PPB)	PRECIP (MM/HR)	VEC WIND SPEED (METERS/SEC)	VEC WIND DIRECTION	STD DEV DIRECTION (DEGREES)	FLOW (LPM)	SCALAR WIND SPEED (METERS/SEC)	WETNESS	SH TEMP (CENT)
10/1/11 0:00	15.2	0.63	23.9	4	35	0.00	5.2	177	6.9	3.00	5.2	0.00	23.0
10/1/11 1:00	13.4	1.07	28.1	4	29 <	0.00	4.6	195	4.1	3.00	4.7	0.00	22.9
10/1/11 2:00	13.0	0.95	29.5	4	28 <	0.00	4.9	198	4.3	3.00	4.9	0.00	23.0
10/1/11 3:00	13.7	0.60	27.4	4	32	0.00	5.7	194	5.5	3.00	5.7	0.00	22.6
10/1/11 4:00	13.3	0.54	28.4	4	32	0.00	5.0	189	6.2	3.00	5.0	0.00	22.4
10/1/11 5:00	12.3	0.69	31.1	2	29	0.00	3.4	183	8.1	3.00	3.4	0.00	22.2
10/1/11 6:00	11.3	1.27	33.6	6	25	0.00	2.9	175	6.2	3.00	2.9	0.00	21.9
10/1/11 7:00	12.1	0.21	33.0	119	27	0.00	4.6	185	5.9	3.00	4.6	0.00	21.6
10/1/11 8:00	16.0	-0.46	24.9	324	34	0.00	4.9	179	9.3	3.00	5.0	0.00	21.8
10/1/11 9:00	19.3	-0.75	19.4	522	38	0.00	5.7	190	11.3	3.00	5.8	0.00	22.7
10/1/11 10:00	22.2	-0.96	16.0	682	44	0.00	6.7	189	10.8	3.00	6.8	0.00	22.6
10/1/11 11:00	23.8	-1.09	15.9	788	49	0.00	7.2	193	11.4	3.00	7.4	0.00	22.4
10/1/11 12:00	25.2	-1.09	15.3	833	51	0.00	6.8	191	13.8	3.01	7.0	0.00	22.3
10/1/11 13:00	26.5	-1.01	14.6	809	51	0.00	6.1	192	14.6	3.01	6.3	0.00	22.3
10/1/11 14:00	27.3	-0.90	14.4	715	52	0.00	6.1	191	16.2	3.01	6.3	0.00	21.9
10/1/11 15:00	27.9	-0.71	14.1	570	52	0.00	5.7	188	15.9	3.01	5.9	0.00	21.7
10/1/11 16:00	27.8	-0.40	14.1	381	52	0.00	5.7	178	13.7	3.01	5.9	0.00	21.7
10/1/11 17:00	27.1	0.09	14.8	175	52	0.00	5.3	180	10.4	3.01	5.4	0.00	21.5
10/1/11 18:00	25.3	0.62	16.5	18	48	0.00	4.9	177	7.9	3.01	5.0	0.00	21.5
10/1/11 19:00	23.2	0.61	18.6	3	45	0.00	5.8	176	7.3	3.01	5.8	0.00	21.9
10/1/11 20:00	21.6	0.52	20.4	3	39	0.00	6.3	176	8.5	3.01	6.4	0.00	21.9
10/1/11 21:00	20.0	0.43	22.3	4	38	0.00	6.6	175	8.0	3.01	6.6	0.00	22.3
10/1/11 22:00	17.7	0.49	25.6	5	32	0.00	4.7	170	9.3	3.01	4.8	0.00	22.2
10/1/11 23:00	16.2	0.59	28.1	4	31	0.00	3.5	165	9.9	3.01	3.6	0.00	22.7
AVG.	19.6	0.08	22.1	249	39	0.00	5.3	183	9.4	3.00	5.4	0.00	22.2
MIN.	11.3	-1.09	14.1	2	25	0.00	2.9	165	4.1	3.00	2.9	0.00	21.5
MAX.	27.9	1.27	33.6	833	52	0.00	7.2	198	16.2	3.01	7.4	0.00	23.0
TOTAL	471.2	1.95	530.0	5981	946	0.00	128.2	4402	225.5	72.10	130.5	0.00	532.7

4.3.1.1.1 Standard Data Changes

The routine changes performed by the Level 1 automated screening program to correct values either above or below the full scale of instrument response or to standardize delta temperature data are shown in Tables 4-2 and 4-3 and are described in the following subsections.

4.3.1.1.2 Rescale Delta Temperature

For sites using RM Young equipment, the data for delta temperature are calculated by subtracting the temperature value measured at 2 m from the temperature value measured at 9 m. This is consistent with standard meteorological convention. At sites with Climatronics instrumentation installed, delta temperature is calculated in reverse. As a result, the sign of all Climatronics delta temperature sensors is reversed when compared to similar data from a RM Young sensor. Therefore, delta temperature values for Climatronics sites are multiplied by -1.00 by the auto adjust feature. For this specific standard data change, electronic transactions are not recorded in the TRANSACTION_LOG table in the *castnet_working* database because the correction is based on the instrumentation setup of the site and therefore applies to all records.

4.3.1.1.3 Zero Solar Radiation

Nocturnal solar radiation readings below zero occasionally occur due to zero drift in the sensor. Nighttime values between -1 and -14 are converted to zero, while values lower than -14 W/m^2 are flagged invalid.

4.3.1.1.4 Set Maximum Relative Humidity

Relative humidity values between 100.0 and 109.0 are replaced with 100.0.

4.3.1.1.5 Set Maximum Wetness

The wetness sensor has a full-scale output of 1.024 V, which corresponds to a full-scale reading of 1.024 instead of 1.00. This voltage output occurs when the sensor indicates moisture for an entire hour. Wetness values between 1.00 and 1.024 are replaced with 1.00.

4.3.2 Site Operator Actions

All site operators send documentation to the DMC. Weekly, after the sample custodian has logged in the filter packs, the laboratory sends the original white SSRF forms that accompanied the filter packs to a CASTNET DMC data analyst. Upon receipt of the package, the data analyst checks each SSRF for valid elapsed times and corrects any errors or omissions by the site operator. Using the CDMSA, the data analyst then enters the data from the original SSRF into the *FILTER_PACK* table in the *castnet* database and files the original in the SSRF Notebooks at the DMC. All data manually entered into the database are validated for accuracy through double entry.

Figure 4-6 Sample Missing Field Data Report

Level 1 Flag Report

DRY DEPOSITION NETWORK

Wednesday, October 05, 2011

STATION ID: ***BVL130***

Date Time	01 PRECIP (MM/HR)	02 VEC WIND DIRECTION	03 VEC WIND SPEED (METERS/SEC)	04 TEMP (CENT)	05 DELTA or TEMP2 (CENT)	06 REL HUMID	07 OZONE (PPB)	08 STD DEV DIRECTION (DEGREES)	09 SOLAR RADIATION (WATTS/M2)	10 FLOW (LPM)	11 SCALAR WIND SPEED (METERS/SEC)	12 WETNESS
9/6/11 15:00	M	M	M	M	M	M	M	M	M	M	M	M

Monthly, the DMAIRM or designee generates a report of missing or problem data within the *FILTER_PACK* table. The analysis of the *FILTER_PACK* table is run within the CDMSA and provides the following:

- Records that have the on date and time for a sample falling before the off date and time for the previous sample;
- Records with an excessively long duration between the on date and time for a sample and the off date and time for the previous sample;
- Records without associated total microgram records from the laboratory; and
- Records of total microgram from the laboratory without associated *FILTER_PACK* records.

The report is sent to the QA Manager, LOM, and/or DMC data analyst as appropriate. Problems are researched by checking the SSRF in question, verifying the presence or absence of any potentially missing data, and communicating results of the investigation to the previously mentioned personnel. Once the problem is identified, the database is corrected either by updating the on date and/or off date on and/or date off records, inserting SSRF data, or inserting laboratory data.

In addition to the electronic documentation, all changes to the CASTNET database during Level 2 and Level 3 procedures are recorded on hard copy forms using a combination of continuous data review form (CDRF) (Figure 4-7) and/or continuous data validation summary (CDVS) (Figure 4-8) forms.

4.3.3 Level 2 Data Processing

The purpose of Level 2 validation is archiving the completed (but not validated) database. Level 2 archives all collected data into a single processing table. At this point, all data that can be collected have been collected. Previously, Level 2 included assembling all missing data that were subsequently available. Now, the collection of missing data is completed during Level 1.

4.3.4 Level 3 Data Processing

Level 3 validation consists of adjusting or flagging data after review of all field documentation (Section 4.3.4.3), including results from semiannual calibrations. All changes to the CASTNET database during Level 3 are reviewed using forms designed to assist the data analyst. The forms include a data review form (CDRF) (Figure 4-7) and/or a continuous data validation summary (CDVS) (Figure 4-8) form.

Figure 4-7 Sample Continuous Data Review Form (CDRF)

CASTNET
Continuous Data Review Form

Site Name: BEL116 Period Reviewed: 08/11/14 – 02/24/15

Parameter	Date	Time	Action Performed	Reason
Flow	08/17/14	19:00	} I	Possible PF
↓	08/18/14	10:00		
Flow	08/20/14	19:00	} I	— " —
↓	08/21/14	09:00		
Flow	08/29/14	07:00-12:00	I	— " —
ΔT	11/12/14	12-13	I	Suspect
Wetness	01/29/15	16:00	I	Sensor not responding
— " —	02/14/15	18:00	I	— " —

Reviewed by: A. Karmazyn Date: 03/25/15

Approved by: MJ Date: 9/2/15

Figure 4-8 Sample Continuous Data Validation Summary (CDVS) Form

CASTNET
Continuous Data Validation Summary

Site ID: BEL 116	Period Reviewed: 08/11/14 – 02/24/15

Calibration Information:

Calibration Date: 02/24/15	Pass? Yes X No ___

Failed Parameter	Transfer	Site	S	I	A	Factor	Date (from/to)
							__/__/__ to __/__/__
							__/__/__ to __/__/__
							__/__/__ to __/__/__
							__/__/__ to __/__/__

Comments:

MS 4/2/15

Audit Information:

Audit Date: __/__/__	Did All Parameters Pass? Yes ___ No ___

Failed Parameter	Transfer	Site	S	I	A	Factor	Date (from/to)
							__/__/__ to __/__/__
							__/__/__ to __/__/__

Comments:

Reviewed by: A. Karmazyn Date: 03/25/15

Approved by: MS Date: 4/2/15

In general, the Level 3 validation procedure is an investigative process. For each site, the following information will be assembled for review:

- Six-month data packet including daily reports, CDRF, and CDVS data forms;
- Site history notebook containing field data forms such as the SSRF and narrative logs;

- Electronic calibration forms containing all calibration results;
- Field Operations PTS reports; and
- Electronic site call-in log records.

This site documentation is used to determine validation actions. Calibration and audit results are important sources of information about the accuracy of data. Calibration results are checked for all parameters using the criteria shown in Table 2-7. If precalibration results fail acceptance criteria, the data corresponding to the failing parameter are flagged as suspect or invalid from the date of calibration back to the previous passing calibration or successful audit date. In the case of catastrophic sensor failure, data are flagged from the date and time of the sensor failure through the repair date. Currently, only flow rate data are adjusted.

Once the site documentation is reviewed, Level 3 data validation begins. Attainment of this validation level is achieved by:

- Establishing and performing necessary corrective actions to the data affected by defined and documented deviations from the acceptable ranges of all sampling equipment;
- Reviewing all available documentation pertaining to the validation time period to establish validity of collected data;
- Generating and reviewing: outlier reports, all hourly O_3 concentrations with >25 ppb difference between two consecutive hours, statistical summaries generated for all parameters, counts of data status flags, and total number of records;
- Documenting performance of all actions that result in changes to data points, data status flags, or both; and
- Archiving hard copy documentation in the appropriate location and inserting final Level 3 continuous data into the METDATA table in the *castnet* database.

For the data to be considered valid, each sensor must pass semiannual calibrations that effectively bracket the period in question. While validating data, the data analyst will review the data for discrepancies and inconsistencies but will only invalidate data if one or more of the following occur:

- Failure of a semiannual calibration;
- Failure of O_3 data to meet critical criteria (Table 4-12, Ozone Validation Template);
- Apparent equipment malfunction;
- Apparent DAS malfunction; and/or
- Apparent corruption of data during performance check by site operator, calibrator, or auditor.

Descriptions of each continuous parameter and the criteria used to adjust or invalidate the data are presented in the following subsections. Table 4-4 lists the current validation criteria and the type of adjustment by parameter (flow only), and Table 2-6 lists the DQI and associated measurement criteria for the continuous measurements. When precalibration results are outside of measurement criteria but within two times the criteria, affected data may be flagged as suspect for all parameters except flow. Flow data are adjusted within this range. Adjustments to ozone values are not permitted. Data associated with precalibration results outside of the two times criteria range are flagged as invalid.

Independent or external audit results may also be evaluated during Level 3 validation in order to assist with validation decisions. Audit results may be used to help determine the time frame for data flagging or adjustments. Audit results may also be used to determine if data require flagging; however, audit results are never used to quantify adjustments. In practice, audit results are confirmed by reviewing the Field Problem Report for documentation of audit findings or responses. If audit results are confirmed in the Field Problem Report, the corrective actions are taken as necessary.

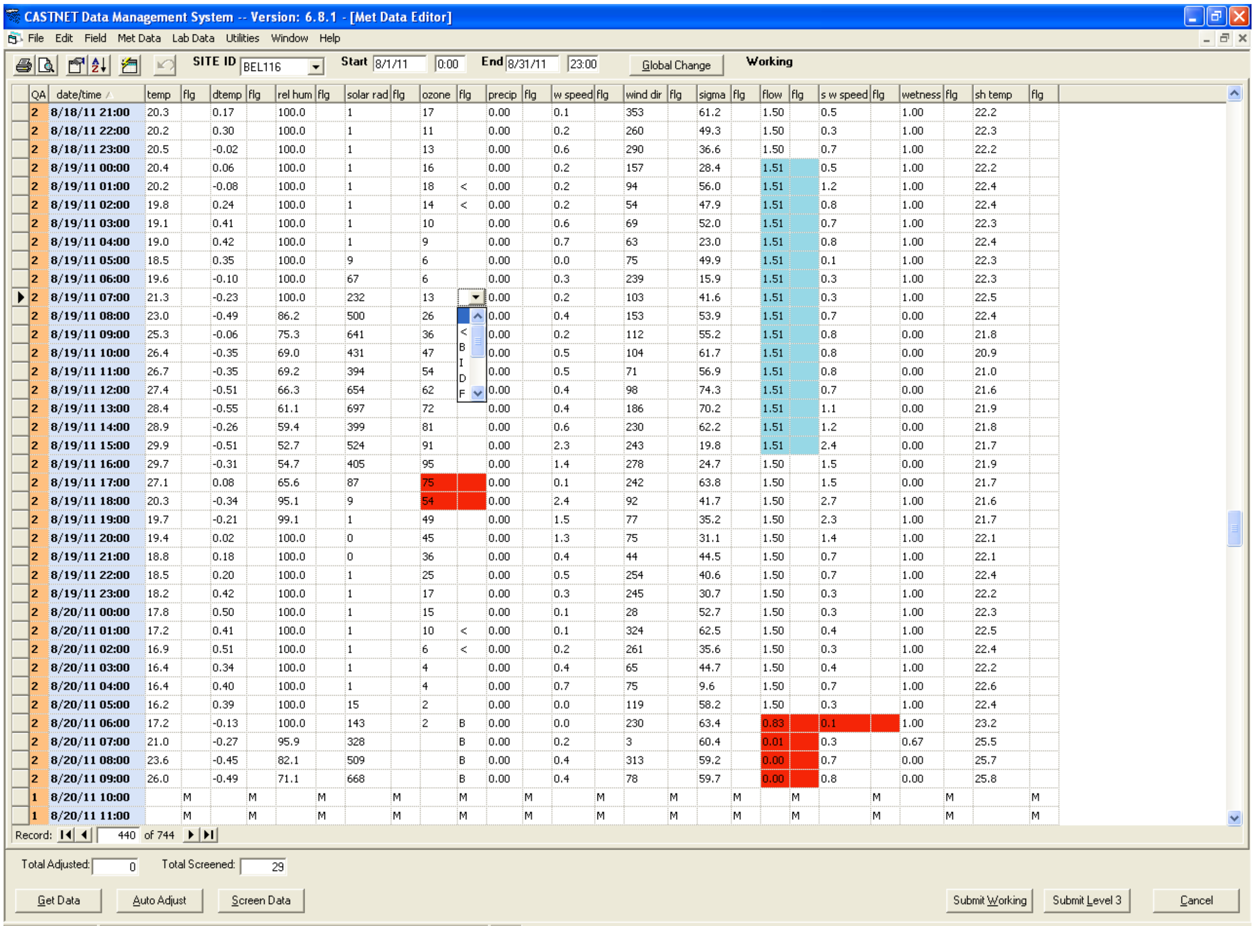
Level 3 validation for the trace-level gas measurements (Appendix 11) is similar to the process for the standard CASTNET measurements. Automated z/s/p checks are performed every two days. Data will be invalidated if the zero and span checks fall outside established criteria. Data are considered invalid back to the previously acceptable z/s/p check. At least one valid z/s/p check is required every two weeks. The trace gas data will be invalidated if the semiannual unadjusted calibration results fail acceptance criteria. Data will be flagged as invalid back to the last acceptable z/s/p check. The data will be invalidated if the analyzer had obviously malfunctioned. In this case, the data will be invalidated from the time of instrument repair back to the last acceptable QC check.

All changes to continuous data completed during the Level 3 validation process are made by utilizing the Metdata Editor (Figure 4-9) program within the CDMSA. Metdata Editor offers Level 3 data analysts an interface to directly access the *METDATA_L2* table in the *castnet_working* database. As data are processed within the Metdata Editor and changes are submitted, processed data are updated in the METDATA_L2 table in the *castnet_working* database. To accompany the data updates, all transaction are documented using two methods:

- Hard copy – either the CDRF or the CDVS is utilized; and/or
- Electronic – a record describing each change including original value, new value, original status flag, new status flag, reason for change and editor responsible for change is inserted into the *TRANSACTION_LOG* table in the *castnet_working* database.

Monthly, continuous data for all NPS/BLM sites are delivered via e-mail by ARS. Data are considered final, or validated at Level 3, upon receipt. Amec Foster Wheeler performs no additional corrective actions associated with the validation of these data. See Section 4.3.7.3 for an explanation of the verification process used to screen data submitted by ARS. Annually, ARS sends updates to the continuous data for NPS/BLM sites that undergo further validation based on calibration results and/or additional QC actions.

Figure 4-9 Metdata Editor Interface



4.3.4.1 Data Continuity and Reasonableness Checks

4.3.4.1.1 Ozone

Measurement Criteria: ±2 percent of full scale of best fit straight line.

Unadjusted manual checks of the O_3 analyzer versus transfer response consist of O_3 concentrations measured at approximately: 0, 40, 60, 90, 150, and 225 ppb. In addition, the analyzer performs daily automatic checks of 0 ppb level for zero check, 60 ppb level for precision check, and 225 ppb level for span check. The O_3 calibration results are recorded on an electronic Ozone Calibration Form (Figure 2-13). The daily z/s/p checks (Figure 2-15) are recorded by the data logger and are acquired by the DMC during hourly polls.

O_3 values should change gradually from one hour to the next. Any significant hourly changes (25 ppb or more) in O_3 are scrutinized. Large upward changes in concentration (spikes) are usually caused by the O_3 analyzer performing a self-calibration after a power failure. If a power failure occurs shortly before the O_3 “spike” (indicated on the daily review form by “<” or “F”), then the high reading is invalidated. All values with a status of “C” (internal zero and span) are also invalidated. Section 4.3.6 describes uses and meanings of data status flags.

A validation template for criteria pollutants, including O_3, was developed by EPA and described in the EPA Quality Assurance Handbook, volume II, Appendix D (2013). In this template, criteria are categorized as critical, operational, or systematic. These categories are defined as follows:

- Critical - the data for which one or more of these criteria are not met is invalid until proven otherwise.
- Operational - the data for which one or more of these criteria are not met is suspect unless other quality control information demonstrates otherwise.
- Systematic - those criteria which are important for the correct interpretation of the data but do not usually impact its validity.

The validation template for O_3 including additional specific response actions for CASTNET operations is shown in Table 4-12.

Annual review screening will be conducted for each site once all ozone concentrations for the year (e.g., Figure 4-10) are finalized. Screening will be done in conjunction with data reduction performed for the annual report so that problems detected will be corrected prior to publication of the report.

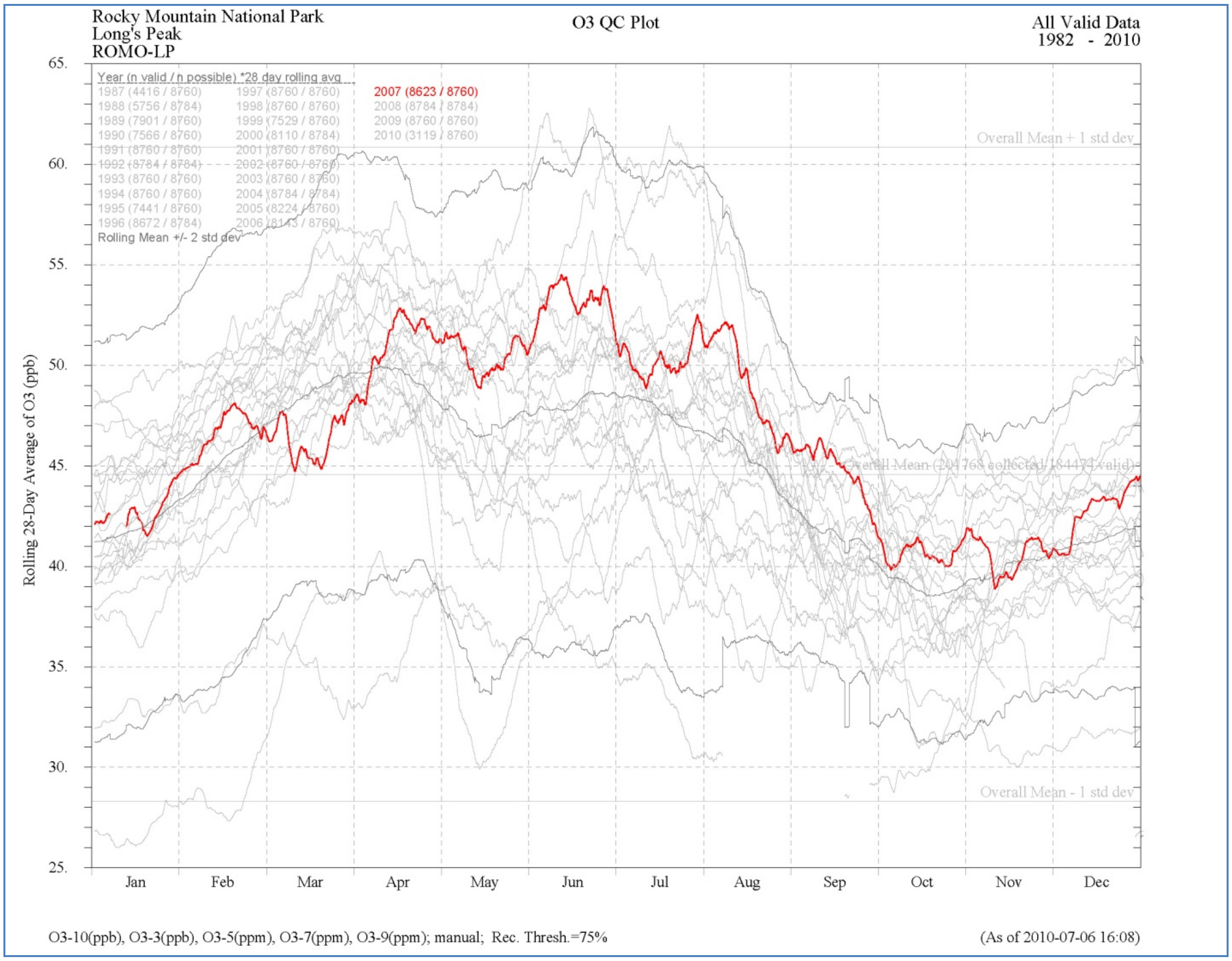
This screening will utilize site-by-site graphical review of hourly ozone concentrations for the entire year. Concentrations will be compared with historical values and with statistical computations such as the rolling mean and the rolling mean ± 2 standard deviations or rolling 10^{th} and 90^{th} percentiles may be used. In addition to the rolling statistics, overall mean and ± 1 standard deviation values (or 10^{th} and 90^{th} percentiles) will be utilized.

Values outside of these statistical ranges will be subjected to additional review along with step functions in concentration values. Additional review will include an analysis of

- Synoptic meteorological conditions (if available):
- Site visit log; and
- Data from nearby sites (including SLAMS sites, where applicable)

Data found to be unreasonable based on these comparisons will be invalidated following approval by the QAM. Invalidation will be documented using current procedures noting the specific statistical tool used to identify the problem (e.g., greater than the rolling mean + 2 standard deviations) and relevant comments from additional review (e.g., values unreasonable per comparison with nearby site).

Figure 4-10 Example of Annual Data Plot (for site-year ROM406-2007)



4.3.4.1.2 Flow

Measurement Criterion: ±5 percent of expected Lpm flow.

Adjustment Method: Percent value.

The calibration procedure for flow incorporates three main checkpoints:

- Pump off - zero value;
- Existing flow at standard temperature and pressure (STP); and
- Leak check.

These check points provide useful information for determining possible starting points for adjustments or invalidation. Adjustments are usually applied to data from the date of the failed calibration. Supporting documentation is used as a reference to determine at what point in the past to start applying the adjustment. When this point has been determined, the data are then scaled either by a step progression or by a flat value depending on the nature of the failure.

4.3.4.1.2.1 Pump Off-Zero Adjustment:

The pump off - zero value determines the zero drift of the system when no flow is running through the system. The amount of drift can be used to calculate and adjust the flow rate accordingly.

4.3.4.1.2.2 Existing Flow Rate at STP:

After a calibration check has been performed on the existing flow rate at STP, the final data logger voltage output is converted through the appropriate full scale and zero of the system to engineering units of Lpm. This value is then used to calculate a percent difference from the transfer flow STP value at the same flow rate. This percent difference is used as a guide for possible adjustment or, if necessary, invalidation of the data.

4.3.4.1.2.3 Leak Checks:

Leak checks determine if there is a physical break in the system. If a leak is detected during a calibration or noted by a site operator on the weekly SSRF, the data must be treated accordingly. Data affected by small leaks (0.0 to 0.1 Lpm) are left as valid until concentration calculations are finished in order to determine if there was any measurable influence on the data. Data affected by large leaks (> 0.1 Lpm) are invalidated.

4.3.4.1.2.4 Flow Data Validation:

The data analyst looks for events that interrupt flow data. If the channel is not downed during change-out of the filter pack, an abnormal value is averaged into that hour's data, resulting in an invalid hourly average. If the hourly average is less than 70 percent of the expected value (1.50 Lpm for eastern sites, 3.00 Lpm for western sites) during the time of a site operator visit, this datum is invalidated. Occasionally, the site operator forgets to turn the vacuum pump back on after a Tuesday check, resulting in a flow rate that is steady but low (near the zero offset). In this event, it is necessary to verify that the filter pack was on the tower during this time, change the flow to 0.00 Lpm (passive flow), and flag the data as null. This allows the CASTNET laboratory to analyze the filter pack for passive flow. If the filter pack was not on the tower and the pump was disconnected, the data for that time period are flagged invalid. Flow rates that are low but accurate and have confirmation that the filter pack was installed are left as valid.

The flow data may have been polled with the wrong full-scale and zero offset due to a lag between calibration and entry of the corresponding change into LoggerNet or DataLink. This is especially noticeable when a flow rate suddenly changes to a higher or lower value for a period of hours or even days after a calibration event. To correct the problem, the correct full scale and zero are determined, and the values in the database are adjusted accordingly. The following equations illustrate the relationship between full scale and zero offset values and the data values:

Flow = (voltage x full-scale range) + zero offset Eq. 4-2

Full scale range = full scale - zero offset

The type of problem detected is the key factor in deciding whether or not flow is invalid. Problems that entail a total loss of flow through the filter (i.e., the filter was not properly secured to the quick disconnect fitting at the inlet) will result in invalidation. Problems that impede flow to the filter (i.e., kinked tubing or moisture in the flow lines) may not cause an invalidation of the flow. Questionable flow rates may be used to calculate concentration as a means of determining if flow should be invalidated. SSRF documentation of leak checks and site operator comments in the narrative site log are useful guides in determining the starting point for the invalidation.

4.3.4.1.3 Temperature/ Shelter Temperature

Measurement Criteria: ± 0.5°C as an average error of three readings taken at Low (~0.0°C), Middle (~24.0°C), and High (~40.0°C) range.

The normal temperature range is -20°C to 40°C. An hourly average usually does not change more than 4°C per hour. If these extreme values or rate of change are exceeded, the calibration summaries, SSRF, narrative logs, daily reviews, and site histories are reviewed to determine if there is a problem and if data must be invalidated.

If the shelter temperature differs from the test temperature by more than ±2°C, then shelter temperature data are flagged as invalid for exceeding 2°C.

4.3.4.1.4 Delta Temperature

Measurement Criteria: ± 0.5°C as an average error of three readings taken at: Low (~0.0°C), Middle (~24.0°C), and High (~40.0°C) range.

Normal delta temperature is defined as the difference in temperature between the 9 m (T1) and the 2 m (T2) sensors. The normal delta temperature range is -3°C to 3°C. The sign pattern for delta temperature values in a 24-hour period should generally be positive at nighttime and negative during the daytime hours. Values should approach 0°C under high wind conditions or during significant rainfall events.

4.3.4.1.5 Relative Humidity

Measurement Criterion: ± 10.0 percent of full scale.

All relative humidity values should fall between 0 and 100 percent. The data >100 and ≤ 102.5 percent are corrected to 100 percent. Extremely low values (e.g., < 20 percent for eastern sites and < 10 percent for western sites) or negative values could indicate a failure of the sensor or the data logger. Based on information in the calibration summaries, site histories, and narrative logs, the data analyst ascertains the reasonableness of the data and decides if the data should be invalidated.

4.3.4.1.6 Precipitation

Measurement Criteria: ±10 percent of 50.0 tips or 0.50 V DAS output.

An unadjusted check of tipping bucket response is conducted during semiannual calibrations by comparing an input of a known volume of water with the number of tips recorded as an output by the tipping bucket's measuring device. Usually 231.5 mL (0.50 inch) of water is used, which should produce an output of 50 tips, corresponding to 0.50 V recorded by the data logger.

Weekly checks of tipping bucket responses are performed by the site operator and recorded on the SSRF. Typically 2.54 mm (0.10 inch) of water is used to be recorded as 10 tips. Occasionally, the operator will forget to down the channel when the tip check is performed, and the data will show a precipitation event of 2.54 mm of rain. When corresponding to a site visit with no evidence of precipitation, these events are flagged as invalid. Weekly site operator check results are used to determine a time frame for a drift in sensor response.

Snowfall during the winter is not recorded with the same accuracy as rainfall is during the summer. This is due to limitations of the tipping bucket during cold weather. Occasionally, the tipping bucket indicates no precipitation during the actual snow event, but records precipitation after a slight warming trend or after the tipping bucket heater has melted the snow. The heater should melt the snow as it is falling. If snow is recorded at the wrong time, the data are invalidated.

4.3.4.1.7 Wind Direction and Wind Speed

Measurement Criterion: – Wind Direction: ± 5.0° difference from actual angle as determined by a compass.

The wind direction sensor response is checked at four directions: north, east, south, and west. All four unadjusted readings are listed on the calibration form. Data are flagged as suspect or invalidated if any of the four readings exceed criteria.

Measurement Criteria: – Wind Speed: ± 0.5 m/sec for values < 5.0 m/sec, ± 5.0 percent difference between readings recorded by transfer and unadjusted readings of a sensor for values ≥ 5.0 m/sec.

CASTNET sensors collect wind direction and wind speed as two separate measurements that are used by the data logger to create hourly averages for vector wind speed, scalar wind speed, vector wind direction, and sigma theta. Only the wind speed sensor measures the scalar wind speed data; and only the wind direction sensor affects the sigma theta data. Vector values are a function of both speed and direction. If a sensor failure occurs, more than one channel of data may need to be invalidated. If any channels are invalidated, the calibration data are checked for the corresponding sensor to determine why the data are invalid. Corresponding channels (i.e., wind speed, wind direction) are then invalidated.

A linear error in wind direction response does not have an effect on sigma theta values. A nonlinear error of wind direction response results in erroneous sigma theta values.

Scalar wind speed should exhibit slightly higher values than vector wind speed. If scalar wind speed is lower than vector, calibration forms are checked to determine if the values are valid. If the sensor is working and there is no reason to invalidate data, very low or negative scalar wind speed values are flagged "alarm low."

The site operator occasionally neglected to down the wind system channels when performing an electronic zero and span check on a Climatronics system. This omission was detected by the presence of a spike in the sigma theta parameter, status flags on other channels around the same time, and a documented operator check on the SSRF or narrative log. The affected data are invalidated.

Invalidation Protocols:

- Wind direction error is nonlinear. Three parameters, vector wind direction, vector wind speed, and sigma theta, are invalidated (Table 4-5);
- Wind direction error is linear. Sigma theta is reported, and vector wind direction and vector wind speed values are invalidated. (Table 4-5); and/or
- Wind speed data results are invalid. Three parameters, scalar wind speed, vector wind speed, and vector wind direction, are invalidated (Table 4-6).

4.3.4.1.8 Solar Radiation

Measurement Criterion: ±10.0 percent difference between average readings recorded by the transfer standard and average unadjusted readings of the site sensor.

Measured values should be between 0 and 1,100 watts per square meter (W/m^2). Expected values should be 0 during the night and range from 200 to 1,100 W/m^2 during the day, depending on the amount of cloudiness, season of the year, and latitude of the site. Low midday values (i.e., ≤200 W/m^2) are frequently the result of precipitation and heavy cloud cover. Values < - 14 W/m^2 may indicate sensor failure, zero drift, or improper calibration of the sensor or DAS and, consequently, are invalidated.

A special case occurs when precalibration results are > 10 percent error, but calibration check points were taken below 250 W/m^2 because of low light conditions. In such cases data are not adjusted or invalidated because checkpoints at these levels are not representative of sensor function.

4.3.4.1.9 Surface Wetness

Measurement Criteria: ≥ 0.50 VDC. Percent undefined. An adjustment is made, when necessary, to correct reading to full scale of 1.00 VDC.

There is some variation in the sensitivity of the wetness sensors at different sites. However, this variation is not a reason to invalidate the data. Surface wetness data are only invalidated if the sensor failed a weekly site operator wetness or calibration check, or if the sensor indicates wet or dry conditions contrary to other measured parameters (e.g., precipitation or humidity) for the same time period. If the data are questionable, the data analyst uses the information from SSRF, daily data reports, narrative logs, and site histories to determine the reasonableness of the data before deciding if the data need to be invalidated. Wetness will typically record full-scale during nighttime to early morning hours (approximately 11:00 p.m. to 9:00 a.m.) due to the higher nighttime humidity levels. These recordings are considered valid since they indicate presence of dew. During the colder months, the wetness sensor may indicate daytime wetness combined with high solar radiation levels and low relative humidity. This may be caused by snow melting on the sensor. Such data are considered valid because they indicate a change in the state of the ground cover.

4.3.4.2 Uncertainty Levels of the Validation Process

The reproducibility of results related to Level 3 validation incorporates uncertainty levels due to potential differences in the data validator's choice of numerical correction factors. The correction factors are based on each meteorological instrument's accuracy DQI (see Table 2-6).

The numerical correction factor can range from the minimum value (actual instrument response minus allowed instrument maximum deviation) to the maximum value (allowed instrument maximum deviation). For example:

The passing criterion used for flow validation is ±5 percent. During calibration, the flow rate is found to be 8 percent above the standard for the site, representing a failure of +3 percent. Flow data for the corresponding time period (to the previous calibration or service visit, as appropriate) are adjusted by a correction factor determined by the data validator as follows:

Actual flow reading	=	1.62 Lpm
Expected flow reading	=	1.50 Lpm
Allowed deviation	=	± 5 percent, 1.50 Lpm * 1.05 = 1.58
Minimum correction factor	=	1.62 Lpm – 1.58 Lpm = 0.04 Lpm/1.50 Lpm = 3 percent
Maximum correction factor	=	Allowed deviation = 5 percent
Uncertainty	=	5 percent – 3 percent = 2 percent

Therefore, the allowable range for applied correction factors is 2 percent. Uncertainty increases as the difference between actual and expected readings approaches the allowed deviation. The maximum correction factor cannot be greater than the allowed deviation (i.e., accuracy goal) defined for the instrument. If the correction factor is greater than the maximum allowed deviation, the data are invalidated. Table 4-4 lists the possible uncertainty ranges for all parameters. The table also summarizes the adjustment procedure for flow, and the adjustments made to meteorological parameters prior to 2000.

4.3.4.3 Editing Procedures

4.3.4.3.1 Adjusting Values

Values are adjusted in the database either individually or by using the global change feature in the Metdata Editor. The global change feature, or query method, can change all values specified within a range of dates to a specific number, or it can be used to perform a linear adjustment. Specifically, the global change feature can be used to:

- Change all values in a block to a specific number;
- Add or subtract a fixed quantity to or from all values in a block;
- Multiply or divide all values in a block by a factor; or
- Both multiply or divide by a factor and add or subtract a fixed quantity.

4.3.4.3.2 Setting Status Flags

Data status flags (Table 4-7) indicate whether data are valid, invalid, suspect, missing, high, low, or correspond to a power failure or a calibration event. Status flags are changed during the Level 3 validation process for data that are invalidated and for data corresponding to time periods when the data logger channel assigned to the parameter was down. Data status flags can be corrected point-by-point or by using the query method as described in Section 4.3.4.3.1. The point-by-point method is useful for modifying small numbers of records. When large numbers of data status flags must be corrected, the query method is preferable.

4.3.5 Laboratory or Discrete Data Validation

Data management within the CASTNET laboratory encompasses the entire information transfer process, from planning sample collection to reporting data. Table 5-14 illustrates the sequence of validation steps for the discrete laboratory measurements. The CASTNET laboratory uses Element to manage all data for this project. A complete description of Element is given in Section 3.5.

4.3.5.1 Level 0 Filter Pack Data Processing

In the laboratory, Level 0 procedures begin before shipment of sample collection media to the sites. The laboratory data assistant establishes work orders for weekly field sampling in Element. These work orders are assigned a number based on the scheduled sampling date for each site. As the work order numbers are assigned, Element generates unique filter pack lot number labels, chain-of-custody labels, shipping labels, and laboratory sample labels for each filter pack. This process provides each site with a unique sample number for each sampling event. Once all of the labels for a work order have been generated, the filter packs are prepared and shipped to the sites according to the procedures described in Sections 3.1.2 and 3.1.4.

After sample collection, the site operator returns the exposed filter pack with its corresponding SSRF to the CASTNET laboratory in Gainesville, FL, according to the procedures described in Section 3.1.2.1. As described in Section 2.1.2 ninety-five percent of exposed filter pack samples from EPA-sponsored sites must be received by the CASTNET laboratory within fourteen days of removal from the sampling tower. The Amec Foster Wheeler receiving clerk delivers the sealed shipping container to the sample custodian who examines the shipping container for damage and verifies that the filter pack lot number and site number match the numbers on the SSRF chain-of-custody label. The sample custodian notes any damage or unusual findings on the SSRF and signs the chain-of-custody label. The “Laboratory Use Only” section of the SSRF is provided to document the samples received, the date received, and the signature of the person processing the samples. The sample custodian also verifies that the site operator completed the on and off sampling dates and documents any discrepancies. The sample custodian then assigns the correct work order and sequence number to the filter pack by using the on date recorded on the SSRF. This laboratory sample number (work order + sequence number) is then recorded on the SSRF in the “Laboratory Use Only” section.

Samples are unpacked from the shipping containers and recorded in the weekly Filter Pack Receipt Log as described in Sections 3.1.5 and 3.1.6 and SOP GLO3180-012 (Appendix 4). During the unpacking process, the filter pack lot number label is removed from the filter pack and matched to its corresponding Element laboratory sample number label. The labels are placed next to each other on a log in label page in the Filter Pack Receipt Log. As described in Section 3.1.6.1, each of the filters (Teflon, nylon, and cellulose) is carefully removed from the filter pack and placed into a properly labeled extraction bottle. Problems identified with the internal filters are documented by placing the correct comment code next to the pair of labels on the log in label page. See Table 4-8 for an explanation of these codes. When all of the samples for the week have been unpacked, the sample custodian submits this label page to the laboratory data assistant who enters the information into Element. This information consists of the sample number, date of receipt, comment codes, and parameter list. This process, referred to as “sample log in” or “sample activation,” places the sample number on the laboratory’s available sample number report. This report notifies the laboratory analysts that the samples are in-house and ready to undergo the necessary analytical procedures. The corresponding SSRF that accompanied the logged in filter packs are sent to the DMC for entry into the database once a week. All data manually entered into Element and/or the database is validated for accuracy through double entry.

4.3.5.2 Level 1 Data Processing

Level 1 data processing is currently defined as the automated screening of level 0 polled field data and is not therefore a laboratory data processing activity.

4.3.5.3 Level 2 Filter Data Processing

Level 2 procedures begin with extraction of the Teflon, nylon and cellulose filters according to the procedures described in CASTNET laboratory SOP GLO3180-001 (Appendix 4). After extraction procedures are completed, the samples are ready for analysis. The samples to be analyzed are sorted into distinct groups for each analytical method. These groups or "batches" are analyzed as a unit with a standard curve, beginning and ending reference samples, CCV, and replicates. Each laboratory batch that is analyzed by the CASTNET Gainesville, FL laboratory is assigned a sequential number beginning with the letter "L" followed by a unique five-digit number. Batch documentation pertinent to the analytical run is filed in a laboratory data batch folder that is labeled with the batch number. These documents include a copy of the sample preparation notebook pages, extraction information, run log, instrument output, Certificate of Analysis of Standards, Element batch printouts containing the analytical results, QC checks, and any other information that is pertinent to the analysis.

After the analyst completes the analysis, the results are reviewed. The analytical methods used for the dry deposition samples are summarized in Table 3-2. The Element system has various automated checks to alert the analyst to any outlier flags or possible problems. The Element batch is reviewed to determine if the analysis meets the criteria listed in Table 3-4.

At this time, the data batch folder containing all documentation is given to a peer reviewer. The peer reviewer has comparable technical knowledge and experience with the analytical procedure. The reviewer verifies that all required documentation is present and that the resulting data are compete and reasonable. Once the peer analyst has thoroughly reviewed the analytical batch and has signed and dated the inside cover data batch checklist, the data batch folder is complete.

The data batch is turned over to the Lab Operations Manager for final review. Documentation of any outliers is further reviewed for justification and acceptance by the LOM. If the data results documented in the batch folder and the corresponding electronic data in Element under the section Laboratory/Data Entry Review are acceptable, the LOM then updates the batch to "Reviewed" and locks the data.

Once a batch has been locked, the data cannot be changed. If during data review and validation, a change to a locked batch is identified as necessary, the LOM or QA Manager unlocks the batch and documents the action, change, and reason electronically in the notes section of the batch. The audit trail function in Element automatically tracks locking and unlocking and the responsible person. After the analyst makes the changes, the new batch printout is given to the LOM and QA Manager. The updated batch is subject to the same review process as the original. Batch folders, with all the pertinent documentation, are filed in the data management area of the laboratory and may be checked out as needed for further review.

4.3.5.4 Level 3 Filter Data Processing

Level 3 data validation involves a comprehensive review and screening of the finalized data, data status flags, QC results, and supporting documentation generated during the course of producing the data. Each week, the LOM retrieves the data results for the laboratory batches finalized during the week and reviews the finalized results for completeness and reasonableness. The LOM reviews and evaluates any outlier flags noted in the batches and submits the written justification to the QA Manager for review and approval. Element then retrieves all of the samples and QC data associated with the samples to create an electronic data deliverable (EDD), which is a dBASE data file that contains the analytical results, batch number, analysis date, corresponding site number for each sample in the batch, QC sample results, and other parameters. The EDD is submitted monthly to the DMC. Upon receipt, the DMAIRM utilizes the Import Labdata function in the CDMSA to import the EDD. The data are imported into temporary tables, formatted, and screened for incorrect site designations, or laboratory sequence numbers. Finally, the utility imports the concentration data and comment codes into the LAB DATA and LAB_COMMENTS tables respectively. Both tables are located in the *castnet_working* database.

Quarterly, the LOM reviews and summarizes the QC information for all of the analytical batches generated during the quarter. The following items are extracted from the *castnet_working* database and checked to verify compliance with internal and external (client) requirements for each method:

- Reference samples;
- Continuing verification samples; and
- Replicates.

This review is conducted using an Access program that retrieves and summarizes the results. The laboratory Level 3 validation process is completed upon submittal of the transfer files to the DMC and summary of the quarterly QC information. Additionally, the QA Manager or designee performs quarterly Level 3 review of laboratory data as described in Sections 4.4.1.1 and 5.9.3. This review includes:

- Reference samples;
- Continuing verification samples;
- Replicates;
- Method blanks;
- Laboratory blanks; and
- Field blanks.

4.3.6 Data Quality Codes and Status Flags

4.3.6.1 Data Quality Codes

Data quality codes or flags are used throughout the entire sampling process. They begin with data collection in the field and continue through sample receipt, data processing, data validation, and reporting.

4.3.6.2 Continuous Data Status Flags

Continuous data status flags indicate whether a datum is valid, missing, high or low, or corresponds to a power failure or a calibration event. These flags are generated by the DAS at time of collection. Data status flags are changed for data invalidated during Level 3 or for data corresponding to time periods when the channel was downed by the site operator, auditor, or field calibration technician. A summary of the data status flags associated with sample collection is provided in Table 4-7.

4.3.6.3 Laboratory Data Flags

Additional data quality flags or comment codes are used when the samples are received by the laboratory. These comment codes result from notes on the SSRF or from observation of the physical sample during unpacking. The codes are entered into Element as a text file. Each comment code is assigned the same filter pack ID number as the data from samples. Comment codes are transferred to the database by the LOM along with the laboratory analytical data. The explanation of these codes is found on the Concentration Report for the dry deposition data (Figure 4-11).

Data quality codes are intended to add information about data points. Once data are reviewed by the Project Manager and validated at Level 3, all invalid data have been flagged as such. Data with other flags have been checked and deemed valid.

Figure 4-11 Sample Dry Deposition Concentration Report

Historical Concentration - Standard Conditions

First Quarter 2013 5/30/2014

Site Id: CHA467

Filter Pack	On Date/Time	Off Date/Time	Teflon SO4 ug/m3	Teflon NO3 ug/m3	Teflon NH4 ug/m3	Teflon Ca ug/m3	Teflon Mg ug/m3	Teflon Na ug/m3	Teflon K ug/m3	Teflon Cl ug/m3	Nylon SO4 ug/m3	Nylon HNO3 ug/m3	Whatman SO2 ug/m3	Comment Code	Flow Valid Hours	Flow Volume m3
1301001-19	12/31/12 08:30	01/08/13 08:21	0.47	0.18	0.22	0.070	0.006	0.014	0.013	0.014 U	0.06	0.47	0.26	3	192	34.68
1302001-19	01/08/13 08:49	01/15/13 09:07	0.32	0.41	0.18	0.177	0.022	0.090	0.028	0.064	0.08	0.24	0.61	3	169	30.52
1303001-19	01/15/13 09:18	01/22/13 08:15	0.51	0.13	0.21	0.175	0.012	0.035	0.030	0.017 U	0.06	0.38	0.48	3	167	30.16
1304001-19	01/22/13 08:34	01/29/13 09:05	0.47	0.22	0.20	0.120	0.012	0.036	0.023	0.025	0.15	0.25	0.39	3	169	30.52
1305001-19	01/29/13 09:15	02/05/13 08:20	0.16	0.07	0.08	0.058	0.004	0.007	0.010	0.017 U	0.06	0.29	0.19	3	167	30.16
1306001-19	02/05/13 08:33	02/12/13 08:50	0.56	0.36	0.25	0.108	0.019	0.108	0.021	0.084	0.18	0.35	0.38	3	168	30.34
1307001-19	02/12/13 09:20	02/19/13 08:15	0.48	0.11	0.19	0.134	0.015	0.031	0.021	0.017 U	0.05	0.38	0.35	3	167	30.16
1308001-19	02/19/13 08:15	02/26/13 08:32	0.54	0.44	0.21	0.174	0.025	0.089	0.025	0.021	0.15	0.36	0.28	3	168	30.34
1309001-19	02/26/13 09:15	03/05/13 08:17	0.43	0.13	0.17	0.177	0.022	0.028	0.034	0.017 U	0.04	0.39	0.25	3	167	30.16
1310001-19	03/05/13 08:35	03/12/13 08:40	0.50	0.25	0.18	0.117	0.024	0.086	0.023	0.051	0.12	0.27	0.36	3	168	30.34
1311001-19	03/12/13 08:55	03/19/13 08:19	0.70	0.26	0.25	0.346	0.048	0.074	0.063	0.020	0.05	0.54	0.39	3	168	30.34
1312001-19	03/19/13 08:19	03/26/13 08:33	1.77	0.63	0.53	0.382	0.071	0.185	0.075	0.037	0.07	0.69	0.72	3	168	30.34
1313001-19	03/26/13 08:52	04/02/13 08:20	0.97	0.45	0.30	0.275	0.043	0.133	0.051	0.027	0.05	0.58	0.51	3	167	30.16
Filter Count: 13	**Mean**		0.61	0.28	0.23	0.178	0.025	0.070	0.032	0.03	0.09	0.40	0.40			
	Std. Deviation		0.40	0.17	0.10	0.10	0.02	0.05	0.02	0.02	0.05	0.14	0.15			

Data Status Flags:
'L' less than 90% but greater than or equal to 75% of valid flow data
'I' invalid chemistry data
'U' undetected - value listed is the reporting limit corrected by flow volume
'M' missing or completely invalid flow data
'N' sample not analyzed
'R' re-run sample
'#' Both 'L' and 'U' status flags apply
'S' Both 'L' and 'R' status flags apply

Comments Codes:
1 = unidentified debris/particles on filter
2 = torn; hole; ripped filter noted during unpacking
3 = excessively wet filter noted during unpacking
4 = excessively dirty filter noted during unpacking
5 = filter pack loose upon arrival, possible leakage during sample period
6 = apparent solenoid problem
7 = filter pack endcaps cracked/missing upon receipt
8 = outside of filter pack excessively dirty upon receipt
9 = support screen raised up, noted during unpacking
10 = insect inside filter pack; noted during unpacking
11 = laboratory accident
12 = filter pack on tower incorrect length of time
13 = filter pack not run in field
14 = unusual odor noticed during unpacking
15 = low extraction efficiency off filter
16 = on/off dates and times are assumed
17 = filter given to EPA for analysis
18 = field accident or error
19 = field equipment problem
20 = filter used for special study
21 = forest fire/agricultural activity in area
22 = site closed down
23 = SSRF not received with filter pack
24 = chain of custody incomplete or incorrect
25 = filter pack run on wrong week
26 = suspect value

sa - Mean temperature for sample period used in conversion factor - primary source

mo - Mean temp for month-year as determined by sample midpoint used in conv factor - secondary source

wk - Historical weekly mean temp as determined by sample midpoint used in conv factor - tertiary source

se- Mean temp for season-year as determined by sample midpoint used in conv factor - quaternary souce

na - No valid mean temperature is available for sample and therefore conversion was not performed

Filter Type Abbreviation: T = Teflon; N = Nylon; W = Whatman

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4.3.7 Data Transfer and Verification

The data for the CASTNET project are acquired and transferred into the database from many different sources. It is imperative that these transfers and the subsequent submittals to EPA are accurate to ensure the integrity of the database. As a result, Amec Foster Wheeler has checking routines in place for all transfers to and from the database.

4.3.7.1 Continuous Data Verification

The process used to collect continuous data and import them into the SQL Server CASTNET database is described in Section 4.3.1. The collection of these data is verified by the DMAIRM through:

- Archiving the polled raw data and Level 1 data into archive database tables;
- Monitoring the successful operation of the Visual Basic programs responsible for inserting the data template, reporting on data collection, and archiving Level 1 data; and
- Reviewing the automated daily completeness report.

Documentation for data changes made by the data analyst as a part of Levels 1, 2 or 3 validation processes are recorded both electronically and on hard copy reports. This documentation includes the name of the analyst and the reason changes are necessary. For an explanation of data changes made during the validation process, see Section 4.3.3 through 4.3.6.

Contents of the weekly documentation package received from each site by the CASTNET DMC are described in Section 4.3.1. Receipt of this information is entered into a logbook along with a notation of any missing items. The DMC also receives the white SSRF form from the laboratory each week. Each SSRF is processed by the data analyst as follows:

- Forms are checked for valid elapsed times;
- Site operator errors or omissions are corrected;
- Changes or additions are documented and initialed; and
- Information from the forms is entered into the database at the DMC. All data manually entered into the database are validated for accuracy through double entry.

4.3.7.2 Laboratory Data Verification

Weekly, the LOM uses Element to create EDD files of validated laboratory data. The data set is checked by the LOM for completeness. The EDD files are e-mailed monthly to the DMC for transfer to the database. The EDD files include a text file containing the laboratory comment codes. Monthly, the Concentration Report (see Figure 4-11) is generated at the DMC following the calculation of atmospheric concentrations using laboratory total microgram values and continuous flow data. This process is described in Section 4.4.1. The QA Manager, DMAIRM or designee use this report to verify completeness of the data transfers and identify and investigate any missing or suspect laboratory data. Additions and corrections are sent to the DMC for inclusion in the database and another Concentration Report is generated for verification. All data manually entered into the database are validated for accuracy through double entry.

4.3.7.3 NPS/BLM Data Verification

Monthly, ARS sends continuous data for one month for all NPS/BLM sites to the DMC. The submittal is formatted as a space-delimited text file and is sent via e-mail along with the sum of all values and count of all invalid flags. Special routines are used to import the files including a set of queries and macros designed to format each field in the temporary data tables. The data are checked for completeness, compared with the submitted sum and counts, and screened for outliers before transfer to the historical continuous data table. If problems with the data submitted are found, the missing records or outliers are identified and the appropriate ARS personnel are notified. The process is repeated until all issues with the submittal are resolved.

4.3.7.4 Transfers to and from the Database

In addition to the procedures detailed above, the DMAIRM runs a checksum query on all tables affected by any data transfer to ensure the accuracy of data imported or exported from the database. This includes submittals sent by ARS, the DMC, the FOM, and the LOM. Checksums are values computed, via either parity or hashing algorithm, on information requiring protection against error or manipulation. Checksums are intended to detect data integrity problems.

In general, a checksum query calculates the sum of the values in each numeric field and a count of the entries in each character field.

4.4 Calculations

4.4.1 Atmospheric Concentrations

Atmospheric concentrations are calculated by combining the field flow data with the chemistry total microgram data. To accomplish this, the following inputs are necessary:

- Field flow data from EPA sites: Values are imported into the database and validated using the procedures described in Section 4.3;
- Field flow data from NPS/BLM sites: Values are sent to the DMC via e-mail from ARS (Section 4.3.7.3); and
- Total microgram filter pack concentration data from all sites: Values are sent to the DMC from the in the EDD.

Once all of the data are available in the SQL Server CASTNET database, the DMAIRM utilizes the dry chemistry calculation process feature in the CDMSA to complete the calculations. First, the DMAIRM or designee executes comparison checks to confirm that sample date ranges do not overlap and that the number of laboratory sample records matches the number of field data records entered from SSRF by a DMC data analyst. The results of the checks are used to verify the successful completion of the Level 1 data validation process for SSRF entry detailed in Section 4.3.1. Second, using the EPA and NPS/BLM sources of hourly field flow data, the dry chemistry calculation process creates a temporary flow table by combining all available data for the calculation time period. Finally, atmospheric concentrations are calculated by combining the field flow data with the total microgram chemistry data. Following completion of the calculation process, the dry chemistry concentration report feature in the CDMSA is used to print the Concentration Report (Figure 4-11) for distribution to the QA Manager, LOM, and other project scientists.

Atmospheric concentrations are reported as valid only if valid hourly averages for filter pack flow represent at least 75 percent of the sampling period, and analytical data meet all QC criteria. Otherwise, concentration data for samples failing these requirements are invalidated during the calculation process.

Filter pack samples with greater than or equal to 75 percent but less than 90 percent valid flow data are flagged to indicate uncertainty in the atmospheric concentration calculations.

Atmospheric concentrations are calculated as follows:

$$\text{Volume (in } m^3\text{)} = \frac{\text{total sample time (hr) x average flow x 60}}{1{,}000} \qquad \text{Eq. 4-4}$$

Atmospheric Concentration (in µg/m³)	=	$\frac{\text{µg of analyte/filter x analyte dependent constant}}{\text{Volume}}$	Eq. 4-5
Constant	=	$\frac{\text{molecular weight of analyte in air}}{\text{molecular weight of analyte in solution}}$	Eq. 4-6

Conversion constants applied to obtain atmospheric concentrations are listed in Table 4-9. The calculations performed to obtain total NO_3^- and total SO_2 are listed in Table 4-10.

4.4.1.1 Dry Deposition Filter Pack Data Review and Validation

After the Level 3 atmospheric concentrations are calculated, the concentrations are assessed for reasonableness. This process includes the following steps:

- A Concentration Report (Figure 4-11) showing the information needed to assess the validity of the concentration data is generated by the DMAIRM. This report is generated monthly and consists of data for the specific group of sites scheduled for Level 3 validation in that month. It combines field and laboratory data to calculate atmospheric concentrations as described in Section 4.4.1.
- Within the Concentration Report, certain checks are made before the concentration data are reviewed. The on/off dates and times of the filter packs are checked for accuracy and compared to the number of valid hours. The validity of the samples is then evaluated based on the accompanying data status flags and comment codes.
- Expected ratios (Table 4-11) of analytes are used to help determine outliers in the concentrations. In general terms, Teflon SO_4^{2-} should be greater than nylon SO_4^{2-} and Teflon NO_3^- should be less than nylon HNO_3^-. Large spikes (positive and negative) in concentration are noted as well.
- Concentrations of the outlier samples identified by this procedure are compared to concentrations from other surrounding sites for the same time period and/or to previous quarterly final concentrations for the site in question. Concentrations from the three filter types for the same time period are also compared. At this point, a list of suspect samples is compiled, and the suspect values are researched. The research focuses on field sampling, laboratory handling, and sample analysis procedures. The research is handled by a team consisting of the QA Manager, LOM, and designated scientist. All documentation for these samples is checked including SSRF and laboratory data batch folders. For field problems, the FOM furnishes the DMAIRM with the corrected data to be entered in the database. The team uses the printout of the Concentration Report as a work sheet to mark those samples that are to be investigated.
- If laboratory procedures were suspect, the sample is reanalyzed at the discretion/direction of the QA Manager. If the sample does not warrant reanalysis due to known circumstances such as contamination of the entire sample, the sample is assigned a data status flag. The LOM gives the laboratory a list of those samples that require reanalysis. After all samples are reanalyzed, the new data are reviewed and sent to the DMAIRM. The team is sent a report

with recommendations as to which samples should be updated or flagged in the database. The team reviews the report with the QA Manager and then instructs the DMAIRM accordingly.

- After a sample is reanalyzed, the same criteria described above are used to review the rerun sample data. Final concentrations are the original data, the rerun data, or the original concentration value with a corresponding data status flag. The QA Manager reviews the data, flags, reruns, and documentation to make the final determination of usable data and flags. The QA Manager sends an e-mail to the DMAIRM listing the samples that he recommends be updated with new data. A copy of this e-mail and the original and rerun data are filed by quarter.

4.4.2 Deposition Velocity

The influence of meteorological conditions, vegetation, and chemistry is simulated by V_d. Previously, V_d was modeled using MLM. Both TDEP and MLM/Bowker approaches are now used to estimate deposition. Dry deposition processes are modeled as resistances to deposition. A general form of the resistance model is:

$$R = R_a + R_b + R_c = 1/V_d \quad \text{Eq. 4-7}$$

R_a signifies aerodynamic resistance or the resistance to turbulent vertical transport; R_b is the boundary layer resistance to vertical transport in a very shallow layer adjacent to the surface; and R_c is the canopy resistance or the resistance to pollutant uptake by the vegetative canopy.

R_c simulates several physical and chemical processes. A resistance model specific to the MLM is depicted in Figure 4-12. A schematic of the MLM in Figure 4-12 shows the relationships among the various resistances and illustrates the meteorological and other data that are required as model input. For example, temperature, relative humidity (RH), solar radiation (SR), and LAI data are required to calculate the stomatal resistance, which is a component of the overall canopy resistance. Similarly, wind speed and sigma theta data are required to estimate the aerodynamic resistance.

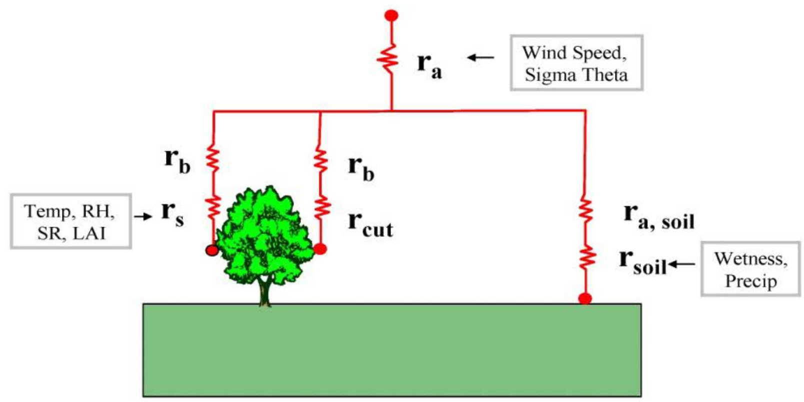
Figure 4-12 Multi-Layer Model

$$\text{Flux} = \overline{C} \; x \; \overline{V_d}$$

$$1/V_d = \frac{1}{\frac{1}{r_s + r_b} + \frac{1}{r_{cut} + r_b} + \frac{1}{r_{a,\,soil} + r_{soil}}} + r_a$$

Resistances

r_a = aerodynamic
$r_{a,\,soil}$ = aerodynamic near soil
r_b = boundary layer in thin layer at surface
r_{cut} = cuticular
r_s = stomatal
r_{soil} = soil



The meteorological variables used to determine R_a and R_b were obtained from the 10-m meteorological tower at each of the sites. The tower is normally located in a clearing over grass or another low vegetative surface. Data on vegetative species, LAI, and percent green leaf out were obtained from site surveys and observations by the site operator.

As described in Section 1.1 of this QAPP, as of January 2011, meteorological parameters were measured at five of EPA-sponsored sites. As of April 2013 and currently, meteorological data are collected at four sites. In order to replace missing values for V_d caused by missing and discontinued meteorological parameters and improve data completeness, EPA applied a method based on the process developed by Bowker *et al*. (2011) to substitute hour-specific historical averages for missing V_d values at specific sites. This approach resulted in nearly 100% data completeness. A new hybrid approach (EPA, 2014a), which incorporates air quality monitoring data with Community Multiscale Air Quality Modeling System (CMAQ) output, is currently the primary tool for analyses of dry and total deposition.

LAI measurements were taken during 1991, 1992, and 1997 at times of summer maximum leaf out. Vegetation data are updated as new sites are added. Aerial photographs of vegetation data from new NPS/BLM sites were provided by ARS. LAI values used in the MLM were extrapolated from the actual LAI measurements, the vegetation types and their geographic distribution from the photographs, and data using percent leaf out observations. The resistance terms (R_a, R_b, and R_c) were calculated for each chemical species and major vegetation/surface type for every hour with valid meteorological data. The V_d for a site was then calculated as the area-weighted V_d over vegetation types within 1.0 kilometer (km) of the site.

4.4.3 Deposition Flux

The original network design was based on the assumption that dry deposition or flux could be estimated as the linear product of ambient concentration (C) and V_d:

$$Flux = \overline{C} \; x \; \overline{V_d} \qquad \text{Eq. 4-8}$$

where the overbars indicate an average over a suitable time period (e.g., one hour).

Hourly deposition fluxes are calculated as the product of the hourly V_d obtained from the MLM and the corresponding hourly concentration. Hourly concentrations are obtained from the weekly filter pack results and measured hourly O_3 concentrations; all hourly concentrations during a filter pack sampling period are calculated using the weekly filter pack sample concentration and are assumed to be constant for the duration of the sample.

Weekly deposition fluxes are the mean of the valid hourly fluxes for a standard deposition week multiplied by the total number of hours in the standard week to account for missing or invalid values. A standard deposition week is defined as the 168-hour period from 0900 Tuesday to 0900 the following Tuesday. For some weeks, the filter pack sampling period did not correspond exactly with the standard deposition week resulting in some deposition weeks being derived from hourly concentrations obtained from more than one filter pack sample.

Similarly, quarterly fluxes are calculated from weekly values. In order for a specific weekly value to be included in a quarterly aggregation, the midpoint of the week must fall within the calendar quarter. Because of this restriction, the number of weeks considered in a quarterly aggregation varies from 12 to 14 weeks. To compute the quarterly flux estimate, the mean of the weekly values included is calculated and multiplied by 13 to achieve a value for the standard deposition quarter.

Annual values are calculated by computing the mean of the respective quarterly values and multiplying by 4.

Weekly, quarterly, and annual mean V_d and atmospheric concentrations are aggregated based on the same methods described above for the flux aggregations. However, the deposition velocities and concentration are only averaged over the given time period while the fluxes are averaged and then multiplied by the appropriate temporal factor to obtain the final estimates. Specific validity requirements for aggregations are summarized in Section 4.4.5.

4.4.4 Ozone

Annual fourth-highest daily maximum 8-hour O_3 concentrations are calculated for all available CASTNET data according to the data handling conventions and computational standards outlined in Appendix I of 40 CFR Part 50 (EPA, 2015). The months comprising the O_3 season vary by state. All available records for each site/year/season are selected and processed. Completeness is determined by comparing the number of valid records to the total possible days for each site/season.

Averages are calculated for each available consecutive 8-hour block of O_3 monitoring data. Averages, in ppb, are assigned to the beginning hour of each period. Blocks with fewer than 6 valid hours are considered valid only if, after substituting 1 ppb for missing values, the average exceeds 75 ppb. Values are truncated to units of ppb for reporting purposes.

Daily 8-hour average concentration maxima are calculated for all days with 18 or more valid hours. Days with fewer than 18 valid hours, but with a maximum exceeding the standard (75 ppb), are also considered valid.

The fourth-highest annual daily maximum value is selected for all sites with at least 75 percent of O_3 season days having valid daily maximum values. Years at sites having fewer than 75 percent valid hours but with fourth-highest values exceeding the threshold (75 ppb) are considered valid. Fourth-highest annual daily maximum O_3 concentrations are used in the CASTNET quarterly and annual reports.

4.4.5 Aggregations

Analyses are performed for multiple purposes using various tables within the CASTNET data set. These analyses are often based on the aggregation of data from shorter time periods into longer time periods (i.e., weekly to quarterly) and are used in the preparation of quarterly reports, annual reports, and various QC activities. In addition, certain data tables, which are included in regular data submittals to EPA, are populated with the results of aggregation procedures. Generally, hourly values are aggregated to weekly values if 70 percent of all hours are valid. Weekly values are aggregated to quarterly values if 69 percent of all weeks are valid. Quarterly averages are aggregated to annual values if three of four quarters are valid.

4.4.5.1 Data Averaging Conventions

CASTNET concentration data are analyzed and presented for several averaging times. This section summarizes the averaging conventions. These conventions apply to the following data:

- Hourly O_3 concentrations and meteorological data:
  - ◊ 75 percent of 3600 1-sec values;
- Filter pack concentrations:
  - ◊ Valid flow for 168 hours of sample period ± 10 percent: concentration is calculated and reported with no flag;

  - ◊ Valid flow for 168 hours of sample period + 10 percent to + 25 percent or from -10 to -25 percent: concentration is calculated and flagged to indicate uncertainty;
  - ◊ Quarterly mean: 69 percent of weekly averages must be valid; and
  - ◊ Annual mean: three valid quarterly means.
- Filter pack concentrations used in trend analyses:
  - ◊ Quarterly mean: 69 percent of weekly means must be valid;
  - ◊ Missing quarterly means: interpolated from adjacent quarterly means (EPA, 2000);
  - ◊ Missing quarterly data at beginning or end of period of trend: assumed equal to adjacent quarterly means; and
  - ◊ Annual mean: four quarterly means, some of which may be interpolated or extrapolated values.

4.4.5.2 Filter Pack Dry Deposition Velocities and Fluxes

In order to replace missing values for V_d caused by missing and discontinued meteorological parameters and improve data completeness, EPA had selected a method based on the process developed by Bowker *et al*. (2011) to substitute hour-specific historical averages for missing V_d values at specific sites. Although TDEP is now the primary model for estimating deposition, MLM/Bowker results are likewise produced and delivered to EPA annually. The rules used for calculation of V_d using MLM output were as follows:

- Weekly mean: For calculations of weekly means by site, 69 percent of hourly data for that week is required to be valid. For weeks meeting this criterion, the mean of the valid hourly values is calculated.
- Quarterly mean: For calculations of quarterly means by site, 69 percent of weekly data for that quarter is required to be valid. For quarters meeting this criterion, the mean of the valid weekly values is calculated.
- Annual mean: For calculations of annual means by site, 75 percent of quarterly data for that year is required to be valid. For years meeting this criterion, the mean of the valid quarterly values is calculated.

The rules used for calculation of fluxes are as follows:

- Weekly sums: For calculations of weekly sums by site, 69 percent of hourly data for that week is required to be valid. For weeks meeting this criterion, the mean of the valid hourly values is calculated and multiplied by 168.
- Quarterly sums: For calculations of quarterly sums by site, 69 percent of weekly data for that quarter is required to be valid. For quarters meeting this criterion, the mean of the valid weekly values is calculated and multiplied by 13.
- Annual sums: For calculations of annual sums by site, 75 percent of quarterly data for that year is required to be valid. For years meeting this criterion, the mean of the valid quarterly values is calculated and multiplied by four.

4.5 Reconciliation with User Requirements

The basic CASTNET objectives as stated in Section 1.1 of this QAPP include:

- Estimation of dry deposition of pollutants;
- Definition of spatial distribution of pollutants; and
- Detection and quantification of trends in pollutant concentrations and deposition fluxes.

Amec Foster Wheeler conducts all activities for CASTNET with these objectives and the final data user in mind. Systems are in place throughout all processes to ensure the most complete, accurate, and usable data possible. Careful consideration has been given to all project activities as described in the following sections:

- Site selection (Section 1.3.1.2.1);
- Quality objectives and criteria for measurement data (Section 1.5);
- Special training for personnel (Section 1.6);
- Documents and records (Section 1.7);
- Sample handling (Section 3.1);
- Data collection (Section 1.3.1.4);
- QA Assessments/Oversight (Section 5.0);
- Ozone and continuous data validation (Section 4.3.4);
- Laboratory data validation (Section 4.3.5);
- Data submittals to EPA (Section 4.6); and
- Data set usability (Sections 5.3 and 5.5).

4.6 Data Submittal to EPA

Data are uploaded to the AQS data submittal Web application in batch format using text files of raw ozone data and measurement accuracy and precision data. Data are submitted to the EPA in both electronic and hard copy formats according to a regular schedule. Format and scheduling are described in the following subsections.

4.6.1 Electronic Data Submittals

Data from the database are submitted electronically to EPA on a regular basis using Oracle. Data files are sent monthly, quarterly, and annually depending on the type of data being sent. Data submitted for specific tables are accompanied by a record inserted into the TABLE_UPDATE table. If submittals are appends, they are transferred into the CASTNETSCRATCH schema in OAK. If submittals are updates, they are transferred into the CASTNETUPDATE schema.

4.6.1.1 Daily Data Submittals

The following data table is sent in the daily data submittals:

- Level 1 continuous meteorological data (METDATA);
- Level 1 continuous trace gas data (HOURLY_GAS); and

- Gas calibrator data (GAS_CALIBRATION)

The continuous data sent to EPA each day are for all sites for the previous day. For example, data for September 1 are submitted on September 2.

4.6.1.2 Monthly Data Submittals

There are two distinct submission protocols executed each month. The Oracle submission described in 4.6.1 and batch text file submissions to the AQS web application.

4.6.1.2.1 The following data tables are sent in the monthly data submittals:

- Level 3 continuous meteorological data (METDATA);
- Level 3 dry chemistry concentrations (DRYCHEM);
- Level 1 dry chemistry concentrations (DRYCHEM);
- Associated field information from the SSRF (FILTER_PACK);
- Automated gas calibration results (GAS_CALIBRATION); and
- Updates as necessary to support tables SITES, FORMATS, CODES, and TABLE_DESCRIPTIONS.

The continuous and atmospheric concentration data sent to EPA each month depend on which sites were calibrated during the month prior to the submittal (for the EPA sites) or on which month was most recently submitted by ARS (for the NPS/BLM sites).

Approximately 11 EPA, 26 NPS, and 5 BLM sites are submitted each month. In order to complete the draft annual report by the contractual deadline, no calibrations are performed at EPA-sponsored sites in December or June. As a result no Level 3 data for EPA-sponsored sites are delivered in February or August.

As an example, for EPA sites calibrated in July, a six-month block of data is delivered to EPA in September. The time period represented by the data included in this submittal is January through June of the same year. ARS delivers a given month of data for all NPS/BLM sites approximately 90 days after the end of the month. Amec Foster Wheeler submits this data to EPA approximately 120 days after the end of the given month submitted. Based on the previous example, May continuous and atmospheric concentration data for NPS/BLM sites are sent with the September monthly data submittal.

Occasionally, ARS is unable to deliver data for a specific NPS/BLM site for the month being submitted. Reasons may include lack of availability of state-collected data (specifically for the sites at ACA416, ME and THR422, ND) or delays in receiving necessary field information from the site operators. Data for other NPS/BLM sites are still submitted to EPA on schedule. When available, data for the missing site are included in the next scheduled monthly submittal.

Automated gas analyzer calibration results from the previous month are sent with each monthly submittal. Preliminary dry chemistry concentrations for one month for all sites are also sent with each monthly submittal. These data comprise concentrations from the month ending 60 days prior to their submittal.

4.6.1.2.2 AQS Data Submittals

Additionally, one month of validated O_3 and trace gas data are uploaded to the AQS data submittal Web application for the month ending 90 days prior to their submittal. Data are uploaded in batch format using text files of raw O_3 and trace gas data and measurement accuracy and precision data. Site information for sites submitting data to AQS is reviewed annually and updated when warranted by site changes. The AQS data submittal Web application is accessed at http://www.epa.gov/ttn/airs/airsaqs/aqsweb/.

4.6.1.3 Quarterly Data Submittals

The following data tables are submitted to EPA quarterly:

- Summary of calibration results (CALIBRATION_SUMMARY);
- Raw total microgram laboratory values and comments (LABDATA, LABDATA_QC, SAMPLE_REFERENCE); and
- Site operator information (SITE_OPERATOR).

Quarterly data submittals coincide with the production of the quarterly data reports. The data submittal and report for a given quarter are delivered approximately 120 days after the end of the quarter. For example, the second quarter data submittal and report are sent to EPA in October of the same year.

4.6.1.4 Annual Data Submittals

The following data tables are submitted annually to the EPA:

- Dry deposition values (MODEL_OUTPUT); and
- Inventory information (EQUIPMENT_INVENTORY).

With the exception of EQUIPMENT_INVENTORY, all tables scheduled for annual submittal are sent with the delivery of the draft annual report in mid-August. For example, model output data for year 2014 were delivered in mid-August 2015. Inventory data are delivered following the end of the fiscal year, usually packaged with the October monthly data submittal and second quarter data submittal.

4.6.2 Reports to EPA

Tables, maps, figures, and reports are produced from data in the database and submitted to EPA regularly. At a minimum, these annual and/or quarterly reports include the following elements:

- Percent recovery for continuous measurements and pollutant concentrations;
- Precision results for collocated sampling and individual samplers;
- Laboratory precision and accuracy estimates;
- Maps of pollutant concentrations;
- Trends analysis for 34 eastern and 17 western CASTNET sites;

- Maps of daily maximum 8-hour ozone concentrations; and
- Data analyses, interpretations, and supporting text.

Section 4.4.5 and 5.4.6 contains a detailed discussion of data aggregation conventions and calculations and how they are applied to specific reports to EPA. These analyses are produced and reviewed by appropriate project personnel including the Project Manager, Work Assignment Manager, DMAIRM, FOM, LOM, and QA Manager.

4.6.3 Response Actions

All questions to Amec Foster Wheeler concerning data submitted to EPA should be directed to the Project Manager for resolution. He will immediately contact, via e-mail, the appropriate members of the management team. The management team, which consists of the Work Assignment Manager, DMAIRM, FOM, LOM, and the QA Manager, will investigate the questions and determine the response in concert with the Project Manager. All actions taken are documented in the same manner as validation changes using both hard copy and electronic media as appropriate. The Project Manager makes the final determination and communicates actions and responses to the EPA.

4.6.4 Data Submittals to NPS and BLM

Data submittals are made to NPS and BLM upon request. Special requests for data at specific sites are handled as quickly as possible. The data transmitted are in the form of files, usually MS Excel spreadsheets or MS Access databases, populated with data from the appropriate database table.

Table 4-1 Continuous Data Validation Process

Data Validation Level	Source Of Data Files	Data Processing And QC Activities	Data Storage Format
Level 0 Data Polling	Raw data and status files.	• Check completeness of automated daily poll activities. • Daily data review.	Raw data and status files.
Level 0 Data Input	Raw data and status files.	Pull files into MS SQL Server Level 0 Data Table.	MS SQL Server METDATA_RAW Data Table.
Level 1	MS SQL Server Level 0 Data Table.	• Apply automated screening protocols. • Locate all missing data points using MS SQL Server queries. • Poll CR3000 data loggers with LoggerNet and update database.	MS SQL Server METDATA_L1 Data Table in the *castnet_working* database*.
Level 2	MS SQL Server Level 1 Data Table containing auto-screened data.	Archives all collected data into a single processing table. At this point, all data that can be collected have been collected.	MS SQL Server METDATA_L2 Data Table in the *castnet_working* database*.
Level 3	Six months of data for each site accessed from MS SQL Server METDATA_L2 Data Table, processed using Metdata Editor and inserted into MS SQL Server Level 3 Data Table.	• Confirmation of Level 1 & 2 activities. • Changing the values only - corrective action initiated from the review of initial and final calibration information. • Changing the status only - corrective action initiated from field documentation. • Changing both: values and status flags -corrective action initiated if erroneous data are detected. • Generating of statistical information for review.	MS SQL Server Level 3 Data Table.
Level 3 Final Statistical Review	MS SQL Server Level 3 Data Table.	Final review of all statistical results generated by site and validated data set inserted into Archive Level 3 Data Table.	MS SQL Server Archive Level 3 Data Table.
Data Transfer Oracle and EPA	MS SQL Server Archive Level 3 Data Table.	Records are transferred via database link from SQL Server to Amec Foster Wheeler's Oracle database and then to EPA's Oracle database. Documentation is added to TABLE-UPDATE tables in Oracle database.	Amec Foster Wheeler Oracle database; EPA Oracle database.

Note: * All other referenced tables are in the *castnet* database

Table 4-2 Current Auto-Adjustment Criteria

Parameter	Condition	Action
Relative Humidity	value < 0 and > -5	set value = 0
Solar Radiation	value < 0 and > -14	set value = 0
Wetness	value < 0.1 and > -0.05	set value = 0
Wetness	value > 1	set value = 1
Wind Direction	value < -2	set value to 0
Wind Direction	value > 362	set value to 360
Wind Speed	value < -0.4	set value to 0
Wind Speed (Scalar)	value < -0.2	set value to 0

Table 4-3 Current Outlier Criteria

Parameter	Condition	Action
Flow	value outside nominal flow by > 10 percent	flag N
Temperature	value < -40 or > 50	flag P
Delta Temperature	value < -5 or > 7	flag P
Relative Humidity	value < 0 or > 100	flag P
Solar Radiation	value < 0 or > 1400	flag P
Ozone	value < -2	flag P
Ozone	value > 150	flag P
Precipitation	value < 0 or > 49	flag P
Vector Wind Speed (VWS)	value < 0 or > 25	flag P
Wind Direction	value < 0 or > 360	flag P
Sigma Theta	value < 0 or > 100	flag P
Sigma Theta	value = 0	flag *all* wind parameters P
Scalar Wind Speed (SWS)	value < 0 or > 25	flag P
Wetness	value ≤ -0.05	flag P
Scalar Wind Speed (SWS)	VWS-SWS ≥ 0.2	flag both parameters P
Solar Radiation at night	value > 20 between hours 2200 and 0300	flag P

Table 4-4 Data Reasonableness Criteria and Uncertainty Ranges

Parameter Name	Prior to January 2000*			After January 2000		
	Type of Adjustment	**Maximum Deviation**	**Uncertainty Range†**	**Type of Adjustment**	**Maximum Deviation**	**Uncertainty Range**
Ozone§	Slope/Intercept Percent	0.90 ≤ slope ≤ 1.10 – 5.00 ≤ int ≤5.00 ± 10.00% of actual	1.0% - 10.0%	Slope/Intercept Percent	0.90 ≤ slope ≤1.10 – 5.00 ≤ int ≤5.00 ± 10.00% of actual	1.0% - 10.0%
Flow	Percent	± 10.0% of expected Lpm	1.0% - 10.0%	Percent	± 5.0% of expected Lpm	1.0% - 5.0%
Temperature	Linear or Slope/Intercept	± 0.25°C from actual	0.01 - 0.25°C	N/A	± 0.5°C from actual	N/A
Delta Temperature	Linear	± 0.20°C	0.01 - 0.19°C	N/A	± 0.5°C	N/A
Relative Humidity	Linear	± 10% of full scale	1.0% - 10.0%	N/A	± 10.0% of full scale	N/A
Precipitation	Percent	± 10.0% of 50 tips or 0.50 V output	2.0% - 10.0% (1 tip = 2.0%)	N/A	± 10.0% of 50 tips or 0.50 V output	N/A
Wind Direction	Linear	± 5.0° from actual angle as determined by a compass	1.0 - 5.0°	N/A	± 5.0° from actual angle as determined by a compass	N/A
Wind Speed	Linear Slope/Intercept	± 0.2 m/sec for values < 5.0 m/sec ± 5.0% for values ≥ 5.0 m/sec	0.01 - 0.2 m/sec for values < 5.0 m/sec 1.0% - 5.0% for values ≥ 5.0 m/sec	N/A	± 0.5 m/sec for values < 5.0 m/sec ± 5.0% for values ≥ 5.0 m/sec	N/A
Sigma Theta	None	N/A	N/A	N/A	N/A	N/A
Solar Radiation	Percent	± 10.0% between average sensor and transfer readings	1.0% – 10.0%	N/A	± 10.0% between average sensor and transfer readings	N/A
Surface Wetness	Percent	as necessary to correct readings to full scale of 1.00	N/A	Zero drift correction for all values < 0.50 VDC	as necessary to correct readings to full scale of 1.00	N/A

Notes: * Beginning with 2000 data, Amec Foster Wheeler did not adjust meteorological measurements. However, the types of adjustments are listed in the table for historical perspective.
† Uncertainty ranges are those due to potential differences in the data validator's choice of correction factors.
§ Beginning with 2011 data, Amec Foster Wheeler did not adjust O_3 measurements. Please refer to Section 4.3.4.1.1 and Table 4-13 for validation criteria.

Table 4-5 Summary of Wind Direction Invalidation Options

Parameter	Invalid (Nonlinear Error)	Invalid (Linear Error)
Vector Wind Direction	•	•
Vector Wind Speed	•	•
Sigma Theta	•	
Scalar Wind Speed		

Table 4-6 Summary for Wind Speed Invalidation Options

Parameter	Invalid
Vector Wind Direction	•
Vector Wind Speed	•
Sigma Theta	
Scalar Wind Speed	•

Table 4-7 Data Status Flags*

Flags Present in Raw Data Tables	Flags Present in Edited Tables	Meaning of the Status Flag
<	<	Less than 15 minutes of hourly sample missing
B	B	No sample (all dataloggers), channel downed by operator (CR3000 collected data)
C	C	C – calibration
D	D	Channel downed by operator (Odessa, ESC collected data)**
F	F	Power failure
M	M	Missing data
R	R	Used for flagging ozone or trace-level gas QC check results. The R flag indicates that the QC check is valid but that associated ambient measurements are not valid and the check should not be submitted as a 1-point QC check to AQS.
U	null	> 3600 seconds included in hourly average
W	null	Temperature blower motor not operating
null	S[§]	Suspect due to calibration failure
null	null	Valid with no conditions
null	P	Potential problem with ozone value (only appears in screened daily submittal – data considered invalid)
null	K	Potential problem with flow value (only appears in screened daily submittal – data considered valid)
null	I	Not valid

Notes: * Automated screening flags are not presented in this table. See Table 4-4 for auto-screening flags.
** Odessa data loggers are no longer used. An ESC logger is used at CHE185, OK.
§ The S flag is applied only to meteorological data.

Table 4-8 Laboratory Analyst Remarks on Exposed Filter Samples

Code	Description
T	Numeric code following applies to the Teflon filter analysis
N	Numeric code following applies to the nylon filter analysis
W	Numeric code following applies to the cellulose filter analysis
01	Unidentified debris/particles on filter
02	Torn; hole; ripped filter noted during unpacking
03	Excessively wet filter noted upon unpacking
04	Excessively dirty filter noted upon unpacking
05	Filter pack loose upon arrival, possible leakage during sample period
06	Apparent solenoid problem
07	Filter pack end caps cracked/missing upon receipt
08	Outside of filter pack excessively dirty upon receipt
09	Support screen raised up; noted during unpacking
10	Insect inside filter pack; noted during unpacking
11	Laboratory accident
12	Filter pack on tower for less than 6 or greater than 8 days
13	Filter pack not run in field
14	Unusual odor noticed during unpacking
15	Low extraction efficiency off filter
16	On/off dates and times are assumed
17	Filter given to EPA for analysis
18	Field accident
19	Field equipment problem
20	Filter used for special study
21	Forest fire/agricultural activity in area
22	Site closed
23	SSRF not received with filter pack
24	Chain-of-custody incomplete or incorrect
25	Filter pack run out of sequence
26	Suspect value; no reason recorded

Table 4-9 Conversion Constants

Teflon		Nylon		Cellulose	
Parameter	**Constant**	**Parameter**	**Constant**	**Parameter**	**Constant**
SO_4^{2-}	1.0	SO_2	1.0	SO_2	0.667
NO_3^-	4.429	HNO_3	4.5	NO_3^-	4.429
NH_4^+	1.286	N/A	N/A	N/A	N/A

Note: Conversion constant for Cl^-, Na^+, K^+, Mg^{2+}, and Ca^{2+} is 1.0.

Table 4-10 Calculations for Total NO_3^- and SO_2

Parameter	Calculation
Total NO_3^-	Teflon- NO_3^- + (nylon-HNO_3*0.984)
Total SO_2	Cellulose- SO_2 + (nylon-SO_4^{2-}*0.667)

Table 4-11 Ratio Tests

Ratio	Expected Range
Teflon-NH_4^+ / (Teflon-NH_4^+ + Teflon-NO_3^-)	0.15 to 0.375
Teflon-SO_4^{2-} / Nylon-SO_4^{2-}	> 1.0
Nylon-NO_3^- / Cellulose-NO_3^-	> 1.5
lTeflon-SO_4^{2-} / Nylon-NO_3^-	> 1.0, except during winter
Cations/Anions for pH dissolved $\leq$ 4.5	0.85 to 1.15
Cations/Anions for pH dissolved > 4.5	0.75 to 1.25

Table 4-12 Ozone Validation Template* - CASTNET (1 of 4)

Requirement	Minimum Frequency	Acceptance Criteria	Action
CRITICAL CRITERIA			
One Point QC Check Single analyzer	1/ 2 weeks	≤ ±7% (percent difference)	CASTNET protocol requires daily checks. Invalidate all data associated with a failure – from the last check that met the criterion to the next meeting the criterion. If the problem can be verifiably traced to a system or subsystem that does not affect reported data, the associated data may be treated as valid. Otherwise, invalidate all associated data. Missing checks will not automatically require invalidation until they drop below the minimum EPA-required frequency of once every 2 weeks. Drift in ozonator concentrations should be treated as an operational criterion. If reference concentrations (those generated by the transfer standard) are not within 2% of full scale** compared with their targeted value, investigate the problem as described above.
Zero/span check	1/ 2 weeks	Zero drift ≤ ± 1.5 ppb Span drift ≤ ± 7 %	
OPERATIONAL CRITERIA			
Shelter Temperature			
Temperature range	Daily (hourly values)	20 to 30° C. (Hourly average)	Investigate data associated with temperatures outside of the criterion: Review data for reasonableness†. If temperature is outside of this window for any recorded hour, verify analyzer internal temperature‡ is between 25 and 40° C during the excursion. Invalidate data deemed unreasonable† for ambient conditions or per site history and any data collected while analyzer internal temperatures were not between 25 and 40° C.
Temperature Control	Daily (hourly values)	≤ ± 2° C SD over 24 hours	If a 24 hr period is outside of the criterion, review associated data as described above and for overall reasonableness†.
Temperature Device Check [Applies to routine site calibration visits.]	2/year	± 2° C of standard	CASTNET requirement for device field calibration is ± 0.5° C of standard. Data associated with a failure of ± 2° C or greater must be reviewed as described above. If the failure is linear 2° C may be added or subtracted as appropriate to determine which periods require further investigation. If the failure is non-linear or the temperature device is otherwise non-functional the entire period must be reviewed for reasonableness† and to verify internal analyzer temperatures.

Table 4-12 Ozone Validation Template* - CASTNET (2 of 4)

Requirement	Minimum Frequency	Acceptance Criteria	Action
Precision(using 1-point QC checks) *[Calculation performed by Data Manager and results reviewed by Data and QA Managers.]*	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 7% *[90% confidence limit of coefficient of variation.* ***40CFR Part 58 App A sec 4.1.2****]*	This metric is reviewed as part of the annual review screening procedure. Exceeding the criterion will trigger additional review including data from nearby sites (including SLAMS), site narrative logs, and the analyzer's internal systems monitoring data.
Bias (using 1-point QC checks) *[Calculation performed by Data Manager and results reviewed by Data and QA Managers.]*	Calculated annually and as appropriate for design value estimates	95% CL ≤ ± 7% *[95% confidence limit of absolute bias estimate.* ***40CFR Part 58 App A sec 4.1.3****]*	Same as above.
Annual Performance Evaluation			
Single analyzer *[EPA Responsibility]*	Every site 1/year 25 % of sites quarterly	Percent difference of each audit level ≤ 15% or ± 1.5 ppb for audit levels 1 & 2.	Results reviewed as part of the annual review screening procedure. Exceeding the criterion will trigger additional review as noted above.
Primary QA Organization (PQAO)	Annually	95% of audit percent differences fall within the one point QC check 95% probability intervals at PQAO level of aggregation	Same as above.
Verification/Calibration *[Applies to routine site calibration visits.]*	Upon receipt/adjustment/repair/ installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	All points within ± 2% of full scale of best fit straight line Linearity error < 5%	If verification results are outside of the listed criteria, review the calibration forms, problem tickets and repair logs to confirm proper operation of the analyzer and onsite transfer standard. If a starting point for the problem can be determined and documented, use this period as that to be invalidated. If the problem can be verifiably traced to a system or subsystem that does not affect reported data, the associated data may be treated as valid. Otherwise, invalidate all associated data.
Zero Air *[Applies to routine site calibration visits.]*		Concentration below LDL	If the criterion is exceeded (± 0.003 ppm), correlate with any zero/span results that exceed critical criteria. If the zero air system is implicated, report this finding immediately to the project manager, field operations manager, and QA manager.

Table 4-12 Ozone Validation Template* - CASTNET (3 of 4)

Requirement	Minimum Frequency	Acceptance Criteria	Action
Ozone Level 2 Standard			
Certification/recertification to Standard Reference Photometer	1/year	single point difference ≤ ± 3%	If the standard exceeds the criterion and its authority has been used at any sites for re-verification or calibration the associated site analyzers must be re-verified with a properly certified standard.
(if used as a travelling transfer standard)	1/year	single point difference ≤ ± 3%	See above. Additionally, the travelling transfers are audited with a stationary standard 2x/calendar quarter to verify proper calibration w/o applying the certification calculation. The audit results must meet the criteria listed below: New slope = ± 0.05 of previous and RSD of six slopes ≤ 3.7% Std. Dev. of 6 intercepts ≤ 1.5 Failure to meet these criteria will require servicing and/or recertification as appropriate.
Ozone Transfer Standard			
Qualification	Upon receipt of transfer standard	±4% or ±4 ppb (whichever greater)	All analyzers are on the list of USEPA Designated Equivalent Methods and are therefore qualified by their manufacturer. To maintain designation, they must not be modified or operated contrary to manufacturer's instructions or QA requirements.
Certification††	After qualification and upon receipt/adjustment/repair	RSD of six slopes ≤ 3.7% Std. Dev. of 6 intercepts ≤ 1.5	If the analyzer has been used at any sites for re-verification or calibration. The associated site analyzers must be re-verified with a properly certified analyzer.
Recertification to level 2 standard	Beginning and end of O_3 season or 1/6 months whichever less	New slope = ± 0.05 of previous and RSD of six slopes ≤ 3.7% Std. Dev. of 6 intercepts ≤ 1.5	See above. This applies to onsite stationary Level 3 transfer standards.
Lower detectable level	1/year	0.003 ppm	Ref. **40 CFR Part 136 App B**. If the standard exceeds the criterion and its authority has been used at any sites for re-verification or calibration the associated site analyzers must be re-verified with a properly certified standard.

Table 4-12 Ozone Validation Template* - CASTNET (4 of 4)

Requirement	Minimum Frequency	Acceptance Criteria	Action
		SYSTEMATIC CRITERIA	
Standard Reporting Units	All data	ppm (final units in AQS)	Data must be converted to correct units.
Completeness (seasonal)	Daily	75% of hourly averages for the 8-hour period	If the criterion is exceeded, data may not be used for reporting 8-hour averages.
Sample Residence Times		≤ 20 seconds	Report any sites found to exceed this criterion to the project manager, field operations manager, and QA manager.
Sample Probe, Inlet, Sampling train		Borosilicate glass (e.g., Pyrex®) or Teflon® or equivalent inert material such as Kynar§	See above.
Siting		Un-obstructed probe inlet	See above.
EPA Standard Ozone Reference Photometer (SRP) Recertification	1/year	Regression slope = 1.00 ± 0.03 and intercept < 0 ± 3 ppb	If the standard exceeds the criterion and its authority has been used at any sites for re-verification or calibration the associated site analyzers must be re-verified with a properly certified standard.

Notes: *Guidance for the application of data flags based on the ozone validation template in Appendix D of volume II of the EPA Quality Assurance Handbook, May, 2013. No data adjustments will be made during routine procedures.

**Full scale = 250ppb
‡Internal temperatures are based on manufacturer recommendations
†Review for reasonableness may include:

- Synoptic meteorological conditions (where available)
- Comparisons with historical data
- Site visit log including calibration schedule

Data from nearby sites (including SLAMS sites, where applicable)

††Dedicated transfer of authority with all 6-days traceable to a single Level 2 standard.

§Technical Assistance Document for the Calibration of Ambient Ozone Monitors, EPA 600/4-79-057, September 1979
Perfluoroalkoxy (PFA) Teflon will be the preferred standard material at CASTNET sites by the end of 2015.

CL = Confidence Limit
CV = Coefficient of Variation
LDL = Lower Detectable Level
RSD = Relative Standard Deviation
SD = Standard Deviation

5.0 Quality Assurance

5.1 Overview of Assessments and Response Actions

5.1.1 Assessments

In order to ensure that the CASTNET measurements are conducted as planned and executed properly, a process of evaluation and validation is necessary. This section describes the procedures necessary to ensure that:

- ♦ All elements of the QAPP are correctly implemented as prescribed;
- ♦ The quality of the data collected meets project DQO and DQI measurement criteria; and
- ♦ Corrective actions are implemented in a timely manner and their effectiveness is confirmed.

The CASTNET QA Management Team performs assessments of key project activities that affect achievement and maintenance of project DQO. This team is comprised of the Amec Foster Wheeler Project Manager, QA Supervisor, QA Manager, and operations managers; the EPA QA Officer; NPS QA Coordinator; ARS Program Manager and QA Officer; and other agencies and organizations, as needed (Section 1.2).

The CASTNET QA Management Team members are responsible for both assessing the effectiveness of project implementation of the CASTNET QA Program and for initiating corrective action if the assessment indicates such a response is required. The broad range of QC procedures present throughout all aspects of project operations are highlighted in Figure 5-1. The core of the QA program is the internal audit system. Independent and external audit systems are also utilized. These audit systems are used to assess the components of the project and their compliance with the QA Program and project DQO. In addition to assessment, the three systems incorporate corrective action and implementation systems. CASTNET project assessments include:

- ♦ Program Level
    - ◊ Data quality assessments and response actions
    - ◊ Management systems reviews
    - ◊ Readiness reviews
    - ◊ TSA
    - ◊ PE
    - ◊ Surveillance
    - ◊ Assessments of DQI
    - ◊ Peer review of project deliverables
    - ◊ QA/QC reports to management
    - ◊ Review, revision, and approval of the CASTNET QAPP

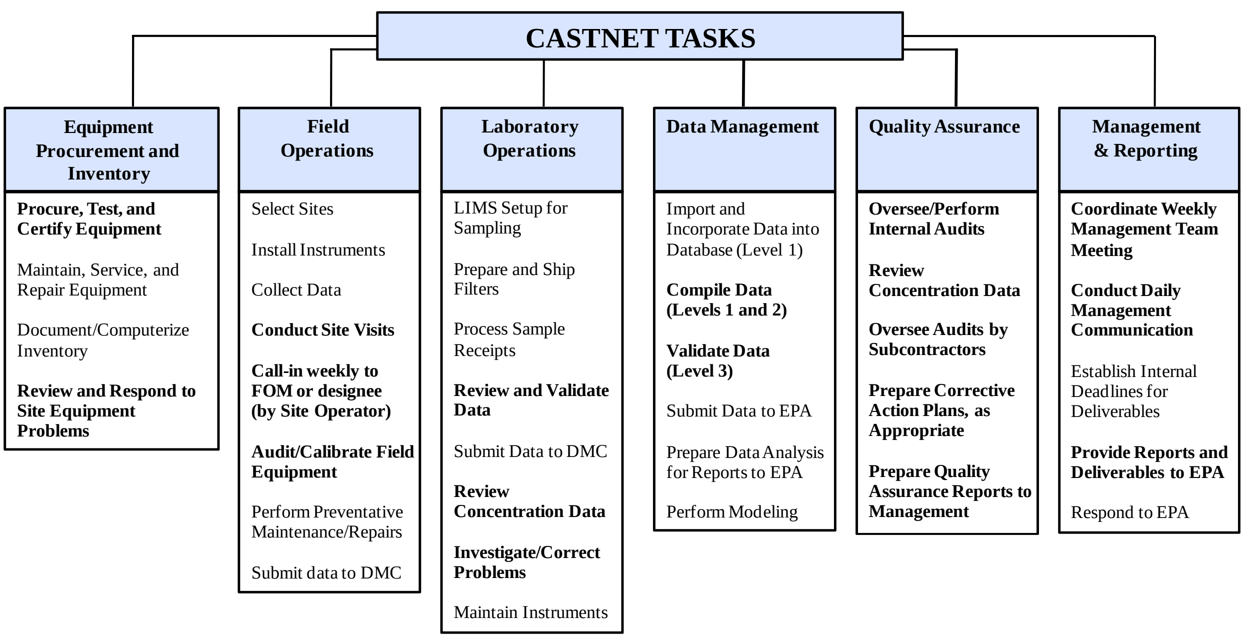
- Operating Unit Level
  - Surveillance
  - TSA
  - PE
- Task Level
  - Surveillance
  - Readiness reviews

These project assessments are summarized in Table 5-1 and discussed in the following subsections. The external audit program is managed and executed by EPA, at its discretion, as necessary to ensure that the CASTNET QA program meets the needs of the project. Since EPA conducts these audits, information on audit frequency and procedures are not presented in this QAPP.

Established DQO and procedures for gauging achievement of DQO are necessary to perform the assessments listed previously. The CASTNET project DQO are defined in Section 1.5 and summarized in Table 1-7. The CASTNET DQI used in assessment of the DQO are precision, accuracy, bias, completeness, representativeness, and comparability. The DQI are discussed in Section 5.3.

DQI and the associated measurement criteria are described in Section 1.5.2 and summarized in Tables 2-6, 3-3, and 3-4. Assessments of DQI are discussed in Section 5.3.

Figure 5-1 Overview of CASTNET QA/QC Tasks (in bold font)



5.1.2 Scope of Authority

The scopes of authority for the members of the QA Management Team are described in Section 1.2 and Table 1-2. For example, if deemed necessary during the course of an assessment, a Stop Work Order may be issued upon finding a significant condition that would affect the quality and usability of the data. The EPA QA Officer and the Amec Foster Wheeler QA Supervisor, QA Manager, and Project Manager, or designees, have the authority to issue a Stop Work Order. The EPA Project Officer and Amec Foster Wheeler Project Manager, or designees, have the authority to lift the Stop Work Order and allow resumption of project activities once the effectiveness of the response actions has been confirmed. The EPA Project Officer and the Amec Foster Wheeler Project Manager, or designees, have the responsibility for initiating and implementing response actions associated with findings identified during an audit. Once the response actions have been implemented, the EPA QA Officer, or designee, or the Amec Foster Wheeler QA Manager, or designee, performs a follow-up audit to verify and document that the response actions were implemented effectively.

5.1.3 Response Actions

An effective QA program requires rapid and thorough correction of problems. Two types of corrective actions are used for CASTNET: short-term or “informal” actions and long-term or “formal” actions. Short-term corrective actions include any action that can be taken immediately by the personnel who discover the problem without violating established rules or procedures. They include correcting improper procedures and/or repairing instruments that are not working properly. Long-term corrective actions are those designed to eliminate the sources of problems by correcting systematic errors. Such an action may involve modification of established rules or procedures. The possibility that the corrective action may have a potential effect on other areas of the project is considered for each corrective action. On-going project surveillance serves to identify whether actions taken in one area of the project have unexpectedly affected another area of the project.

The QA Manager reviews and tracks all formal corrective actions. If no response has been received within one month of initiation of a Nonconformance/Corrective Action Form (NCAF) or a scheduled response date, a reminder memorandum is sent to the recipient of the NCAF. A response to an NCAF may consist of a solution to the problem, a memorandum detailing the current status of a problem, or an explanation of why the problem has not been resolved or addressed. If no response of any type is received, or a resolution to a problem is unnecessarily delayed, the QA Manager and Project Manager will mandate a short-term resolution. See Table 5-2 for standard response actions for each of the specific assessments. See Figure 5-2 for a depiction of the NCAF.

Figure 5-2 Sample Nonconformance/Corrective Action Form

amec foster wheeler

Form

Title: **Corrective and Preventive Action** Register No.: **CA_0050**

Non-Conformance Event: ME-051915 Report Finding	
Project Title: NA	Description: Laboratory Activity Records
Project No.: NA	Discipline: Laboratory Services

Description of non-conformance or potential non-conformance (include results of root cause analysis if applicable) -

Laboratory extraction solutions are prepared and listed by analyst name or initials and the solution preparation date in the appropriate laboratory analysis log books. While these solutions are acceptance tested and the hardcopy records of test results filed along with traceable documentation, there is no log book maintained documenting preparation of the solutions.

Root cause analysis:

1. Extraction solutions have only been documented on the labels of the prepared solution containers.
2. Solutions are rapidly consumed and fresh ones are made frequently.
3. Short solution lifespan led to an expedient visual display system for users (the bottle labels).
4. Hardcopy records of acceptance test results were available if needed for reference.
5. Acceptance testing prevented use of "bad" solutions.

Originator: M. Stewart Date: 6/25/15

Corrective / preventive action with responsibility assignment

Establish extraction solution preparation log(s) that include traceability information (e.g. lot numbers). Enter information into analysis logs etc. in a manner similar to that used for calibration standards.

Monitoring Period: June 25th to July 17th, 2015

Proposed close-out date: July 17th, 2015

	Laboratory Manager	Quality Representative
Name	Garry L. Price	Marcus O. Stewart
Signature	Garry Price	Marcus O. Stewart
Date	1 July 15	7/16/15

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Figure 5-2 Sample Nonconformance/Corrective Action Form (continued)

amec foster wheeler

Form

Title: **Corrective and Preventive Action** Register No.: **CA_0050**

Proposed resolution from root cause analysis (where required)

Same as corrective action listed above.

	Investigator	Quality Representative
Name	Garry L. Price	Marcus O. Stewart
Signature		
Date	1 July 15	7/16/15

Review or verification record

Logs established for each extraction solution type.

A "live" entry in an analysis log utilizing the method of documentation similar to instrument standards.

Training records for laboratory personnel for using the new logs.

	Reviewer/Verifier	Quality Representative
Name	Garry L. Price	Marcus O. Stewart
Signature		
Date	7/16/15	7/16/15

Follow-up and close-out details

Corrective action procedures are satisfactory.

	Project Manager	Quality Representative
Name	H. Kemp Howell	Marcus O. Stewart
Signature		
Date	7-16-15	7/16/15

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5.1.4 Documentation

To provide a complete record, all QC problems and corrective actions are documented. Management may use such historical records for identification of long-term problems and for application of long-term corrective actions such as training of personnel, replacement of instrumentation, and improvement of sampling procedures. An NCAF is used to document all formal, long-term corrective actions (Figure 5-2). A formal corrective action requires defined responsibilities for scheduling, performing, documenting, and ensuring the effectiveness of the required action. Any individual who identifies a problem may initiate the corrective action.

Short-term corrective actions in the field are documented in field logbooks and problem summaries. Short-term corrective actions in the laboratory are documented in batch narratives. In addition to online documentation, the DMC utilizes a variety of online forms to document short-term corrective actions.

5.2 Data Quality Objectives and Criteria

DQO are qualitative and quantitative statements that:

- Clarify the intended use of the data;
- Define the type of data needed to support decisions and policies;
- Identify the conditions under which the data should be collected; and
- Specify tolerable limits on the probability of making a decision error due to uncertainty in the data.

The CASTNET DQO were developed to support these basic project objectives:

- To monitor the status and trends in air quality and atmospheric deposition
- To provide atmospheric data on the dry deposition component of total acid deposition, rural ground-level O_3, and other forms of atmospheric pollution that enter the environment as particles and gases
- To assess and report on geographic patterns and long-term, temporal trends in ambient air pollutant concentrations and acid deposition
- To provide scientifically defensible data to gauge the effectiveness of EPA emission reduction programs

The network design was developed based on the assumption that dry deposition can be estimated mathematically using ambient concentration and meteorological input data.

CASTNET DQO are summarized in Table 1-7. These DQO have been established to ensure that the data provided are of known and documented quality for the continuous field data and the integrated samples, including exposed filters. DQO are discussed further in Appendix 7. The DQI are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of the data collected. CASTNET DQI with associated measurement criteria are monitored to ensure that processes for field and laboratory data collection are operating such that project

DQO are achieved. In other words, CASTNET data collection processes are considered to be operating as required to achieve established goals (Table 1-7) when monitored DQI meet established measurement criteria. DQI measurement criteria were determined based on MLM input requirements as well as on instrument and method limitations. All CASTNET sites operate according to the procedures described in this QAPP. This QAPP is the guiding document for implementation of all monitoring at CASTNET sites.

5.3 Data Quality Indicators

The DQI for CASTNET are precision, accuracy, bias, completeness, representativeness, and comparability. These DQI are further discussed in the following subsections. The current precision and accuracy measurement criteria for the CASTNET field and laboratory measurements are listed in Tables 2-6 and 3-3. Completeness measurement criteria and a summary of completeness criteria for data aggregations are listed in Table 5-3.

The application of the DQI to the hourly, weekly, and annual data that are required to satisfy CASTNET DQO are summarized in Tables 5-4 through 5-6.

5.3.1 Precision

Precision is a measure of the mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. The primary assessment of overall precision is made using collocated sets of equipment at two selected sites. Filter concentration measurements and continuous field measurements except gas analyzers are compared using the same protocol. Precision for gas analyzers, including O_3, is calculated as described in Table 4-12. In addition, all laboratory measurements require an assessment of analytical precision via replicate analysis.

The overall precision of meteorological variables and flow rate is assessed annually when the measurements have been validated at Level 3. O_3 precision is calculated quarterly for each analyzer as described in Table 4-12. Otherwise, precision is estimated by calculating the difference between simultaneous measurements (i.e., hourly averages) taken by separate instruments at collocated sites. Collocated sites have been selected to be representative of the observed range of pollutant concentrations and environmental conditions that exist within the network. Current collocated sites are Mackville, KY (MCK131/231) and Rocky Mountain National Park, CO (ROM206/ROM406). EPA sponsors the two sampling systems that are operated at MCK131 and also ROM206. ROM406 is sponsored by NPS. Although collocated, the two sites at Rocky Mountain National Park are serviced by different operators and calibrators. The overall precision of filter concentration and dry deposition data is assessed quarterly by calculating the absolute relative percent difference (ARPD) of values for simultaneous samples at collocated sites and averaging these values to produce the MARPD. MAD is used as a measure of precision for difference criteria such as for temperature.

Analytical precision within sample batches is assessed by replicating 5 percent of the filter extract samples within a run and by calculating the relative percent difference (RPD). Samples to be replicated are selected at random.

5.3.2 Accuracy

Accuracy is the difference between measured and referenced values. The difference between the two is expected to be within the precision interval for the measurement to be deemed accurate. The accuracy of field measurements is determined by challenging instruments with standards that are traceable to NIST. Continuing accuracy is verified during semiannual calibrations by Amec Foster Wheeler or subcontractor personnel. Accuracy objectives for field measurements are listed in Table 2-7.

The accuracy of laboratory measurements is determined by analyzing an independently prepared reference sample in each batch and calculating the percent recovery relative to the target (theoretical) value. The percent recovery must meet the acceptance criteria listed in Tables 3-3 and 3-4. The reference sample is traceable to NIST, or obtained directly from NIST (when available) as a standard reference material (SRM). Accuracy is also estimated by calculating the percent recovery of CCV spike samples in a batch. CCV are independently produced standards, which approximate the midpoint of the analytical range for an analyte, and are run after every tenth environmental sample.

5.3.3 Bias

Bias may be defined as the systematic or persistent distortion of a measurement process that causes errors in one direction. While no specific measurement criteria are currently established for reporting purposes, bias in the measurement process is monitored within the CASTNET program in the following ways:

- Analytical bias is assessed through the monitoring of reference sample recoveries over time via graphs and charts. The range of acceptable bias is bounded by the accuracy criterion for the parameter and method. Analytical bias is calculated and reviewed quarterly.
- Filter acceptance tests are performed to ensure that only batches of filters that meet the acceptance criteria are used for sample collection. In the filter acceptance testing process, 4 percent of nylon, Teflon, and impregnated cellulose filters are selected from each new box of filters and tested for background contamination. If results exceed nominal detection limits, the box of filters is rejected for use in field sampling. Statistical analysis has demonstrated that 4 percent of Teflon and nylon filters (or 4 filters from a box of 100) must be analyzed and found to be less than the reporting limit before 95 percent confidence that all filters in the box have blank contamination less than twice the reporting limit is established. Four percent of impregnated cellulose filters are also tested; although statistical analysis has not been performed.

- Laboratory filter blanks are analyzed to control for detection of sample contamination that could result in a positive bias. In the laboratory filter blank analysis process, an accepted blank filter is taken through the extraction process with each batch of field samples extracted and analyzed. If analysis results for the extracted blank are twice the nominal detection limit or higher, the cause of the problem is investigated and corrected and the corresponding batch of samples is reanalyzed, or the data are flagged, and documentation is supplied to justify acceptance of the data. The blank filter concentrations are analyzed for trends.

Bias in continuous data is assessed by monitoring internal performance audit results over time. The magnitude and difference between audit/calibration standards and site instrumentation are calculated.

5.3.4 Completeness

Completeness is defined as the percentage of valid data points relative to total possible data points. The minimum completeness objective for CASTNET is 90 percent (by parameter) for each calendar quarter. Any period for which the percent of valid data is less than 75 percent by site is reported as an invalid sampling period. This information is summarized in Table 5-3. The table also summarizes completeness criteria for data aggregations.

5.3.5 Representativeness

The representativeness of the CASTNET measurements can be assessed in terms of site locations and measurement methods. Most site locations are rural and were selected as regionally representative. The measurement methods were selected based on the best technology available at the beginning of the network.

Regional representativeness refers to the overall similarity of the site to the region surrounding the site. Regional representativeness is a desired site characteristic for assessing patterns in dry deposition and O_3 concentrations. Major and local sources of SO_2, NO_x, volatile organic compounds (VOC), and particulate matter are avoided to reduce the likelihood of local perturbation of concentration fields. In addition, land-use classification in the vicinity of the site generally matches the dominant regional land-use pattern to make use of meteorological data in V_d calculations. In areas of complex terrain, sites are located on relatively high ground to maximize wind fetch. As part of the process of determining a site’s regional representativeness, site-specific criteria that relate to conditions in the immediate vicinity of a prospective monitoring site are considered. Specifically, these criteria concern local features that may affect air quality, precipitation, and meteorological observations. Thus, local features that could influence wind speed, wind direction, and deposition patterns are evaluated. See Section 1.3.1.2 for an additional discussion of siting criteria.

CASTNET eastern sites were selected to represent their selective regions while at the same time to capture gradients in pollutant concentrations. The western sites were selected for locations where natural resources were at risk (e.g., national parks/monuments) or where specific research issues could be addressed.

The CASTNET open-faced filter pack was not designed to collect particles of a specified size distribution. Consequently, the size distribution of the particles collected on the Teflon filter is unknown, although other studies (e.g., Jansen *et al*., 2001; Malm, *et al*., 2000) suggest that the CASTNET filters collect SO_4^{2-} particles with a diameter in the range of 2.5 micrometers (µm). These studies also suggest that the size distribution of the collected NO_3^- particles is variable, depending on nearby land use, latitude, relative humidity, and other meteorological variables, and season. Lavery *et al.*, (2009) reported that CASTNET filter packs operated at Beltsville, MD (BEL116) measured a significant quantity of large nitrate particles in the form of sodium and calcium nitrate.

Representativeness of field sampling methodology may be evaluated by determining whether the particle size distribution on the filter is representative of the particle size distribution of the local atmosphere. To date, this has not been a requirement of CASTNET.

Established regional representativeness, data comparability (see following section), and sample integrity are the indicators in the representativeness of laboratory analyses.

5.3.6 Comparability

Field data comparability means that data collected during the sampling period are uniform in activity and purpose. The following procedures are employed to guarantee data comparability:

- Application of EPA and American Society for Testing and Materials (ASTM) methods, when available
- Reporting of data in conventional and standard units
- Implementation of identical SOP at each site
- Collocation of at least one site to ensure instrument/sensor comparability
- Comparability with other similar monitoring networks

CASTNET O_3 monitoring systems comply with regulatory monitoring requirements described in 40 CFR Part 58, Appendix C (EPA 2013), and data collected are routinely submitted to AQS.

The comparability of laboratory data may be defined as the confidence with which one data set can be compared with another. All data are calculated and reported in units consistent with standard procedures so the results of the analyses can be compared with those from other laboratories. Laboratory comparability objectives are:

- To demonstrate traceability of standards to NIST sources;
- To report results from similar matrices in standard units;
- To apply appropriate levels of QC within the context of the QA program; and
- To participate in interlaboratory comparison studies to document laboratory performance.

5.4 Data Quality Assessments

5.4.1 Purpose and Background

The CASTNET QA program encompasses all major QC procedures depicted in Figure 5-1. Internal, independent, and external audits are utilized. These audits are used to assess the components of the project and their compliance with the QA program.

All ambient monitoring methods or analyzers used for CASTNET field and laboratory operations are tested periodically to quantitatively assess data quality. Measurements of accuracy, precision and other DQI are estimated for both field and laboratory parameters at regular intervals and are specified for each type of monitor or method.

5.4.2 Internal and Independent Audits

The core of the QA program is the internal audit system. The internal audit program addresses all aspects of project operations from project level to task level. Internal audits are conducted routinely to assess all aspects of the project (Figure 5-1, Table 5-1, and Table 1-5). Additional, non-routine internal audits are performed at the QA Manager's discretion and/or at the request of other project personnel. The routine audits use CDMSA tools to trace data from their origin into the final validated database. These audits verify that established protocols are followed, data quality is achieved and maintained, and updates to the database are performed correctly and documented accurately.

Independent audits are conducted by qualified auditors who are not participants in the CASTNET program. These audits are used to assess the systems for obtaining project data and the performance of the instruments and technicians collecting or processing the data. After the audits are complete, recommendations are made to the Project Manager with respect to changes in procedures and documentation.

The results of all QA activities are reported in monthly progress reports, quarterly reports, quarterly QA reports, and reports to the CASTNET Management Team. Internal and independent audits of project operations are classified in the following subsections.

5.4.2.1 Project-Wide Assessments

Project-wide assessments address all components of the project including field, laboratory, and data operations. Internal project-wide assessments are used to:

- Monitor if actions in one area of the project affect other areas of the project,
- Verify that QA/QC procedures are being conducted according to this QAPP and applicable SOP, and
- Provide a framework for quick detection and response to problems that may occur.

Internal audits such as data quality assessments, surveillance, assessments of DQI, and QA/QC reports to management provide continuous monitoring of project status. Assessments of DQI are conducted quarterly. Additionally, changes to this QAPP and SOP are reviewed, revised, and approved as necessary. The document is reviewed a minimum of once annually. Other internal assessments such as management systems reviews and readiness reviews are conducted as needed.

An independent gauge of overall project quality is provided in the form of peer review of the publications and conference papers that result from the data generated by the project.

5.4.2.2 Operating Unit Assessments

Internal and independent assessments address various components of the project at the operating unit level. Different assessments are used for each operating unit to satisfy specific QA/QC requirements and to verify that procedures are being conducted according to this QAPP and operating unit related SOP.

5.4.2.2.1 Field Operations Assessments

Internal assessments are used by Amec Foster Wheeler field and field subcontractor personnel on an ongoing basis. Surveillance of field activities is performed weekly on Tuesdays when site operators call Amec Foster Wheeler field personnel to report on site status and complete the SSRF that is returned to Amec Foster Wheeler with the exposed filter pack. Additional surveillance activities include weekly meetings and review of calibration documentation. Field surveillance activities verify that sites are operating properly and provide timely notification to Amec Foster Wheeler field personnel when a problem occurs. Field TSA are performed biannually to verify that stations are properly sited, installed, operated, and maintained and to verify conformance of field sampling activities with the CASTNET Field SOP (Appendix 1) and this QAPP. Field PE are performed biannually with the TSA to challenge each gaseous analyzer, filter pack/deposition monitor, meteorological sensor, and support system with a certified reference standard to verify that each is operating within CASTNET accuracy goals.

Independent field assessments are generally not performed for this contract. However, field laboratory and field management systems are assessed by A2LA. If utilized, independent audit personnel who are not involved in operation of the CASTNET project would provide an unbiased review of a site’s conformance to documented procedures and operation of instruments with regard to accuracy goals. The independent auditors would report findings to the Amec Foster Wheeler QA Manager and Field Operations Manager. The Amec Foster Wheeler CASTNET Project Manager would be notified of findings as well.

5.4.2.2.2 Laboratory Operations Assessments

Internal laboratory assessments are conducted on an ongoing basis. Surveillance is used by the LOM and other personnel to verify that laboratory analytical procedures and instrumentation continue to meet project DQO. Surveillance activities include frequent review of laboratory data and QC documentation and weekly meetings. Internal TSA are conducted routinely by the QA Manager and consist of separate audits of data and procedures that, when combined, yield an overview of the entire process. Internal TSA consist of various types of audits such as method audits, life history audits of laboratory data, and filter acceptance audits. Internal PE are ongoing and consist of routine QC procedures implemented for each analytical method to verify achievement of project DQI. The CASTNET laboratory analyzes a reference sample of known value and traceable to NIST at the beginning and end of each analytical run for each group of CASTNET samples. Analytical accuracy is determined by the analysis of reference samples and CCV. Laboratory precision is estimated via analysis of replicate samples.

Independent TSA are conducted by qualified independent auditors. Additionally, laboratory performance is independently evaluated on a quarterly basis through participation in intercomparison studies conducted by Environment Canada (ECAN) and the USGS Interlab. A2LA assesses laboratory operations every two years. Study results are reviewed by the LOM and QA Manager. The Project Manager is notified of the audit results.

5.4.2.2.3 Data Operations Assessments

Data generated by project activities must be as precise, accurate, complete, and usable as possible. The internal data assessment process is ongoing with both program level and operations level daily, weekly, quarterly, biannual, and annual assessments incorporated into the data review and data validation process (see Table 1-5, Project Assessments by Program Component). The data validation process involves each level of data processing from data collection and entry into the system through data delivery. In addition to the redundancies built into the data validation process, internal TSA and PE trace data points from field collection through laboratory analysis and data validation. In addition to the data validation process, the DMAIRM and data operations personnel take steps to ensure that the documentation and data processing, validation, and backup procedures conform to procedures described in this QAPP. Additionally, they verify that the computer software and hardware used for storage of CASTNET data and management of the DMC are operating within CASTNET goals. These internal TSA and PE are conducted annually by the DMAIRM and QA Manager.

A thorough, independent TSA by a qualified auditor not associated with CASTNET reviews data management activities from data ingestion through reporting to EPA. Independent data operations TSA are conducted every two years. Likewise, an independent PE is conducted every two years to verify that the hardware, CASTNET Data Management System software, data security, and computer programming necessary to manage, maintain, and deliver the CASTNET data are operating within CASTNET accuracy goals and in conformance with this QAPP. Results are evaluated by the DMAIRM and QA Manager and reported to the Project Manager.

5.4.2.3 Task Level Assessments

Task level assessments are built into daily project activities and are performed as needed. Surveillance is performed at all levels of the project by all project personnel. Readiness reviews are conducted as needed. For field operations, readiness reviews are generally performed before instrument installations (e.g., for small footprint sites), site visits (e.g., repair or calibration visits) or before embarking on a multi-site task (e.g., upgrading the site ozone systems). Readiness reviews for the laboratory and for data operations are performed as needed, generally when preparing for a special study or other non-routine activity.

5.4.2.4 Readiness Review

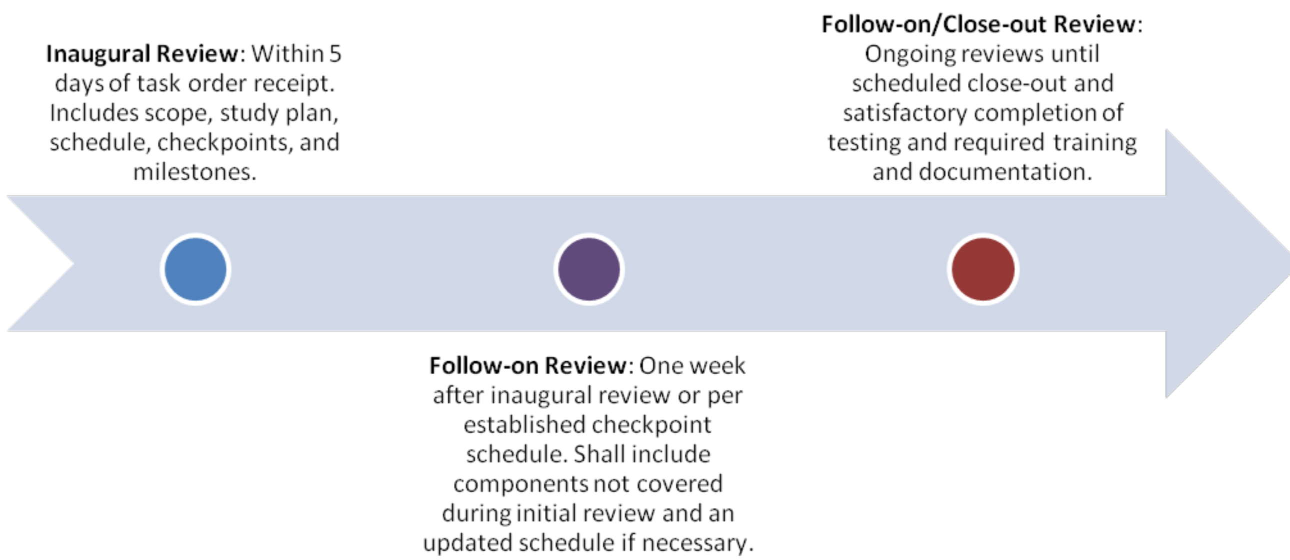
5.4.2.4.1 Overview

A readiness review is a systematic assessment of the preparedness of an organization to start or continue a project phase. Readiness reviews are conducted as needed. For field operations, readiness reviews are generally performed before site visits (e.g., repair or calibration visits) or before embarking on a multi-site task (e.g., upgrading the site ozone systems). Readiness reviews for the laboratory and for data operations are performed as needed, generally when preparing for a special study or other non-routine activity. A readiness review is performed to determine if the manpower, equipment, and supply needs have been addressed.

5.4.2.4.2 Review Components for New Tasks

The following figure illustrates the overall assessment. For new tasks within CASTNET most items may already be in place and assessed as satisfactory or only in need of minor change. The review may include several meetings until all checkpoints and associated reviews have been successful as determined by the project manager.

Figure 5-3 Readiness Review



A readiness review covers:

- Scope
- Equipment list/cost
- Budget
- Schedule

- Contracts/subcontracts
- Safety design and preparation
- Acceptance criteria
- QA plan (if required by task order)
- Management review of completed scope/deliverables

5.5 Assessments and Audits

5.5.1 Data Quality Assessments and Response Actions

Data are continually evaluated at each task level for validity and reasonableness. Operating unit and program level assessments are performed by members of the Management Team quarterly and annually to determine the adequacy of the data for its intended use. The rest of Section 5.5 will discuss the assessments performed for the CASTNET project. Assessments and response actions are summarized in Tables 5-1 and 5-2.

5.5.2 Management Systems Review

Prior to using any subsidiary organizations or subcontractors to perform data collection, processing, or analysis for the project, an assessment of that organization is performed by the Project Manager, QA Supervisor, and QA Manager or their designated representatives. This qualitative assessment verifies that the QA management structure, policies, practices, and procedures of the organization or subcontractor are adequate for ensuring the type and quality of data needed for the program. It also verifies that sufficient management controls are in place and carried out in a manner consistent with the overall program objectives. Standard response actions to nonconforming conditions disclosed by a management systems review audit are summarized in Table 5-2.

5.5.3 Readiness Review

A readiness review, or kick-off meeting, is performed to determine if all components of the program are in place so work can commence on specific tasks. This is a task-level assessment that incorporates program-wide participation. Personnel who are invited to this readiness review include the Project Manager, QA Manager, FOM, LOM, DMAIRM, Task Order Managers, field coordinators, and subcontractors or their designated representatives. For example, prior to the semiannual site visits for instrument calibrations, a readiness review is performed to determine if the manpower, equipment, and supply needs have been addressed.

5.5.4 Technical Systems Audits and Performance Evaluations

TSA provide thorough, systematic, on-site, qualitative audits of facilities, equipment, personnel, training, procedures, record keeping, data validation, data management, and reporting aspects of a system. These audits reveal how the data were handled; what judgments were made; and whether any errors occurred during data handling, validation, and documentation. Systems audits monitor the effectiveness of the QC system. The CASTNET QA program employs internal, independent, and external TSA to verify conformance of the various components of the project with the QAPP. Specific types of TSA are used for the field, laboratory, and data operations components of the project. Field TSA are performed in conjunction with field PE.

PE are a type of audit in which the quantitative data generated by the measurement system are obtained independently and compared with routinely obtained data to evaluate the precision, accuracy, or proficiency of a field or laboratory instrument, laboratory analytical method, or computer program. The CASTNET QA program utilizes internal, independent, and external PE of field, laboratory, and data operations to assess project conformance with DQI measurement criteria. Specific types of PE used for the field, laboratory, and data operations components of the project are described in the following subsections.

5.5.4.1 Field Operations

5.5.4.1.1 Field Operations - Technical Systems Audits

The objective of a field systems audit is to verify that stations are properly sited, installed, operated, and maintained in compliance with project QA procedures, DQO, and SOP. The CASTNET QA program employs internal TSA performed by Amec Foster Wheeler field operations or management personnel and external TSA sponsored by EPA. Independent, third party TSA are not currently performed.

These TSA are used to verify conformance of field sampling activities with the CASTNET Field SOP (Appendix 1) and this QAPP.

Reference standards used to audit the CASTNET instrumentation are certified by an approved certifying agency. Certification documentation for reference standards is maintained in the field laboratory by the FOM.

5.5.4.1.2 Field Operations - Performance Evaluations

The objective of a field PE is to physically challenge each gaseous analyzer, filter pack/deposition monitor, meteorological sensor, and support system with a certified reference standard to verify that each is operating within CASTNET accuracy goals. The CASTNET QA Management Team utilizes PE performed by internal Amec Foster Wheeler or subcontractor field operations personnel and external PE administered by EPA, or its designee, at its discretion to assess field operations conformance with DQI criteria. Different CASTNET monitoring site configurations exist, depending on specific site objectives. The instrumentation type employed for CASTNET Base Operations may include:

- Filter pack for estimating dry deposition
- Data acquisition systems (DAS)
- Ozone analyzers
- Trace gas analyzers at six EPA sites
- Meteorological instruments at four EPA sites

- ◊ Wind speed sensors
- ◊ Wind direction sensors
- ◊ Temperature sensors
- ◊ Relative humidity sensors
- ◊ Solar radiation sensors
- ◊ Precipitation sensors
- ◊ Surface wetness sensors

All instruments at each site are audited. Audit results are compared to the current CASTNET acceptance criteria to determine whether an instrument passes or fails an audit (Table 2-6).

Reference standards used to audit the CASTNET instrumentation (Table 5-7) are certified by an approved certifying agency. Certification documentation for reference standards is maintained in the field laboratory by the FOM.

5.5.4.1.3 Field Operations - Internal Technical Systems Audits

Internal TSA of field operations are conducted by the QA Manager; FOM; field coordinators, field technicians, and/or other designated field operations personnel; or management personnel. Detailed procedures are performed by the field operations personnel for equipment checks, preventive and corrective maintenance, sample media collection, DAS operation, filter pack change-outs, documentation preparation, and shipment of samples and are described in the CASTNET Field SOP (Appendix 1). Amec Foster Wheeler or subcontractor field technicians visit each site once every six months to perform site inspection and evaluation, equipment inventory, and instrument and sensor calibrations. A sample field calibration schedule is provided in Table 2-13. Field Internal TSA components are summarized in Table 5-8.

Transfer standards used to evaluate CASTNET instrumentation (Table 5-9) are certified by an approved certifying agency. Certification documentation for transfer standards and NIST audit standards is maintained by the FOM.

5.5.4.1.4 Field Operations - Internal Performance Evaluations

The semiannual calibrations of field instrumentation also serve as internal PE (Table 5-7) and provide information on instrument accuracy. Every six months Amec Foster Wheeler or subcontractor technicians visit each site to perform routine calibration and maintenance of all sensors and instruments. All instruments at each site are evaluated according to the calibration acceptance criteria listed in Table 2-7. Through monthly review of field calibration results, the FOM and QA Manager monitor field data for completeness, accuracy, and conformance with SOP, DQI criteria, and DQO. Field calibrations are critical to achieving and maintaining conformance with project DQI measurement criteria. Amec Foster Wheeler has developed calibration criteria (Table 2-7) with stricter limits than project DQI (Table 2-6). Calibration results are entered on the individual calibration data forms (Figure 2-13 provides an example completed form for ozone) and are reviewed by the FOM and field coordinators. See Section 2.4 for a description of specific field calibration procedures.

QC failures are monitored monthly through review of the calibration result summaries, percent data recovery reports, and the Field Problem Report database. Quarterly review of the Level 3 continuous database verifies the thoroughness and accuracy of validation decisions prompted by field QC failures.

5.5.4.1.5 Field Operations - Independent Audits

Independent audits (i.e., audits by an independent entity that is not managed by the EPA) of field operations are not performed routinely under the current contract.

5.5.4.1.6 Field Operations - External Technical Systems Audits

External TSA of the sampling sites are managed and executed by EPA or its designee at its discretion. External TSA are performed in conjunction with external PE and are generally described in Table 5-8. Currently, all sites will be audited over a two-year period. Ozone systems are audited annually. Audits conducted by EPA or its designee are conducted outside the auspices of this program.

5.5.4.1.7 Field Operations - External Performance Evaluations

External PE of the sampling sites are managed and executed by EPA or its designee at its discretion. External PE are performed in conjunction with external TSA. All instruments at each site are evaluated according to the methods listed in Table 5-7.

CASTNET O_3 monitoring systems receive the following external audits (see Table 4-12, Ozone Validation Template):

- Annual single analyzer performance audit
- Biennial National Performance Audit Program (NPAP) audit

The NPAP provides EPA a means to assess the proficiency of agencies that are operating monitors in the SLAMS network, under the PSD permits program and in CASTNET. The NPAP is a quality assurance audit program required under Section 2.4 of 40 CFR Part 58, Appendix A. CASTNET audits are performed by injecting known air quality concentrations through the sampling probe.

Audits conducted by EPA or its designee, are conducted outside the auspices of this program and are not further discussed in this section.

5.5.4.2 Laboratory Operations

5.5.4.2.1 Laboratory Operations -Technical Systems Audits

Although the laboratory TSA is similar in philosophy to the field TSA, the procedural activities differ substantially. While the field TSA is site specific, the laboratory TSA encompass both laboratory analysis and data processing activities. The laboratory operations that are audited include:

- Organization and personnel;
- Facilities;
- Material procurement and acceptance testing;
- Instrumentation;
- Analytical methods;
- Sample tracking, data validation, and data management;
- Laboratory records and documentation; and
- Traceability.

As with the field operations component, the CASTNET QA program employs multiple audit systems to perform TSA to verify conformance of laboratory activities with CASTNET Laboratory SOP (Appendix 4) and the QAPP. The external laboratory TSA are performed by EPA at its discretion. Specifics of the internal and independent laboratory operations TSA are described in the following subsections.

5.5.4.2.2 Laboratory Operations - Performance Evaluations

Laboratory PE includes assessments of instrument precision and accuracy through reference sample analysis and evaluation of method performance data, such as precision and accuracy statistics generated via round robin studies. The object of the PE is to verify that each method and instrument is operating within CASTNET accuracy goals. The CASTNET QA Management Team utilizes internal, independent, and external PE to assess laboratory operations conformance with DQI criteria. Internal and independent laboratory PE are described in the following subsections. External laboratory PE are conducted by EPA at its discretion.

5.5.4.2.3 Laboratory Operations - Internal Technical Systems Audits

The QA Manager and LOM conduct routine TSA of laboratory operations. Internal TSA consist of separate audits of data and procedures, which when combined, yield an overview of the entire process. A description of the internal QA/QC procedures used during laboratory TSA can be found in Table 5-10. The following audits and procedures illustrate components of an internal laboratory TSA.

5.5.4.2.3.1 Laboratory - Method Audits

A method audit traces a sample from preparation through chemical analysis and verifies, via *in situ* observations, whether documented procedures are followed. The semiannual audit includes the following procedures.

- Analysis method is selected either at random or in response to observed problems.
- One group of samples scheduled for the analysis method is selected. The extraction process is observed.

- Standard preparation procedures for the appropriate analytical instrument (IC, ICP-OES, or AC) are observed. This portion of the audit may include review of analytical instrument calibration and maintenance logs; standard preparation logs; deionized (DI) water system operation and maintenance logs; glassware cleaning procedures; and acquisition, quality, and storage of reagents.
- Initial start-up procedures (for the run containing the selected samples) for the selected analytical method are observed. These procedures include sequencing and injection of samples, calibration of instrument(s), and analysis of the initial QC samples for precision and accuracy. Maintenance logbooks for each instrument and the results of the initial QC checks with the calibration curve data are reviewed.
- Adherence to (or departure from) SOP is verified, documented, and presented in the audit report. Problems that cannot be immediately resolved are handled by issuing an NCAF.

5.5.4.2.3.2 Life History Audits of Laboratory Data

A life history audit traces a sample from media testing and preparation through chemical analysis and ultimately, to incorporation into the validated database. This type of audit verifies all aspects of the sampling process that are under laboratory control. The audit procedure is performed annually as follows:

- Acceptance testing is audited. All pertinent logbooks, records, and other documentation are reviewed.
- A sample or group of samples is selected at random. The procedures for preparation, shipment, receipt, and extraction are observed.
- Standard preparation procedures for each analytical instrument (IC, ICP-OES, and AC) are observed. This portion of the audit includes a review of analytical instrument calibration and maintenance logs; standard preparation logs; DI water system operation and maintenance; cleaning procedures for glassware; and acquisition, quality, and storage of reagents.
- Initial start-up procedures (for the run containing the selected field group and/or sample) for each analytical instrument are observed. These procedures include sequencing and injection of samples, calibration of instrument(s), and analysis of the initial QC samples for precision and accuracy. Maintenance logbooks for each instrument and results of initial QC checks along with calibration curve data are reviewed.
- Adherence to (or departure from) SOP is verified, documented, and presented in the audit report. Problems that cannot be immediately resolved are handled by issuing a NCAF.

5.5.4.2.3.3 Filter Acceptance Audits

Filter acceptance audits are performed quarterly as follows:

- All acceptance test data for Teflon, nylon, and cellulose filters are reviewed to ensure that only batches of filters that meet the acceptance criteria are used for sample collection.

- If analyses were performed using filters that failed acceptance testing, the resulting data are closely reviewed, and additional filters from the same batch are tested. If the data appear unacceptable or the batch fails the second test, the data are invalidated. If the data appear acceptable and the additional filters from the batch pass the second test, the data are accepted.

5.5.4.2.4 Laboratory Operations - Internal Performance Evaluations

Internal PE consist of routine QC procedures implemented for each analytical method to verify achievement of project DQI goals. The CASTNET laboratory analyzes a reference sample of known value and traceable to NIST at the beginning and end of each analytical run for each group of CASTNET samples. Analytical accuracy is determined by the analysis of reference samples and CCV. Laboratory precision is estimated via analysis of replicate samples. The precision and accuracy requirements of these samples are listed by analyte in Table 3-3. The results of the reference sample analyses are reviewed by the LOM and QA Manager and are reported to EPA quarterly and annually. Table 5-11 provides a summary of laboratory PE components and acceptance criteria.

5.5.4.2.5 Laboratory Operations - Independent Technical Systems Audits

An independent TSA is performed and evaluated every two years by an independent auditor. Additional audits are performed as directed by the Project Manager or EPA Project Officer. The tests and procedures discussed in following subsections may be included as components of an independent laboratory TSA.

5.5.4.2.5.1 Substrate Procurement and Acceptance Testing

This audit applies to filter substrates, reagents, DI/distilled water, and sample transfer containers. The auditor reviews the latest revisions of procurement and acceptance testing policies and prepares a list of sampling substrates, acceptance criteria for each substrate, and the frequency of testing to be performed on each lot received from the vendor. The independent auditor examines all purchase orders for substrates and records the substrate specifications contained in the orders. The lot ID numbers and results of acceptance tests performed on substrates taken from each lot are compiled into a report to verify that testing has been routinely performed and that the materials passed.

5.5.4.2.5.2 Documentation Review

The laboratory documentation is examined to determine that:

- SOP exist for routine procedures;
- Maintenance logs and analysis run logs are in place for instrumentation and supporting equipment (i.e., DI systems);
- Verifiable chain-of-custody documentation exists for samples and data packages; and
- Documentation is conveniently located for use by laboratory personnel.

5.5.4.2.5.3 Standard Operating Procedure Review

The independent auditor reviews the latest revisions of laboratory and data SOP to determine if procedures are up-to-date at the time of the review. The independent auditor, in cooperation with the QA Manager, prepares a set of procedural elements to be verified against the actions of the laboratory analysts and data processing assistants. The independent auditor interviews a selection of laboratory analysts and data processing assistants to ascertain whether the procedural elements are being followed. This interview consists of both questions and observations of personnel activities. The procedural elements selected consist of those which:

- Are most critical for acquisition of valid data;
- Reflect recent changes in procedures; or
- Have exhibited problems in previous audits.

5.5.4.2.5.4 Laboratory Inspection

Substrate processing, shipping, receiving, data processing, and sample analysis areas are inspected for general cleanliness, adequate space, safety, and efficiency. Special attention is given to the potential for contamination from ventilation systems, cleaning fluids (e.g., ammonia floor cleaners), and human contact with substrates. DI/distilled water preparation systems are examined, and records of conductivity meter readings and water quality parameters are reviewed.

5.5.4.2.5.5 Spare Parts and Supplies

SOP and manuals are reviewed by an independent auditor to determine quantity of spare parts, reagents, and blank substrates kept in the laboratory. These parts and supplies are identified by the independent auditor and compared with the specified quantities. If parts and supplies are not present in adequate quantities, the independent auditor makes recommendations to the Project Manager to replenish supplies and spare parts.

5.5.4.2.5.6 Traceability Audit

The independent auditor reviews data reports issued within the previous year and selects a single sample for each type of analysis. The independent auditor also notes whether substrate procurement, acceptance testing, substrate preparation, standardization, data processing, data validation, performance testing, and auditing procedures are performed. This review involves the location of those data sheets, logbooks, purchase orders, audit reports, and control charts that pertain to the particular measurement being traced. The reported value is manually calculated from the raw data to verify automated data management routines. Instrument calibration dates bracketing the measurement value are recorded. The time between these calibrations are compared with those specified in the CASTNET Laboratory SOP (Appendix 4).

5.5.4.2.5.7 Laboratory Operations - Independent Auditor Training

Independent laboratory auditors have training and experience commensurate with that of the laboratory operations staff. Auditors are qualified to train additional auditors, as necessary.

5.5.4.2.6 Laboratory Operations - Independent Performance Evaluations

The CASTNET laboratory participates in laboratory intercomparison studies conducted by the ECAN National Water Research Institute (NWRI) National Laboratory for Environmental Testing (NLET) and the USGS Interlaboratory (Interlab) Comparison Program for Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, NH_4^+, Cl^-, NO_3^-, SO_4^{2-}, pH, and specific conductance. The ECAN study is conducted every six months, and the USGS study is conducted approximately twice each month. Each study result is reviewed by the LOM, who then reports to the CASTNET QA Management Team. A description of NLET, found on the Web site, http://www.ec.gc.ca/inre-nwri/Default.asp?lang=En&n=7A20877C-1, describes their proficiency testing program. Amec Foster Wheeler participates in the Rain and Soft Waters Program.

The USGS Web site, http://bqs.usgs.gov/precip/interlab_overview.php, describes the Interlab program:

> The objectives of the Interlab program are: (1) to verify the quality of chemical analyses of precipitation samples determined by the Central Analytical Laboratory (CAL), (2) to estimate the analytical precision of participating laboratories, and (3) to determine if statistically significant differences exist among the analytical results of participating laboratories. Samples from the following sources are used in the interlaboratory-comparison program: (1) synthetic wet deposition samples (USGS) and ultrapure deionized water samples (Ultrapure) prepared by the U.S. Geological Survey, (2) commercially prepared, standard reference samples with certified values that are U.S. NIST traceable or prepared by the NIST, and (3) excess natural wet-deposition samples collected at NADP/NTN sites and bottled by the [Central Analytical Laboratory (http://nadp.sws.uiuc.edu/cal/defaultnew.htm) in Champaign, Illinois].

Reference standards used to audit CASTNET instrumentation (Table 5-11) are certified by the producing laboratory or by an approved certifying agency. Certification documentation for reference standards is filed in the CASTNET laboratory. Certification documentation for reference samples used for the intercomparisons is available from the agencies administering the studies.

5.5.4.2.7 Laboratory and Data Operations - External Audits

External TSA and/or PE are managed and executed by EPA or its designee at its discretion. These audits may include any or all of the elements described in the previous sections on independent audits. Audits conducted by EPA or its designee are conducted outside the auspices of this program and are not further discussed in this section.

5.5.4.3 Data Operations

5.5.4.3.1 Data Operations -Technical Systems Audits

In order to satisfy CASTNET DQO, the data generated by all project activities must be as precise, accurate, complete, and usable as possible. The data validation process, described in Section 4.3 of this QAPP, involves each level of data processing from data collection and entry into the system through data delivery. The DMC uses internal, independent, and external TSA, in addition to the data validation process, to maintain the high quality of data required for the project and to verify conformance of DMC activities with the QAPP. Internal and independent TSA are described in the following subsections. External data operations TSA are conducted by EPA, at its discretion. The components of a TSA of the DMC are listed in Table 5-12 and are generally described as follows:

- Verification of software documentation and management
- Verification of security procedures
- Verification that operators are trained, and training is documented
- Review and challenge of automated data entry procedures
- Verification and evaluation of procedures for changing data
- Review and verification of data backups
- Verification and documentation of hardware maintenance procedures
- Assessment of system failure procedures

5.5.4.3.2 Data Operations - Performance Evaluations

The object of the DMC PE is to verify that hardware, database management system software, data security, and computer programming necessary to manage, maintain, and deliver the CASTNET data are operating within CASTNET accuracy goals and conformance with this QAPP. The CASTNET QA Management Team utilizes internal, independent, and external PE to assess DMC conformance with DQI goals. Internal and independent data operations PE are described in the following subsections. External data operations PE are conducted by EPA at its discretion. Assessments of the data operations component of the project are also summarized in Table 5-1. The primary components of data operations PE are listed in Table 5-13.

5.5.4.3.3 Data Operations - Internal Technical Systems Audits

The DMC is the repository for CASTNET data and contains data ranging from raw data to those validated at the highest level. In addition to all of the checks and procedures taken to ensure that the data are of the highest quality, the DMAIRM and data operations personnel take steps to ensure that the documentation and data processing, validation, and backup procedures conform to procedures described in this QAPP. An internal TSA of the DMC is conducted annually by the DMAIRM and QA Manager. The primary components of data operations TSA are described in Table 5-12.

5.5.4.3.3.1 Data Operations - Field Data - Internal Technical Systems Audits

A process of evaluation and validation is necessary to ensure that data collection is planned and executed properly. In addition to the redundancies built into the data validation process, internal TSA of field data trace the process from sample collection at the site through Level 3 validation. Field data audits function as internal TSA to verify that manual data transactions and validation decisions are properly implemented and adequately documented. The audit procedures are as follows:

- Field data are validated in monthly groups. Validation documentation includes a Continuous Data Review Form (CDRF) and a Continuous Data Validation Summary (CDVS) on which all validation decisions are documented (see Figures 4-5 and 4-6, respectively).
- The sites in the monthly validation groups are audited quarterly using CDMSA tools.
- Manual data entries noted on the selected CDRF are verified by inspection of the Level 3 database.
- To detect undocumented or inadvertent changes to the Level 3 database, selected sites are reviewed to ensure that all data source flags agree with CDRF entries.

5.5.4.3.3.2 Data Operations - Laboratory Data - Internal Technical Systems Audits

In addition to the redundancies built into the data validation process, internal TSA of laboratory data trace the process from sample analysis through Level 3 validation. Laboratory data processing and QC activities are summarized in Section 4.3.5 and in Table 5-14.

5.5.4.3.3.3 Data Operations - Internal Performance Evaluations

The object of the PE is to verify that the computer software and hardware used for storage of CASTNET data and management of the DMC are operating within CASTNET goals. Internal PE are conducted annually by the DMAIRM and QA Manager. The components of the data operations PE are described in Table 5-13 and are generally described as follows:

- Verification that data were reported accurately in correct units and were appropriately flagged; and
- Determination if data can be traced back to the original measurements.

5.5.4.3.4 Data Operations - Independent Technical Systems Audits

The data management systems audit is conducted every two years by an independent auditor. The procedure consists of a thorough review of data management activities from data ingestion through reporting to EPA. Included in the audit is an examination of documentation, data processing, validation, and backup procedures. Results are evaluated by the Project Manager, QA Manager, and QA Supervisor. The primary components of data operations TSA are described in Table 5-12.

5.5.4.3.5 Data Operations - Independent Performance Evaluations

An independent PE is conducted once every two years by an independent auditor to certify that the computer software and hardware used for storage of CASTNET data and management of the DMC are operating within CASTNET goals. An independent PE follows the same procedures described for an internal PE. See Table 5-13 and Section 5.5.4.3.3.

5.5.5 Surveillance

Frequent monitoring of the project status is performed to ensure that all project requirements are being fulfilled. Surveillance is conducted through various means at levels of the project from program-wide to task level surveillance. During weekly project meetings, action items, upcoming events, deliverable schedules, status of corrective actions and project deadlines are identified and discussed. At a minimum, the following personnel are present at the meetings: the Project Manager, QA Manager, FOM, LOM, DMAIRM, and Task Order Managers or their designated representatives. Subcontractors are present as requested. Surveillance activities used for the field, laboratory, and data operations components of the project are summarized in the following subsections.

5.5.5.1 Field Operations Surveillance

The FOM and field coordinators monitor the status of field operations through:

- ♦ Weekly project meetings with the Project Manager, QA Manager, LOM, and DMAIRM;
- ♦ Weekly telephone calls Tuesday from site operators;
- ♦ Calibration results summaries review;
- ♦ Data review; and
- ♦ Scheduled site visits to determine if the sites and equipment continue to operate such that project DQO are met.

5.5.5.2 Laboratory Operations Surveillance

The LOM monitors the status of laboratory operations through weekly project meetings with the Project Manager, QA Manager, FOM, and DMAIRM, and through data review to determine if laboratory analytical procedures and instrumentation continue to meet project DQO. The LOM also holds routine meetings with laboratory chemists.

5.5.5.3 Data Operations Surveillance

Data for the CASTNET project are acquired and transferred into the databases from several sources. The DMAIRM performs frequent monitoring of the data and the transfer processes to ensure that the integrity of the database is maintained. The DMAIRM monitors the status of the data through data review; weekly project meetings with the Project Manager, QA Manager, FOM, field coordinators, and LOM; and through the procedures detailed in Section 4.0 to determine if data meet project DQO.

5.5.6 Assessments of Data Quality Indicators

DQI apply to the field, laboratory, and data operations components of the project. DQI are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of data. The DQI are precision, accuracy, bias, completeness, representativeness, and comparability. Precision, accuracy, bias, and completeness are quantitative measures; and representativeness and comparability are qualitative measurements. The DQI and their associated measurement criteria are defined in Section 1.5.2 and in the following subsections.

5.5.6.1 Precision

The overall precision of meteorological variables and flow rate is assessed annually by calculating the difference between simultaneous measurements (i.e., hourly averages) taken by separate instruments at collocated sites. Instrument and analytical precision is discussed in Sections 1.5.2.1 and 5.3.1. Precision of O_3 measurements is summarized in Table 4-12.

5.5.6.2 Accuracy

Accuracy results are viewed routinely during the field and laboratory systems audits. Refer to Sections 1.5.2.2 and 5.3.2 for detailed descriptions of methods and corresponding equations for assessment of accuracy.

5.5.6.3 Bias

Analytical bias is assessed by monitoring reference sample recoveries over time via graphs and charts. The range of acceptable bias is bounded by the accuracy criterion for the parameter and method. Analytical bias is calculated and reviewed quarterly. Bias in continuous data is assessed by monitoring internal PE audit results over time. The magnitude and difference between audit/calibration standards and site instrumentation are calculated. Bias is assessed annually using data from specified parameters collected over a minimum of two years at selected sites.

5.5.6.4 Completeness

Adherence to completeness criteria is calculated and reviewed quarterly. The completeness criteria by parameter and for data aggregations are summarized in Table 5-3. If completeness criteria are not met, possible causes are investigated and corrective actions are issued when applicable.

5.5.6.5 Representativeness

The definition of representativeness with respect to the CASTNET program is presented in Section 5.3.5. Within CASTNET there are several types of representativeness and each addresses a different question:

- **Regional:** Are sampling sites representative of the surrounding area? A site's ongoing representativeness is monitored via internal and external TSA.

- **Field sampling methodology:** Are sampling methods representative of actual atmospheric conditions? Field sampling methods used for CASTNET are monitored via collocated precision data from sites collocated with other networks (as discussed in Section 5.3.5).
- **Laboratory analytical methodology:** Are analytical method results representative of the collected sample? Laboratory precision data and results from the USGS and ECAN laboratory intercomparison studies demonstrate representativeness.

5.5.6.6 Comparability

In general, the comparability of field and laboratory measurements was addressed at the onset of CASTNET by adherence to standard practices such as the use of traceable reference and/or transfer standards, and reporting of data in conventional units. See Section 5.3.6 for a more in-depth discussion of these standard practices as well as more information on comparability.

Network comparability is best demonstrated by comparing data from sites collocated with other networks. The collocated CASTNET/CAPMoN site at Egbert, Ontario, Canada is ideally suited for such a comparison, especially since the field sampling methodologies are different: daily sampling for CAPMoN versus weekly sampling for CASTNET. The collocated EPA/NPS site at Rocky Mountain National Park also provides data for evaluation of comparability. IMPROVE measures aerosol pollutants near more than 30 CASTNET sites. These data are useful to gauge comparability of some parameters, e.g., particulate sulfate concentrations.

5.5.7 Peer Review and Presentation of Data

Peer review is primarily designed for scientific review of the project. CASTNET team members submit project data and results to reputable and respected scientific journals or conferences for publication or presentation, subject to approval and acceptance by juried peer reviewers. Reviewers are chosen who have technical expertise comparable to that of CASTNET team members, but who are independent of the project. Peer reviews ensure that the project activities:

- Were technically adequate,
- Were competently performed,
- Were properly documented,
- Satisfied established technical requirements, and
- Satisfied established QA requirements.

Peer reviews assess the assumptions, calculations, extrapolations, alternative interpretations, methods, acceptance criteria, and conclusions documented in the report.

5.5.8 Third Party Audits

Third party audits may be performed by EPA regions or state or local agencies to assess the performance of project monitoring – particularly ozone and ozone precursors. Access to CASTNET sites and equipment will be arranged upon request. Requests for access are submitted to the QAM (primary Amec Foster Wheeler contact) and the PM. The auditing agency will provide:

- Agency and auditor information
- Site(s) to be audited
- Audit parameters
- Proposed audit schedule
- Audit results upon completion

CASTNET management will provide the following to the auditing agency:

- Site access information
- Site operator contact information
- Schedule to accommodate all parties
- Site technical support as needed regarding the audit

CASTNET management will ensure that EPA Technical Monitors are apprised of all audits performed at CASTNET sites along with audit results once received.

5.6 Quality Assurance/Quality Control Reports to Management

5.6.1 Purpose/Background

Effective communication between all personnel is an integral part of the comprehensive CASTNET QA Program. The purpose of planned meetings and reports is to provide a regular, timely structure for apprising the Project Manager and members of the CASTNET QA Management Team of any deviations from the project schedule and approved QA and SOP guidelines, together with the impact of any such deviations on DQI results and conformance with DQO, and the potential uncertainties in decisions based on the data. In addition to weekly meetings with project management, results of QA activities are submitted as routine audit reports to internal CASTNET management personnel and as monthly technical progress reports, quarterly reports, quarterly QA reports, annual reports, and annual QA reports to EPA. See Table 1-6.

5.6.2 Report Frequency

All QA reports or QA sections of reports are prepared and written by the QA Manager, or his designee, and submitted to the Project Manager and other managers as specified. Routine audit reports are submitted within two weeks of any audit. This ensures that management is aware of data quality problems and proposed solutions. Results of QA activities are also submitted to EPA in the following reports:

- **Monthly Technical Progress Reports** – submitted by the 15th of each month.
- **Quarterly Reports** – submitted 120 days after the end of the reporting quarter.
- **Quarterly QA Reports** – submitted 30 days after the end of the calendar quarter.

- **Annual Reports –** submitted as draft by August 15th of the following year with a final copy submitted 30 days after receipt of final comments from EPA.
- **Annual QA Reports –** submitted 30 days after the end of the fourth quarter. The fourth quarter report doubles as the annual report.

5.6.3 Report Contents

The routine audit reports present systems audit results. The information presented includes observations highlighting points of interest, findings requiring corrective action, and associated NCAF.

The monthly technical progress reports to the EPA include information on QA activities performed during the reporting period as well as any activities planned for the upcoming reporting period.

Contents of the QA/QC section of the quarterly reports to the EPA are based on activities performed or reviewed by the QA Manager. These reports include:

- Summary of QA activities;
- Changes to the QA program;
- Results of any QA systems and performance audits;
- Assessment of data quality, including data completeness, precision of O_3 and filter concentrations, and laboratory QC results for that quarter;
- Out-of-control incidents and corrective actions;
- Resolution of issues; and
- Responses to EPA comments on previous reports, if any.

Contents of the quarterly QA reports, while containing minimal text, include:

- Count of QA samples by QA code;
- DQI results (as graphs);
- Percentage of samples suspect or invalid by QA code (i.e., failure type);
- Count of field problems/resolutions with length of time to resolution (outstanding, 30-60-90 days);
- Summary statistics of critical criteria measurements at AQS-protocol ozone sites;
- Summary statistics of critical criteria measurements collected during the quarter for the AQS-protocol trace-level gas monitoring sites; and
- Calibration failure by location and parameter.

The quarterly QA reports also include a discussion of any site safety audits.

Changes to the QA program are made through a systematic approval process coordinated by the QA Manager. Documentation for all changes are maintained and included in reports to management. The status of the approval of any proposed change is also included in the quarterly reports and quarterly QA reports. The assessment of data quality includes tables of estimates of precision and accuracy of the continuous and filter concentration measurements and laboratory parameters. Completeness statistics are also presented.

Annual reports to EPA provide an assessment of project DQI for the continuous and discrete data for the previous year. Annual QA Reports are also the fourth quarter QA report. The Annual QA Report summarizes the previous three quarters in addition to containing information on QA activities and results for fourth quarter. Contents of the Annual QA Report also include the same components of a regular quarterly QA report.

At the end of a project, a report documenting the data quality assessment findings will be prepared at EPA's request and submitted to EPA.

Table 5-1 Quality Management System Project Assessment Number and Frequency Summary (1 of 2)

Assessment Type	Number	Frequency	Schedule/Reference	Assessment Personnel
Technical Systems Audits				
Field Operations				
Internal	2	Biannually	See QAPP Sections 5.5.4.1 and 5.5.4.1.3	Amec Foster Wheeler Field Calibrators and Subcontractors
Independent *Not performed for current contract*	NA	NA	NA	NA
External	1	Biennially for meteorological and flow systems Annually for ozone	As determined by EPA See QAPP Section 5.5.4.1.6	As determined by EPA
Laboratory Operations				
Internal	1	Annually	See QAPP Sections 5.5.4.2 and 5.5.4.2.3	QA Manager
Independent	1	Biennially	See QAPP Section 5.5.4.2.5	TBD by QA Manager
External	As determined by EPA	As determined by EPA	As determined by EPA See QAPP Section 5.5.4.2.7	As determined by EPA
Data Operations				
Internal	1-12	Depends on audit type	See QAPP Sections 5.5.4.3 and 5.5.4.3.3	DMAIRM, QA Manager
Independent	1	Biennially	See QAPP Section 5.5.4.3.4	TBD by QA Manager
External	1	As determined by EPA	As determined by EPA See QAPP Section 5.5.4.2.7	As determined by EPA
Performance Evaluations				
Field Operations				
Internal	2	Biannually	See QAPP Sections 5.5.4.1 and 5.5.4.1.4	Amec Foster Wheeler Field Technicians and Subcontractors
Independent *Not performed for this contract*	NA	NA	NA	NA
External	1	Biennially for meteorological and flow systems Annually for ozone	As determined by EPA See QAPP Section 5.5.4.1.7	As determined by EPA
Laboratory Operations				
Internal	Ongoing	Per analytical batch	See QAPP Sections 5.5.4.2.2 and 5.5.4.2.4	Laboratory Analysts
Independent	Ongoing	Approximately bimonthly	See QAPP Section 5.5.4.2.6	ECAN, USGS
External	As determined by EPA	As determined by EPA	As determined by EPA See QAPP Section 5.5.4.2.7	As determined by EPA

Table 5-1 Quality Management System Project Assessment Number and Frequency Summary (2 of 2)

Assessment Type	Number	Frequency	Schedule/Reference	Assessment Personnel
Performance Evaluations (continued)				
Data Operations				
Internal	1	Annually	See QAPP Sections 5.5.4.3 and 5.5.4.3.3	DMAIRM, QA Manager
Independent	1	Every 2 years	See QAPP Section 5.5.4.3.5	TBD by QA Manager
External	As determined by EPA	As determined by EPA	As determined by EPA See QAPP Section 5.5.4.2.7	As determined by EPA
Data Quality Assessments				
Program-wide				
Internal	Variable	Ongoing	See QAPP Section 5.4	DMAIRM, FOM, LOM, QA Supervisor, QA Manager, Project Manager
Management Systems Review				
Program-wide				
Internal	Variable	As needed	See QAPP Section 5.5.2	Project Manager, QA Manager, or QA Supervisor
Readiness Review				
Operating Units (by task)	Variable	As needed	See QAPP Section 5.5.3	Project Manager, QA Manager, FOM, LOM, DMAIRM, Task Order Managers, Field Coordinators
Surveillance				
Field Operations				
Internal	Ongoing	Weekly	See QAPP Section 5.5.5.1	Site Operators, FOM, Field Coordinators
Laboratory Operations				
Internal	Ongoing	Weekly	See QAPP Section 5.5.5.2	Laboratory Supervisor, LOM
Data Operations				
Internal	Ongoing	Weekly	See QAPP Section 5.5.5.3	DMAIRM
Assessment of DQI				
Program-wide				
Internal	4	Quarterly	See QAPP Section 5.5.6	DMAIRM, FOM, LOM, QA Manager, Project Manager
Peer Review and Presentation of Data				
Program-wide				
Independent	Variable	Minimum of once per year	See QAPP Section 5.5.7	Qualified Reviewers
Review, Revision, and Approval of CASTNET QAPP				
Program-wide				
Internal, External	1	Annually	Yearly update of procedures See QAPP Section 1.7.6	QA Manager

Notes: NA = not applicable, ECAN = Environment Canada, USGS = U.S. Geological Survey

Table 5-2 Response Actions

Assessment Type*	Response Action to Nonconforming Condition
Readiness Review	Arrangements are made by the appropriate personnel to include any and all missing components and documentation prior to commencement of work.
TSA/PE	• The appropriate operations manager(s) is/are informed. An additional assessment is performed to determine possible effects on data quality, and action is scheduled to correct the condition. If any data are affected, reanalysis or flagging is performed as needed. • The QA Manager, through a reassessment of the nonconforming component, evaluates the effectiveness of TSA response actions. • The effectiveness of PE response actions is verified via performance of another audit challenge scheduled by the appropriate operations manager. • The QA Manager verifies the effectiveness of the response action through review of the reassessment results and provides a follow-up report to the Amec Foster Wheeler Project Manager.
Surveillance	• For Field Operations actions, see Table 2-10 • For Laboratory Operations actions, see Tables 3-5 and 5-14 • For Data Operations actions, see Table 5-14 • For combined database actions, see Tables 5-14 and 4-2
DQI/Data Quality	• The appropriate operations manager(s) is/are informed. An additional assessment is performed to determine possible effects on data quality, and action is scheduled to correct the condition. If any data are affected, reanalysis or flagging is performed as needed. • The QA Manager verifies the effectiveness of the response action through review of reassessment results and provides a follow-up report to the Amec Foster Wheeler Project Manager.
Review, Revision, and Approval of QAPP/SOP	Review is performed annually by the QA Manager. Revision and approval are a team effort involving all operations managers, the QA Manager and the Amec Foster Wheeler Project Manager as described in Section 1.7.6.1
Management Systems Review	The prospective organization is informed of the condition. If the condition can be corrected prior to initiation of project activities without negative impact upon the project, the organization may be given the opportunity to correct the condition and be re-assessed. Otherwise, another candidate will be evaluated.
Peer Review of Deliverables	The condition is discussed with the reviewers. Appropriate action is thereby determined, assigned, and verified by the Amec Foster Wheeler Project Manager. The deliverable is revised accordingly.

Note: * Described in text. All assessments are reported to the Amec Foster Wheeler Project Manager and QA Manager.

Table 5-3 Data Collection Completeness Criteria

Data Collection Performance and Completeness Goals*	Averaging Period	Completeness Criteria for Data Aggregations
90% by parameter per quarter	Hour	75% of 3,600 1-second data values
	Week	69% of hourly data
< 75% is an invalid sampling quarter	Quarter	69% of valid weekly values
	Annual	75% of valid quarterly values
	Annual Trends	4 quarterly values**

Notes: * Calculated by percent of valid data points relative to total possible data points
** Some quarterly values may have been interpolated or extrapolated from other quarterly values from same site

Table 5-4 Data Quality Indicators as Applied to Measurements – 1-Hour

Data Increment: 1-Hour	Meteorological and Flow	Ozone
Precision	RPD values are calculated from collocated hourly data that have been validated at Level 3. Results are documented in annual reports to EPA.	Single point internal precision checks are performed daily. See Table 4-12. Results are documented in the quarterly reports to EPA.
Accuracy	On-site instrumentation is challenged by NIST-traceable standards at least two times each year (two calibrations).	On-site instrumentation is challenged by NIST-traceable standards at least two times each year (two calibrations).
Bias	Bias in hourly continuous data may be identified by the Level 3 continuous data validation process detailed in Section 4.3.1 of this QAPP or by monitoring audit results over time. Instrument generated data found outside established calibration criteria are invalidated.	Bias in hourly continuous data may be identified by the Level 3 continuous data validation process detailed in Section 4.3.1 of this QAPP or by monitoring audit results over time. Instrument generated data are invalidated per established calibration and data validation criteria. Flow data might be adjusted. Ozone data are not adjusted.
Completeness	75 percent - See Section 4.4.5	75 percent - See Section 4.4.5
Representativeness	Emission inventory, population, land use, and terrain within 100 km are evaluated. The site-specific criteria listed in Table 2-1 have been established to minimize local interference with continuous and ambient concentration readings.	Emission inventory, population, land use, and terrain within 100 km are evaluated. The site-specific criteria listed in Table 2-1 have been established to minimize local interference with continuous and ambient concentration readings.
Comparability	Siting and equipment specifications are consistent throughout the network, EPA or ASTM methods are used when available, and data are reported in conventional and standard units, ensuring internal data comparability. This is demonstrated by collocated data results (see Precision).	Siting and equipment specifications are consistent throughout the network, EPA or ASTM methods are used when available, and data are reported in conventional and standard units, ensuring internal data comparability. This is demonstrated by collocated data results (see Precision).

Table 5-5 Data Quality Indicators as Applied to Measurements – 1-Week

Data Increment: 1-Week	Meteorological and Flow	Ozone	Deposition Velocities and Fluxes	Ambient Concentration Data
Precision	RPD values are calculated from collocated hourly data. Results are documented in annual reports to EPA.	Single point internal precision checks are performed daily. See Table 4-12. Results are documented in the quarterly reports to EPA.	MLM data generated from collocated sites could be compared via calculated RPD. This procedure utilizes only sites with complete meteorological data. Data from nearby sites are not utilized for this procedure.	Collocated weekly filter pack data are compared via calculated RPD. Results are documented in the quarterly reports to EPA.
Accuracy	On-site instrumentation is challenged by NIST-traceable standards at least two times each year (two calibrations).	On-site instrumentation is challenged by NIST-traceable standards at least two times each year (two calibrations).	This is a calculated parameter. There is no standard of accuracy available. Accuracy may be inferred using the accuracy of the MLM input data.	NIST-traceable standards are analyzed with each batch of samples analyzed. See Table 3-2 for acceptance criteria.
Bias	Results from semiannual calibrations and the Level 3 continuous data validation process detailed in Section 4.3.1 of this QAPP, or by monitoring audit results over time, may identify bias in weekly continuous data. Instrument generated data are either adjusted or invalidated per established calibration and data validation criteria.	See Table 4-12.	Limits on bias may be inferred from bias (if any) in MLM input data from MLM evaluation and intercomparison studies. Historical model evaluation and intercomparison studies indicated that the model generally underestimated SO_2 and HNO_3 dry deposition. However, the extent and scope of the field measurements used in these analyses were insufficient to gauge the degree of underestimation. In order to better assess model performance the model output will have to be compared to recent, independent, multi-year flux measurements.	Percent recoveries of reference and CCV are calculated for each analytical batch to ascertain if recoveries are within acceptable range (Table 3-2). Analysis of field and laboratory blanks is performed to measure any bias through background contamination on filters. For consideration of external bias, please see Comparability.
Completeness	75% - See Section 4.4 and Table 5-3	75% - See Section 4.4 and Table 5-3	70% - See Section 4.4 and Table 5-3	75% - See Section 4.4 and Table 5-3
Representativeness	Collected 75% valid data for sampling period.	Emission inventory, population, and land use within 100 km are evaluated. The site-specific criteria listed in Table 2-1 have been established to minimize local interference with continuous and ambient concentration readings.	This is a calculated parameter. Representativeness depends upon the representativeness of the input data.	Established regional representativeness, data comparability (see Comparability), and sample integrity (see Section 3.1.3) are the indicating factors.
Comparability	Siting and equipment specifications are consistent throughout the network, EPA or ASTM methods are used when available, and data are reported in conventional and standard units, ensuring internal data comparability. This is demonstrated by collocated data results (see Precision).	Siting and equipment specifications are consistent throughout the network, EPA or ASTM methods are used when available, and data are reported in conventional and standard units, ensuring internal data comparability. This is demonstrated by data from collocated networks.	Siting and equipment specifications are consistent throughout the network, EPA or ASTM methods are used when available, and data are reported in conventional and standard units, ensuring internal data comparability. This is demonstrated by data from collocated networks.	NIST-traceable standards are utilized. Data are reported in standard units. The CASTNET laboratory participates regularly in laboratory intercomparison studies. Study results are reported to EPA in quarterly and annual reports after they become available.

Table 5-6 Data Quality Indicators as Applied to Measurements – 1-Year

Data Increment: 1 Year	Meteorological and Flow	Ozone	Deposition Velocities and Fluxes	Ambient Concentration Data
Precision	RPD values are calculated from averages of collocated hourly data. Results are documented in annual reports to EPA.	Single point internal precision checks are performed daily. See Table 4-12. Results are documented in the annual reports to EPA.	MLM data generated from collocated sites could be compared via calculated RPD. Only sites with complete meteorological data are utilized. Data from nearby sites are not utilized.	Collocated filter pack data are compared via calculated RPD. Results are documented in the annual reports to EPA.
Accuracy	On-site instrumentation is challenged by NIST-traceable standards at least two times each year (two calibrations).	On-site instrumentation is challenged by NIST-traceable standards at least two times each year (two calibrations).	This is a calculated parameter. There is no standard of accuracy available. Accuracy may be inferred using the accuracy of the MLM data inputs.	NIST-traceable standards are analyzed with each batch of samples analyzed. Results are documented in annual reports to EPA.
Bias	Results from semiannual calibrations and the Level 3 continuous data validation process detailed in Section 4.3.1 of this QAPP may identify bias in continuous data. Instrument generated data found outside of established calibration criteria are invalidated.	See Table 4-12.	Limits on bias may be inferred from bias (if any) in MLM data inputs and MLM evaluation and model intercomparison studies. Bias may also result from data aggregation procedures. See the discussion in Section 4.	Percent recoveries of reference and CCV are calculated for each analytical batch to ascertain if recoveries are within acceptable range. (Table 3-4). Analysis of field and laboratory blanks is performed to measure any bias through background contamination on filters. For consideration of external bias, see Comparability. Bias may also result from data aggregation procedures. See the discussion in Section 5.
Completeness	75% - See Section 4.4.	75% - See Section 4.4.	75% - See Section 4.4.	75% - See Section 4.4.
Representativeness	Emission inventory, population, and land use within 100 km are evaluated. The site-specific criteria listed in Table 2-1 have been established to minimize local interference with continuous and ambient concentration readings.	Emission inventory, population, and land use within 100 km are evaluated. The site-specific criteria listed in Table 2-1 have been established to minimize local interference with continuous and ambient concentration readings.	This is a calculated parameter. Representativeness depends upon the representativeness of the data inputs.	Established regional representativeness, data comparability (see below), and sample integrity (see Section 3.1.3) are the controlling factors.
Comparability	Siting and equipment specifications are consistent throughout the network, EPA or ASTM methods are used when available, and data are reported in conventional and standard units, ensuring internal data comparability. This is demonstrated by collocated data results (see Precision).	Siting and equipment specifications are consistent throughout the network, EPA or ASTM methods are used when available, and data are reported in conventional and standard units, ensuring internal data comparability. This is demonstrated by data from collocated networks.	Siting and equipment specifications are consistent throughout the network, EPA or ASTM methods are used when available, and data are reported in conventional and standard units, ensuring internal data comparability. This is demonstrated by data from collocated networks.	NIST-traceable standards are utilized. Data are reported in standard units. The CASTNET laboratory participates regularly in laboratory intercomparison studies. Study results are reported to EPA in quarterly and annual reports after they become available.

Table 5-7 Field Performance Evaluation Components and Acceptance Criteria (1 of 2)

Measured Parameter	Measurement Method	Audit Method	Acceptance Criteria†	Standards Traceability	*Standards Certification
Meteorological Measurement Systems					
Wind Speed -Velocity	Cup Anemometer and Propeller/Vane Anemometer	Variable RPM Motor	± 0.5 m/s < 5 m/s or ± 5% of input ≥ 5 m/s	NIST	Manufacturer
Wind Direction - Alignment	Vane and Propeller/Vane	Transit Compass	± 5 degrees from true north	Military	Manufacturer
Wind Direction - Linearity	Vane and Propeller/Vane	Vane Alignment Fixture	± 5 degrees	–	–
Temperature	Thermister and RTD Platinum	Immersion in temperature baths with reference thermometers	± 0.5°C	NIST	Manufacturer
Relative Humidity	Peizoresistive and Capacitance	Collocated in humidity chamber with reference humidity standard	± 10% relative humidity	NIST	Manufacturer
Solar Radiation	Pyranometer	Collocated comparison to reference radiation sensor	± 10% of average	WMO	Manufacturer
Precipitation	Heated Tipping Bucket	Known volume of water introduced at rate of 2 inches per hour	± 10% of input	Volumetric flask	–
Wetness	Conductivity Bridge	Dry conditions, apply water Wet conditions, dry it	Confirm response	–	–

Table 5-7 Field Performance Evaluation Components and Acceptance Criteria (2 of 2)

Measured Parameter	Measurement Method	Audit Method	Acceptance Criteria†	Standards Traceability	*Standards Certification
Deposition Systems					
†Dry Deposition	Three-Stage Filter Pack	Verify flow with primary flow device, i.e., BIOS or certified mass flow meter	± 5% of designated	NIST	Manufacturer
Ozone and Data Acquisition Systems					
†Ozone	UV Photometric	Comparison to certified reference standard	± 15% of designated for annual single analyzer audits ± 10% of designated for biennial NPAP audits	NIST	EPA
Data Acquisition	Data Logger	Input reference voltages over a range of 0 to 1.0V. Verify with certified digital volt meter	± 0.003 VDC	NIST	Manufacturer

Notes: * Certifications listed are for primary standards. Transfer standards may be certified against in-house primary standards for field efforts. All certifications are documented and kept on file.
† Please see Table 2-5 for Amec Foster Wheeler calibration criteria.
Trace gas analyzers for SO_2, NO/NO_y, and CO are discussed in QAPP Appendix 11 (QAP for NCore Monitoring).

Military = MIL-C-58052C
WMO = World Meteorological Organization
CARB = California Air Resources Board
RPM = revolutions per minute
gm/cm = grams per centimeter
VDC = volts direct current
NPAP = National Performance Audit Program

Table 5-8 Field Internal Technical Systems Audit Components

Systems Parameters	Audit Component	Acceptance Criteria	Reporting Procedures
Site Description and Siting Criteria	Verify elevation, latitude, longitude, UTM, site description, site exposure, and land use.	Compare to CASTNET site selection criteria.	Complete audit report and notify Amec Foster Wheeler QA Management Team of inconsistencies or changes.
Site Documentation	Verify site operator has most recent network documentation (forms, manuals, descriptions, SOP). Review completeness, accuracy, and timeliness of on-site documentation (calibration records, performance test charts, maintenance records, logbooks).	Compare on-site documentation to most recent network documentation and verify adherence to CASTNET SOP.	Complete audit report and notify Amec Foster Wheeler QA Management Team of inconsistencies or changes.
Procedures Review	Review field-related SOP. Observe operator performing most critical site visit procedures (filter changes and gas analyzer checks). Verify operator understanding of newly implemented procedures or procedural changes.	Adjust performance audit methods and acceptance criteria to accommodate changes in SOP. Evaluate operator procedures, and solicit operator questions and suggestions.	Notify Amec Foster Wheeler QA Management Team of inconsistencies. Recommend procedural changes or operator training where appropriate.
Instrument and Support Systems Inspection	Inspect overall integrity, cleanliness, safety, and condition of instruments, support systems, and other site hardware: • DAS to instrument connections • Condition of probes, sensors, filters, sample lines • Safety and integrity of towers, fencing, shelters, grounding, lightning rods, power • General site conditions Inventory all instrumentation (model number, serial number, last calibration date).	Complete audit report and site inventory.	Notify Amec Foster Wheeler QA Management Team of inconsistencies.

Note: UTM = Universal Transverse Mercator

Table 5-9 Calibration Standards

Parameter	Amec Foster Wheeler Calibration Standard
Mass Flow	Mass Flow Meter – BIOS Definer 220 or equivalent
Ozone	Thermo Scientific 49i
Wind Speed	RM Young 18802 or equivalent anemometer drive
Wind Direction	Brunton F5008/F5006LM or equivalent pocket transit
Temperature	Resistance Temperature Detector – Extech Instruments, 407907 or equivalent
Relative Humidity	Rotronic portable hygrometer – Hygropalm 22 or equivalent
Precipitation (Tipping Bucket)	250 mL graduated cylinder
Solar Radiation	Pyranometer – LICOR Li-200 or equivalent RM Young translator 70101X or equivalent
Wetness	OHmite 3420 decade box or equivalent
Data Acquisition System Voltage Response	Calibrators, Inc. DVC-350A or equivalent
Voltage Output	Fluke 8060A Multimeter or equivalent
Audit Data Storage	Electronic forms

Note: Trace gas analyzers for SO_2, NO/NO_y, and CO are discussed in QAPP Appendix 11 (QAP for NCore Monitoring).

Table 5-10 Laboratory Technical Systems Audit Components

Systems Parameters	Audit Component	Acceptance Criteria	Reporting Procedure
Laboratory Facilities	Inspect facilities for cleanliness and organization of work areas.	Samples and standards should be stored separately. All containers should be properly labeled.	Complete audit report and notify Amec Foster Wheeler QA Management Team of inconsistencies or changes.
Site Documentation	Verify that most recent network documentation (QAPP, SOP) is readily available. Review completeness, accuracy, legibility, and timeliness of on-site documentation (calibration records, maintenance records, logbooks).	Compare on-site documentation to most recent network documentation.	Complete audit report and notify Amec Foster Wheeler QA Management Team of inconsistencies or changes.
Procedures Review	Review laboratory-related SOP. Review associated laboratory activity records (analysis logbooks, balance logbooks, temperature control logbooks, certificates of analysis for standards and reagents, and chains-of-custody).	Verify adherence to CASTNET QAPP/SOP.	Notify Amec Foster Wheeler QA Management Team of inconsistencies. Recommend procedural changes or operator training where appropriate.
Instrument and Support Systems Inspection	Inspect overall condition of instruments and support systems.	Instruments and support systems should be sufficient in function and organization to accomplish laboratory objectives as related to project requirements (e.g., analytical QC requirements, data processing and submittal requirements, sample storage, etc).	Notify Amec Foster Wheeler team of active and potential problems. Recommend changes where appropriate.

Table 5-11 Laboratory Performance Evaluation Components and Acceptance Criteria

Measured Parameter	Measurement Method	Instrumentation	Audit Method	Audit Ranges	Acceptance Criteria	Standards Traceability	Standards Certification
Laboratory Measurement Systems: Internal Audits							
Anions: NO_2^-, NO_3^-, SO_4^{2-}, Cl^-	IC: modified EPA method 300.0	Dionex ICS-1600, DX-500 or DX-600 IC with autosampler	Analysis of a simulated rainwater reference solution containing analytes of interest, with a certificate of analysis and an expiration date	Target levels vary but approximate expected sample concentrations	Within ± 5% of the certified value	NIST	Manufacturer
Cations: Ca^{2+}, K^+, Mg^{2+}, Na^+	ICP-OES: modified EPA method 6010B	Perkin-Elmer 7300 DV	Analysis of a simulated rainwater reference solution containing analytes of interest, with a certificate of analysis and an expiration date	Target levels vary but approximate expected sample concentrations	Within ± 10% of the certified value	NIST	Manufacturer
Cation: NH_4^+	Automated colorimetry: EPA method 350.1	Bran+Luebbe AutoAnalyzer 3	Analysis of Environmental Resource Associates reference standards for NH_4^+	Target levels vary but approximate expected sample concentrations	Within ± 10% of the certified value	NIST	Manufacturer
Laboratory Measurement Systems: Independent Audits							
Anions: NO_2^-, NO_3^-, SO_4^{2-}, Cl^-	IC: modified EPA method 300.0	Dionex ICS-1600, DX-500 or DX-600 IC with autosampler	Analysis of prepared solution containing analytes of interest.	Target levels are determined by the study administrator.	Within range of a certified value as determined by the study administrator or within a statistical range determined by the distribution of round robin reported results	Administering Agency	Manufacturer; N/A for round robin samples
Cations: Ca^{2+}, K^+, Mg^{2+}, Na^+	ICP-OES: modified EPA method 6010B	Perkin-Elmer 7300 DV	Analysis of prepared solution containing analytes of interest.	Target levels are determined by the study administrator.	Within range of a certified value as determined by the study administrator or within a statistical range determined by the distribution of round robin reported results	Administering Agency	Manufacturer; N/A for round robin samples
Cation: NH_4^+	Automated colorimetry: EPA method 350.1	Bran+Luebbe AutoAnalyzer 3	Analysis of prepared solution containing analytes of interest.	Target levels are determined by the study administrator.	Within range of a certified value as determined by the study administrator or within a statistical range determined by the distribution of round robin reported results	Administering Agency	Manufacturer; N/A for round robin samples

Table 5-12 Data Operations Technical Systems Audit Components (1 of 4)

Systems Parameters	Audit Component	Acceptance Criteria	Reporting Procedure
Computer Program Documentation and Validation			
Software/Hardware Documentation	Verify that the following documentation is present: • Software management plan • Software development plan • Software test and acceptance plan • Software user's operations documents • Software maintenance documents • Hardware assessment	Adequate documentation exists and is readily accessible.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.
System/Operation Documentation	Verify that the following are documented: • Program • Table of definitions • System size and timing requirements • Definitions of subsystems • Requirements for hardware, electricity, and security • Backup and disaster recovery procedures • QC requirements for reliability, maintainability, and flexibility • Testing procedures	Compare on-site documentation to most recent network documentation/ configuration and verify adherence to CASTNET QAPP.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of inconsistencies or changes.
Software Management	Verify that software management includes the following: • Independent validation • Definitions/identifications of interfaces • Definition of software tools including identification of program language and network software requirements • Configuration control (control, release, and storage of master copies) • Flow chart or text showing functional flow • Identification of input/output fields	Adequate documentation exists and is readily accessible.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.
Software Revision and Testing Procedures	Verify that software management includes the following: • Written procedures for software revisions • Testing of software revisions to determine how entire program is affected • Documentation of software revisions	Adequate documentation exists and is readily accessible.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.

Table 5-12 Data Operations Technical Systems Audit Components (2 of 4)

Systems Parameters	Audit Component	Acceptance Criteria	Reporting Procedure
Computer Program Documentation and Validation (continued)			
Procedures for Users	Verify the following: • User's Guide/software descriptions include: whom to contact when problems occur, how to access the system, how to input data, generate reports, update data, description of error codes, and procedures to follow if the system goes down • Testing procedures include: description of the test procedures to perform, expected outcome, documentation of results, and recommendations for handling problems • Security has been addressed with a statement or passwords to safeguard accuracy of the computer program operation • The program alerts provide clear understanding as to what requests will do to the data to ensure the expected or desired results are attained An example is the WARNING: "continuing will reformat the hard drive and erase all existing data permanently. Data will not be recoverable."	Documented procedures exist and are readily accessible.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.
Computer Program Operation			
Security	Verify that a password is required to access the system.	Password is required.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.
Operator Training	Verify that operators are adequately trained, and the training is documented.	Documentation of training is available.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.
System Testing	Confirm if system delays hamper testing.	Testing can be effectively performed.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.

Table 5-12 Data Operations Technical Systems Audit Components (3 of 4)

Systems Parameters	Audit Component	Acceptance Criteria	Reporting Procedure
Computer Program Operation (continued)			
Data Entry – Automated Transfer	Determine the answers to the following questions: • Are data entered into the central database via computer readable media? If so, do the data include: — Information on the source of the data, — Time of data collection, — Conditions of data collection, — Links of data to QC data, and — QC status flags? • If data are entered by prompting the system to access a previously existing data file, are the data validated by: — Comparison of the number/size of files transferred; — A log that documents the files transferred; — The documentation of a record of the data, date, and name of the person transferring the data; and — Periodic audits of data transfers that are documented?	All answers are affirmative.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.
Data Changes	Determine the answers to the following questions: • How are data corrections made and verified? • Are corrections documented on a written log? • Is there a computer-generated record of changed/unchanged data? • If changes were made to data transferred from another source, was the original source corrected? • If changes were made in flags from a central database: — Who determined the need to make the change? — Is authorization for revision documented? — Is the change adequately documented?	All answers are affirmative.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.

Table 5-12 Data Operations Technical Systems Audit Components (4 of 4)

Systems Parameters	Audit Component	Acceptance Criteria	Reporting Procedure
Computer Program Operation (continued)			
Data Backups	Verify and review the following: • Personnel responsible for backups • How often backups are performed • Type of backups - partial or total • Storage of backups: media, labeling, documentation, short term storage procedures of backups, and long term storage procedures of backups • Retrieval of backups: — Arrangement for expedient retrieval — Off-site storage or different location from original data — Security of storage area including limited access, fire protection and environmental controls	All components are verified.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies. Recommend changes to procedures if appropriate.
Hardware Maintenance	Review of the following: • Procedures for conducting and documenting preventative maintenance • Frequency of regularly-scheduled preventative maintenance program • Documentation of preventative maintenance (who, what, and when) • Documentation of non-routine maintenance (who, what, and when) • Provisions for system downtime • Impact of downtime on project	Adequate documentation exists and is readily available.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.
System Failure	Assess and verify the results of system failure due to power outage or other failure: • Availability of backup source • Manual or automatic start of backup source • Power failure indicators if system is running • Potential loss of data being processed due to system failure • System restart at failure point • System indication of data loss if data are lost • Existence of a backup procedure while system is running to minimize data loss during a system failure • Determination of time down until restored after a system failure	All components are verified.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.

Table 5-13 Data Operations Performance Evaluation Components and Acceptance Criteria

Systems Parameters	Audit Component	Acceptance Criteria	Reporting Procedure
Data Reduction, Analysis, and Assessment	Determine the answers to the following questions: • If data quality flags are used, are they defined? • Are qualifying flags correct? • Can new flags be created and how? • Are the mathematical expressions used by the system available in written format? • Were the mathematical expressions reviewed for accuracy? • Was the validation of mathematical expression documented? • Are the automated results of mathematical expressions verified/validated via manual recalculation? • Did revisions affect the overall performance of data manipulations? • If mathematical expressions are modified, is the reason documented? Are the old data recalculated with new formulas? • Are modifications to data reports checked for accuracy? — By whom? — Documented? — Percent checked?	All answers are affirmative.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.
Data Output and Reporting	Review and verify the following: • Written procedures for generating data output such as graphs, charts, and reports • Adequate identification of data used to generate the output • Locking of the database after final output is generated so no further changes can be made without managerial consent • Timely generation of output and data reports	All answers are affirmative.	Complete audit report and notify the Amec Foster Wheeler QA Management Team of any deficiencies.

Table 5-14 Laboratory Data Validation Process

Data Validation Level	Description	Data Processing and QC Activities	Data Storage Format
Level 0	Each sample is assigned to a work order based on the scheduled sampling date. The work order is used for sample and data tracking.	• Work orders and associated labels are created. • Sampling media are prepared for the field and are shipped to site operators. • Sampling media are received from field; filter packs unpacked and assigned laboratory sample numbers. • Samples are logged in and the Laboratory sample numbers are activated in Element.	Work orders are stored electronically in Element and as hard copies in project files.
Level 2	Validation is performed during analysis activities.	• Each analyst uses Element to check for new samples. • Preliminary analytical procedures begin, including extraction and filtration. • Samples are analyzed in laboratory batches; data are uploaded into Element. • Batches are processed through an automated QC checking routine, and results are printed out. • Documentation to support the analytical run is filed in the associated batch folder. • Analyst reviews results of automated QC checklist and completes batch manual QC checklist. • Analyst signs and dates batch and submits the batch for peer review. Analyst changes status of samples to “Batched.” • Batch folder is peer reviewed. If accepted, it is considered complete and signed and dated. • If batch folder is not accepted, it is returned to the original analyst. Batch folder is resubmitted to peer review process. • Upon completion of peer review, the batch folder is submitted to the LOM for review and sign-off. LOM changes status of samples from “Batched” to “Reviewed.” • Batch data are locked in Element and the batch folder is placed in a filing cabinet.	Finalized analytical results are stored electronically in the Element database with hard copy backups. All supporting documentation is filed in the data batch folders.
Level 3	Review of supporting documentation and QC sample results generated during the course of producing the data, review of data that do not meet criteria, and final review of all data.	• Documentation and QC sample results are reviewed. • Analytical results are submitted to the DMC in .dbf files.	Stored electronically in Element and MS SQL Server databases.

6.0 References

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7.0 Revision Tracking Sheet

Revision	*Action*	*Change Description*
Revision 1.0 (delivered 01-2003)	***Action***	***Change Description***
A	Replace	H. Kemp Howell as Project Manager, replaces Thomas Lavery
A.2	Add	Appendices 7 - 9 to the Table of Contents
A.6.2.2.2	Replace	EPA sites are audited annually replace with every 2 years.
A.6.2.2.2	Add	Description of O_3 data collection at the Cherokee Nation site in Stilwell, OK (CHE185).
A.6.2.3	Add	Laboratory sample extract storage and disposition.
A.6.2.5.1	Delete	"…and are bracketed in time by the routine calibration visits."
A.7	Add	Proposed revisions for this section are on hold pending EPA approval.
A.7.1.2	Replace	ARS audits conducted every 2 years instead of annually.
A.7.1.6	Add	Description of CHE185 O_3 data collection.
A.9.1.1	Add	Records disposition protocol.
Table A.6.2	Add	Update sites table. Change HOX 149 to HOX148
Table A.7.1	Delete	Remove table - Proposed revisions are on hold pending EPA approval.
Table A.7.2	Replace	Sigma Theta - Precision and Accuracy columns change to read "undefined"
Table A.7.3	Replace	Conductivity - Accuracy 90 - 110%
		Conductivity - Precision (RPD) 10%
		Conductivity - 0.04 μohms/cm to 0.04 μmhos/cm.
		Correct elemental carbon MDL to 0.04 μg-C/m^3
	Add	Description of MDL/MRL derivation.
Figure A.4.1	Add	EPA Technical Monitors – D. Schmeltz
	Add	8.0 Quality Assurance Manager – J. Lynch
	Replace	Project Manager – T. Lavery with
		9.0 Project Manager – H. K. Howell
Figure A.6.1	Replace	HOX 149 to HOX 148
B.5	Replace	ARS audits conducted every 2 years instead of annually.
B.5	Add	Protocol for treatment of collocated data.
B.6.1.1	Replace	Chloride detection limit should be 0.020
Figure B.3.1	Add	Support ring before Teflon® filter
C.1.4.1.2	Replace	ARS audits conducted every 2 years instead of annually.
C.1.5.1.2	Replace	ARS audits conducted every 2 years instead of annually.
C.1.5.2.2	Add	Description of laboratory intercomparison studies.
C.1.6	Add	Protocol for treatment of collocated data.
D.1	Add	Section describing Level 1x Validation (New D.1.3)
Table D.1.1	Add	Row for Level 1x
Figure D.1.5	Add	Field Validation Window
Section F	Add	Revision Tracking Sheet
Appendix 1	Replace	All SOPs reformatted. Procedures remain the same.
Appendix 4	Replace	Instrument SOPs formatted to resemble GLM3180-004. Procedures remain the same.
Appendix 7	Added	New appendix.

Revision 2.0 **(delivered 12-2003)**	***Action***	***Change Description***
Appendix 9	Added	New QMP.
Revision 2.0	Action	Change Description
All Sections	Replace	Harding ESE, Inc. replaced by MACTEC Engineering and Consulting, Inc.
All Sections	Replace	Harding ESE replaced by MACTEC
All Sections	Replace	All references to Appendix 1, Harding ESE Field Standard Operating Procedures replaced by CASTNET Field Standard Operating Procedures
All Sections	Replace	All references to Appendix 2, Site Contact List replaced by CASTNET Site Contact List
All Sections	Replace	All references to Appendix 4, Harding ESE Laboratory Standard Operating Procedures replaced by CASTNET Laboratory Standard Operating Procedures
All Sections	Replace	All references to Appendix 6, Harding ESE Health and Safety Plan replaced by Appendix 5, CASTNET Health and Safety Plan
All Sections	Replace	All references to Appendix 6, Harding ESE Government Property Control Standard Operating Procedures replaced by Appendix 9, CASTNET Government Property Control Standard Operating Procedures
All Sections	Replace	All references to Appendix 7, Data Operations Standard Operating Procedures replaced by Appendix 6, CASTNET Data Operations Standard Operating Procedures
All Section	Replace	CASTNET Data Management System application replaced by CASTNET Data Management System Application or CDMSA after first mention
All Sections	Replace	All references to Harding ESE laboratory replaced by CASTNET
All Sections	Add	Add after all references to Appendix 5, Sunset Laboratory SOP and Chester LabNet SOP - (See CASTNET QAPP Revision 1.0)
All Sections	Add	Add QA Supervisor to the QA Management Team
All Sections	Replace	Replace Revision 1.0 references to QA Supervisor with QA Manager
All Sections	Replace	The CASTNET Custodial Property Manager (CPM) replaced by The CASTNET Property Control Manager (PCM)
All Sections	Replace	All references to biannual ARS site audits with reference to independent audits conducted at the EPA's discretion
All Sections	Add	Add chloride (Cl^-) to all comprehensive analyte lists, Teflon® filter analyte lists, anion lists and IC analyte lists
All Sections	Replace	All references to inductively coupled argon plasma-atomic emission (ICAP-AE) spectrometer/spectrometry replaced by inductively coupled plasma-atomic emission spectrometer/spectrometry (ICP-AES)
All Sections	Replace	ICP-AES accuracy measurement criterion change from 10% to 5% for all analytes
All Sections	Replace	Change all references to visibility aerosol measurements to past tense
All Sections	Add	Quarterly QA and Annual reports to comprehensive report lists and quarterly report lists
All Sections	Add	Field coordinator to all routine actions listed for the FOM
All Sections	Add	Add state ID to site designation when first mentioned in a section/subsection (e.g. EGB181, ON for site 181 in Egbert, Ontario)
All Sections	Add	After references to manual entry of data add: All data manually entered into the database are validated for accuracy through double entry
A.1	Add	Signature line for John E. Lynch, MACTEC Project Quality Assurance Supervisor
A.1	Replace	Marcus O. Stewart title, Project QA Supervisor, replaced by title, MACTEC Quality Assurance Manager

Revision 2.0 **(delivered 12-2003)**	***Action***	***Change Description***
A.1	Replace	Eric Hebert, Harding ESE Field Operations Manager replaced by Jon J. Bowser, MACTEC Field Operations Manager
A.1	Replace	Christina M. Costakis, Harding ESE Laboratory Operations Manager replaced by Jon J. Bowser, MACTEC Laboratory Operations Manager
A.2	Delete	Appendix 5: Sunset Laboratory and Chester LabNet SOP
A.2	Delete	-placeholder pending EPA approval
A.2	Add/ Replace/ Delete	Changes to Table of Contents, Lists of Tables, Lists of Figures, and Acronyms and Abbreviations made as necessary to match QAPP contents
A.2	Replace	Renumber appendix numbers 6 through 9 to become 5 through 8 – Appendix 5: CASTNET Health and Safety Plan, CASTNET Government Property Control SOP; Appendix 6: CASTNET Data Operations SOP; Appendix 7: DQO Planning Document; Appendix 8: CASTNET Quality Management Plan
A.3	Replace	H. Kemp Howell title, Project Manager/Base Program Work Assignment Manager/Custodial Property Manager replaced by Property Control Manager
A.3	Replace	Thomas F. Lavery title, Technical Director replaced by Data Analysis and Interpretation and Reporting Manager
A.3	Add	John E. Lynch, Project QA Supervisor
A.3	Replace	Marcus O. Stewart title, Project QA Supervisor replaced by QA Manager
A.3	Replace	Eric O. Hebert replaced by Jon J. Bowser
A.3	Replace	Christina M. Costakis replaced by Jon J. Bowser
A.3	Replace	Andrew G. Weitz title, Gainesville Laboratory Supervisor replaced by Gainesville Laboratory Manager
A.3	Add	Bryan C. Bibeau, Field Operations Coordinator
A.3	Replace	Neil Frank title, Technical Monitor replaced by Special Study QAK172, OH Site Work Assignment Manager
A.3	Replace	David Schmeltz replaced by Michael Kolian
A.3	Delete	Jeff Lantz, Technical Advisor
A.3	Add	Karen Watson, Contracting Officer
A.3	Add	Wilson L. Haynes, Mountain Acid Deposition Program Work Assignment Manager
A.3	Add	Air Quality Services, Inc.: Sandy Grenville, Field Calibration Services
A.4.2	Delete	ARS is also responsible for audits of EPA-sponsored sites.
A.6.2.2.2	Add	…exchanged at the site every Tuesday by the local site operator. Exposed filter pack samples from EPA-sponsored sites must be received by the CASTNET analytical laboratory within two weeks of removal from the sampling tower. Blank filter packs….
A.6.2.4.1	Add	New paragraph: Level 1x validation is an intermediate validation process that is performed after Level I validation is complete and before Level II validation begins. Level 1x validation is a review of the data obtained during Level I using field validation recommendations entered by the FOM and/or field coordinators, automated screening of specific meteorological parameters using absolute bounds to check for outliers and reasonableness, and screening of hourly flow and ozone data. Database changes enacted during Level 1x validation are documented electronically and on hardcopy forms.

Revision 2.0 (delivered 12-2003)	***Action***	***Change Description***
A.6.4.4	Replace	Chapter 5 discusses information on PM2.5 concentrations and their chemical constituents, and information on trace metals. replaced by Chapter 5 is reserved for discussion of other aspects of the network.
A.7	Delete	Note: Proposed revisions for this section are on hold pending EPA approval
A.7	Add	These DQO have been evaluated as described in Appendix 7 and established to ensure that the data provided are of known and documented quality for the continuous field data and the integrated samples, including exposed filters.
Table A.4.1	Add	Position: Principal-In-Charge Duties: Reviews performance with Project Manager Conducts periodic and special project review meetings Establishes independent communication link with EPA Reviews performance with Corporate Project QA Supervisor Resolves problems Authorities: Acts as the corporate signatory, as required Delegates appropriate authority downward to project personnel Position: Corporate Project QA Supervisor Duties: Monitors and periodically audits to ensure that QA procedures as identified in the QAPP, Laboratory Operations Manual, Field Operations Manual, and Data Management Manuals are followed by the project team Ensure the appropriate level of QA is assigned to each work assignment Reviews QA audit reports from external QA auditors for laboratory and field operations assignments Authorities: Independently reports to the Principal-in-Charge Approves QAPP Issues stop-work for non-compliance with QA procedures Position: Field Coordinator Duties: Acquiring data from each site daily Detecting problems or potential problems with all equipment Resolving problems that could affect data quality Reporting all problems, resolutions, and the effect, if any, on data accuracy or collection Communicating with the site operators each week or as necessary to resolve problems Reviewing site calibration results Adding information to the problem tracking database to assist data validation Supporting both the site operators and field technicians Authorities: Directing field technicians to unscheduled sites for repair Procurement of supplies Scheduling special efforts for field certification laboratory
Table A.6.1	Add	Update sites table

Revision 2.0 **(delivered 12-2003)**	***Action***	***Change Description***
Table A.6.3	Add	QA Manager to assessment personnel for Management Systems Review; Readiness Review; Surveillance; TSA for Laboratory and Data Operations; PE for Data Operations; Assessment of DQI; Data Quality Assessments; and Review, Revision, and Approval of CASTNET QAPP
Table A.6.3	Delete	QA Supervisor from assessment personnel for Readiness Review; Surveillance; TSA for Laboratory Operations; TSA for Data Operations; PE for Data Operations; Assessment of DQI; and Review, Revision, and Approval of CASTNET QAPP
Table A.6.3	Replace and Add	In TSA and PE for Field Operations – Internal, Assessment Personnel: Harding ESE Field Technicians replaced by MACTEC, ARS, and AQS Field Technicians
Table A.7.1	Add	Add new Table A.7.1
Table A.7.3	Replace	Nominal Detection Limits replaced by Nominal Reporting Limits
Table A.7.3	Add	New Column – Method Detection Limit with calculated MDLs.
Table A.7.3 Notes	Add	Add to Precision notes: The precision criterion is applied as described below: QC conditions: (v1 = initial response; v2 = replicate response) Condition 1: if (v1 or v2 < RL and absolute value of (v1-v2) < RL) = OK Condition 2: if (v1-v2) < RL and v1 < 5 x RL) = OK Condition 3: if (v1 > 5*RL and RPD < 5%) = OK Status: one of the conditions is OK = Precision QC Passes
Figure A.4.1	Replace	Figure updated to reflect CASTNET III contract and personnel changes
Figure A.6.1	Add	Update sites figure
B.1.2	Delete	The remaining eastern sites became operational between July 1990 and July 1995.
B.2.1.3	Delete	…additional background information in the form of maps and aerial photographs is acquired…. And: Recent aerial photographs provide useful information and also are acquired when available.
B.2.3.1	Replace	LAI measurements are required to evaluate rates of transfer of material from the atmosphere to the plant canopy (i.e., V_d). LAI is measured at new CASTNET sites. The Li-Cor LAI-2000 Plant Canopy Analyzer measures LAI using a sensor comprised of five detectors arranged in concentric rings with a filter to reject radiation with wavelengths above 490 nanometers (nm). Lenses focus each of the detectors on a different portion of the sky. In practice, the LAI-2000 requires "zeroing" by taking one or more readings either above the plant canopy or in a large clearing adjacent to the canopy. Vegetative cover and status are determined during peak conditions at each site (Li-Cor, 1989). Specific procedures on the operation of the LAI-2000 are included in CASTNET Field SOP I.B. (See Appendix 1). Replaced by: Previously MACTEC personnel walked the area around each site to perform LAI measurements and "ground truth" verification of the land cover and land use classification maps that were obtained from the USGS (Anderson, et al., 1978). LAI measurements and ground-truth verification were performed for all of the sites in operation through 1999. Any changes to the land cover classification discovered during the ground-truth verification were incorporated into the CASTNET database.

Revision 2.0 (delivered 12-2003)	***Action***	***Change Description***
B.3.2.1	Add	The sealed shipping tube is then transferred to the courier by one person (the site operator). Exposed filter pack samples from EPA-sponsored sites must be received by the CASTNET analytical laboratory within two weeks of removal from the sampling tower.
B.3.4.1.1	Add	Exposed filter pack samples from EPA-sponsored sites must be received by the CASTNET laboratory within two weeks of removal from the sampling tower. When the exposed filter packs arrive back at the CASTNET laboratory, the shipment is inspected and unpacked by following….
B.3.5.1	Add	Filter packs are received at the MACTEC receiving area. Exposed filter pack samples from EPA-sponsored sites must be received within two weeks of removal from the sampling tower.
B.5	Add	Table B.5.1 lists the instruments used by EPA (MACTEC) and NPS (ARS) throughout the network. Figure B.5.1 provides a schematic of a standard EPA-sponsored CASTNET site.
B.5	Replace	Replace paragraph 2 on page 20 with: CASTNET sites are calibrated every six months (every 3 months prior to 2000) with NIST-traceable standards. The results of the initial instrument challenges performed during each calibration from 1990 through 2000 were used to compile the site accuracy results shown in Table B.5.6. All continuous parameters were within DQI criteria more than 90 percent of the time.
B.5.12	Add	…are recorded by the ESC 8816 or Odessa DSM-3260, the primary DAS, and by a DSM-3260L, the backup DAS.
B.5.12	Add	Insert as a new paragraph before Section B.5.12.2 For sites with ESC data loggers, CASTNET data acquisition utilizes ESC's custom communications and data transmittal software to conduct daily polling. The software, E-DAS Ambient ATX, inserts polled measurements directly into the DMC RDBMS, SQL Server™ 7.0 and is installed on a workstation designated for the polling of these specific sites.
B.7.1	Add	…and software developed by Odessa for those sites using Odessa DAS, and ESC's custom communications and data transmittal software, E-DAS Ambient ATX, for those sites using ESC data loggers.
B.7.1.2	Add	…operated CASTNET site has an Odessa DSM-3260 or ESC 8816 primary DAS and….
B.7.1.2	Add	…using a custom version of Odessa' Environmental Aide software or ESC's custom communications and data transmittal software, E-DAS Ambient ATX, for those sites using ESC data loggers.
B.7.2	Replace	Novell® network replaced by Microsoft® network

Revision 2.0 **(delivered 12-2003)**	***Action***	***Change Description***
B.7.7	Replace	Replace first and second paragraphs with: The CASTNET DMC performs full, weekly scheduled backups of the SQL Server™ database for each CASTNET related database. After the backups are complete, the files created by the backup process are archived using WinZip®, a file compression utility. The resulting WinZip® file is stored on the CASTNET server located in MACTEC's Jacksonville, FL office. Archives for the previous six weekly backups are maintained on this server at any given time. Once the archive file has been created, it is copied to the Jacksonville MACTEC server, which is managed by MACTEC IT staff and is backed up daily via tape drive. These tape archives will be stored off-site. In addition, a copy of the compressed backup file is archived to CD monthly. Two CDs are made. One CD is stored locally in the Jacksonville, FL office, and the second is stored off site to ensure that catastrophic loss would not cause the database to be off line for a significant period of time.
Table B.3.1	Add	Base cations and chloride.
Table B.5.1	Add	ESC 8816 data logger to EPA sites.
Table B.5.1	Delete	Delete Row for Performance Audits and corresponding footnotes for NAPAP.
Table B.5.6	Replace	Replace table with historical table titled: Accuracy Results for Field Measurements (1990 – 2000)
Table B.7.1	Replace	Update table.
Figure B.5.1	Add	Insert a new figure and renumber Figures B.5.1 through B.5.17. New figure: Figure B.5.1 Schematic of an EPA Sponsored CASTNET Site
C.1.4.1.1	Replace/ add	Additionally, Harding ESE field technicians visit each site once every six months…. replaced by MACTEC, ARS, or AQS
C.1.4.1.2.1	Replace	Delete the entirety of the section and replace with C.1.4.1.3. Field Operations Traceability and Equivalency Reference standards used to audit the CASTNET instrumentation (Table C.1.8) are certified by an approved certifying agency. Certification documentation for reference standards is maintained by the FOM.

Revision 2.0 **(delivered 12-2003)**	***Action***	***Change Description***
C.1.5.1	Replace	Replace the entirety of the subsections titled Base Program, Option A, and Option B with the following: • Base Program • Dry Deposition • Data Acquisition Systems • Ozone Analyzers • Meteorology: • Wind Speed Sensors • Wind Direction Sensors • Temperature and Temperature Difference Sensors • Relative Humidity Sensors • Solar Radiation Sensors • Precipitation Sensors • Surface Wetness Sensors
C.1.5.1.1	Add/ Replace	Every six months Harding ESE technicians visit each site to perform routine calibration and maintenance of all sensors and instruments. Replaced by: Every six months MACTEC, ARS, or AQS technicians visit each site to perform routine calibration and maintenance of all sensors and instruments.
C.1.5.1.2.3	Delete	Delete entire section.
C.1.5.1.2.4	Delete	Delete entire section.
Table C.1.4	Add	Table C.1.4 Field Internal Technical Systems Audit Components
Table C.1.5	Delete	Delete entire column for ARS Audit Standard
Table C.1.6	Delete	Delete Table C.1.6 and renumber following tables as necessary
Table C.1.8	Add	Add a last bullet to the Audit Component column in the Data Entry-Manual Entry column Were data that were manually entered into the database validated for accuracy through double entry?
Table C.1.9	Add	Add to Instrumentation column in the Data Acquisition row: Odessa DSM3260/3260L ESC 8816
Figures C.1.2, C.1.4, C.1.5	Replace	Update figures.
D.1.1	Add	This process uses the ENVICOM or the E-DAS Ambient ATX software programs to transfer the internal memory of the primary DAS by way of binary voltages and status flags to the polling computer.
D.1.4.1	Replace	Audit results are also evaluated during Level II validation in order to assist with validation decisions. Audit results are used to help determine the time frame for data flagging or adjustments. Audit results may be used to determine if data require flagging; Replaced by: Independent audit results may also be evaluated during Level II validation in order to assist with validation decisions. Audit results may be used to help determine the time frame for data flagging or adjustments. Audit results may also be used to determine if data require flagging;
Table D.4.1	Add	Add note below table: Note: Conversion constant for Cl^-, Na^+, K^+, Mg^{2+}, and Ca^{2+} is 1.0
Section E	Replace	Updated to match citations used in QAPP Sections A through E

Revision 3.0 **(Delivered 04-2006)**	***Action***	***Change Description***
All		Entire document restructured per discussion with EPA regarding document navigation.
Revision 4.0 **(Delivered 06-2007)**	***Action***	***Change Description***
All	Replace	CLASS™ replaced by Element™
All	Reorder	Move Chapter 4 Quality Assurance to Chapter 5; renumber Move Chapter 5 Data Operations up to Chapter 4; renumber
All	Replace	NPS operated 29 sites with NPS operated 27 sites
All	Replace	Whatman filters with cellulose filters
All	Add	Oracle to MS SQL
All	Add	Screened continuous measurements are delivered to EPA daily via Oracle
All	Add	Monthly and Quarterly Data are submitted to EPA via Oracle
All	Add	Data are archived on the Oracle server
All	Add	New site Santee Sioux Tribal Site, Nebraska (SAN189)
All	Add	New site - Wind Cave National Park, South Dakota (WNC4290)
All	Delete	Site Olympic National Park, Washington (OLY421)
All	Replace	CVS with CCV
All	Replace	John E. Lynch replaced by William E. Imbur
All	Replace	John J. Bowser replaced by Mark G. Hodges
Text 1.7.2.1	Add	Sensors for the measurement of temperature and precipitation and a rain gauge are operated - at a nearby NPS site at Great Smoky Mountains National Park, TN (GRS420)
1.7.2.2	Add	In 2005, the filter pack system at GSR420 was used to provide data to MADPro
1.7.4.3	Replace	replace section with "The database for the current year is delivered via e-mail in an Excel file and an Access database."
Table 1-2; 1-3	Replace	Update Tables
Table 1-6	Add	daily screening
Table 1-8	Add	*Notes:* All final projects are archived electronically in CentricProject which is located on the MACTEC server in Alpharetta, GA
Table 1-9	Add	*Note:* *Diskettes are no longer collected. Previously collected diskettes are archived for 7 years.
Figure 1-1; 1-2; 1-3;	Replace	Update figures
Text 2.0	Add	NPS calibration text page 3 LAI text page 3
	Delete	Visibility Sites text page 4
	Add	Six sites were collocated with CASTNET deposition sites and two were independently located.
2.4.2.1	Add	Ozone text
2.4.3	Replace	Climatronics Model 10002425 with Hygrometrix ModelXNAM-10205
2.9	Delete	data cartridges and diskettes of data from this section
Table 2-5	Update	Relative humidity - replace Climatronics 100098 with Hygrometrix XNAM-10205
Figure 2-19	Update	
Text 3.0	Update	Cation Reporting Limit calcium 0.006 mg/L and Potassium 0.006 mg/L
3.0 all	Replace	filter pack lot number with filter pack lab ID number
3.2.1	Update	"… four percent of Teflon® and nylon filters (or four filters from a box of 100) must be analyzed and found to be less than the reporting limit for 95 percent confidence that all filters in the box have blank contamination less than twice the reporting limit is established."
Tables 3.8;	Update	
3-11; 3-12	Replace	
Figure 3-11	Update	
3-14	Delete	
3-1	Replace	

Revision 4.0 **(Delivered 06-2007)**	***Action***	***Change Description***
4.0 Text all	Update	An Oracle database is used for data archival and delivery of data to EPA.
	Update	Each MACTEC operated CASTNET site uses a datalogger for data collection and transmittal of data to the DMC
	Update	VELAN table replaced by VW_MODEL_OUTPUT- view
	Update	script (pending)
Tables	Replace	4-1; 4-4; 4-8; 4-11; 4-13 update
Revision 4.1 **(Delivered 10-2007)**	***Action***	***Change Description***
1.2	Replace	restructured to improve readability
1.3.1.2.1	Replace	numbered list with a bulleted list
1.3.1.2.1	Replace	bulleted list with a numbered list
1.3.1.4.2	Replace	numbered lists with bulleted lists
1.3.1.5.1.1	Replace	dash with hyphen
Table 1-2, 1-3	Update	
Figure 1-1	Update	per EPA
Figure 1-3	Update	
2.9.2	Replace	bulleted list with a numbered list
3.1.6.1	Replace	tweezers with forceps
3.3	Replace	bulleted list with a numbered list
4.2.1.1	Update	Renumber list
4.3.7.1	Insert	Bulleted list
4.6.1.2	Insert	Bulleted list
Revision Tracking Sheet	Add	Add dates for each revision
Revision 5.0 **(Delivered 10-2008)**	***Action***	***Change Description***
All	Delete	Delete all references to Visibility Monitoring
All	Delete	Delete all references to Precipitation Monitoring
Figure 1-1	Update	
Figure 1-2	Update	
Figure 1-3	Update	
Figure 1-4	Delete	
Figure 1-8	Delete	
Figure 2-14	Delete	
Figure 2-15	Delete	
Figure 2-14	Delete	
Figure 2-20	Delete	
Figure 2-21	Delete	
Figure 3-2	Delete	
Figure 3-3	Delete	
Figure 3-9	Delete	
Figure 3-10	Update	
Figure 3-11	Update	
Figure 4-1	Update	
Figure 4-2	Delete	
Figure 4-14	Delete	

Revision 5.0 **(Delivered 10-2008)**	***Action***	***Change Description***
Figure 4-15	Delete	
Table 1-2	Update	
Table 1-3	Update	
Table 2-2	Delete	
Table 2-5	Update	
Table 2-11	Update	
Table 2-14	Delete	
Table 2-15	Delete	
Table 4-1	Update	
Table 5-15	Delete	
Appendix 1	Add	Trace Gas and Ozone Part 58 Monitoring SOP
Appendix 2	Update	
Appendix 3	Update	
Appendix 4	Update	
Appendix 5	Update	
Appendix 9	Update	
Appendix 10	Delete	Delete Appendix 10: Chester LabNet and Sunset Laboratory Standard Operating Procedures Appendix 1: Mountain Acid Deposition Program renumbered as Appendix 10
Appendix 11	Rename	Appendix 10
Section 2.4.2.1	Delete	The two solar powered sites (CAT175, NY and LYE145, VT) use 2B Technologies Model 202 ozone monitors. The 2B monitors are also based on UV absorption. The principal benefit of the 2B system is its low power requirements (3.5 watts), which are appropriate for solar powered. Table 2-8 lists the specifications.
Section 2.9.2	Update	Add Campbell Scientific CR3000
Section 2.9.2	Add	For sites with EPA-supplied CR3000 data logger and 49i Ozone Analyzers data will be polled hourly with Cambell's LoggerNet and uploaded to AIRNow. For any site supplying its own data logger, currently Cherokee Nation, OK (CHE185) and Alabama Coushatta, TX (ALC188), an ESC 8816 data logger will be used, and sites will be polled hourly using Datalink, and hourly data uploaded to AIRNow.
Section 3.3.5 and 3.3.6	Add	This procedure is followed for the determination of conductance in Cloud Water Samples collected for the Mountain Acid Deposition Program
	Update	Past tense to present
Section 3.3.7	Delete	
Revision 6.0 **(Delivered 11-2009)**	***Action***	***Change Description***
All Sections	Replace	Oracle 9i with Oracle 10g DOM with DMAIRM RH change to ± 10 percent of full scale Laboratory precision change from ±5 percent to ±20 percent MS SQL Server 7.0 change to SQL CASTNET database EPA bar code sticker replace with EPA 6-digit inventory number 82 sites replace with 84 sites DAS: Replace Odessa 3260 and H2NS CPP-4794 data loggers with Campbell CR3000 or Environmental Systems Corporation 8816 MACTEC Field Technicians - MACTEC Field Technicians and Subcontractors Ozone is assessed quarterly, met and flow annually
	Remove	SJWMD Visibility network discussion
	Add	Trace-level gas measurement Daily ozone ZSP checks Electronic field calibration forms

Revision 6.0 **(Delivered 11-2009)**	***Action***	***Change Description***
		DAS: Campbell LoggerNet polling software and IP addressable AirLink Raven cellular modems
Section 1		
1.3	Delete	Visibility and NADP/NTN from CASTNET description
1.3.1.1.	Update	Equipment inventory procedures
Table		
1-2	Update	
1-3	Update	
1-4	Update	"Hourly change >=25" added as a condition check
Figures		
1-1	Updated	
1-2	Updated	
1-3	Update	
1-4	Delete	
1-5	New	Typical Setup of an IP Communications CASTNET Site
1-7 – 1-10	Delete	
Section 2		
2.1.5	Update	Add trace gas
2.4.3	add	Met text
2.4.3.4.1	Replace	Hygrometrix 10205 replaced with Vaisala 102425
2.5.1	Update	Environment Canada day/night filter pack sampling description
Tables		
2-2	Delete	
2-12	Delete	
2-2	Update	
2-3	Update	
2-4	Update	
2-5	Update	
2-9	Update	
2-10	Update	
2-11	Update	
Figures		
2-1	Replace	C-3 with C-4
2-2	Replace	Site inventory Form
2-3	New	Site info Electronic Form
2-4	Replace	Page 3 with new shelter layout
2-5	Replace	Cal Sum Electronic Form
2-6	Replace	Ozone Electronic Form
2-7	Replace	Ozone Screen Shot
2-8	Replace	Narrative log
2-9	Replace	Wind Electronic Form
2-10	Replace	Temperature Electronic Form
2-11	Replace	RH Electronic Form
2-12	Replace	Precip Electronic Form
2-13	Replace	SR Electronic Form
2-14	Replace	Flow Electronic Form
2-15	Update	Data Traceability
2-16	Replace	Data Logger Calibration Electronic Form
2-17 – 2-23	Deleted	

Revision 6.0 (Delivered 11-2009)	***Action***	***Change Description***
Section 3		
3.3.5.4.2	Delete	
3.3.5.6.2	Delete	
Tables		
3-3	Updated	Precision criteria and Table Notes revised
3-4	Updated	Precision criterion to 20 percent
Figure		
3-1	Was 3-8	Laboratory Operations - renumber subsequent
3-2	Replaced	SSRF
Old 3-2 and 3-3	Deleted	And renumber subsequent
Old 3-9 and 3-10	Deleted	And renumber subsequent
Section 4		
All	Replace	SQL database is comprised of seven databases replaced by nine databases
	Replace	Field Groups replaced by work orders
4.1.1.1	Insert	Problem ticket tracking
4.2.1.1	Update	List of databases
4.2.2.1	Delete	Archived to CD
4.2.4.2	Update	
4.3.1	Update	
4.3.1.1	Update	
4.3.2	Update	
4.3.3	Update	
4.3.4	Update	
4.3.4.3.2.1	Delete	Example Adjustment During Level 3 Validation
4.3.5.4.1	Update	
4.4.4.2	Delete	SUM06 Ozone
4.6.1	Update	
4.6.2	Update	
Table 4-1	Update	
Table 4-3	Replace	Replaced by two tables: Current Auto-Adjustment Criteria and Current Outlier Criteria Renumber all subsequent tables
Figures	Renumber	Remove Fig 4-2; 4-3; 4-9; 4-10; 4-11;4-12; 4-14; 4-15
4-7	New	Metdata Editor Interface
Section 5		
5.3.1	updated	DQI Precision
5.3.5	updated	Representativeness
5.4.1.1	updated	Field Operations TSA
Appendix 1	Update	Update all for Campbell CR3000 data loggers, AirLink Raven modems, Thermo 49i ozone analyzers, and use of electronic forms.
Appendix 2	Update	
Appendix 3	Update	
Appendix 4	Update	Specific Conductance SOP updated to clarify use of automated temperature compensation.
Appendix 5	Update	Site operator payment contractor updated. Statement added that no specialized safety training is required.
Appendix 8	Update	Updated with most recent MACTEC Quality Management Plan.
Appendix 9	Update	Updated per recent nomenclature requirements.
Appendix 10	Update	Recent modifications to sampling system described. Site operations SOPs added.

Revision 7.0 (Delivered 10-2010)	*Action*	*Change Description*
All		Entire document reformatted per discussion with EPA regarding document organization and navigation.
Revision 8.0 (Delivered 11-2011)	***Action***	***Change Description***
All Sections	Replace	MACTEC Engineering & Consulting, Inc with AMEC E&I, Inc MACTEC with AMEC 84 sites with 82 sites
	Update	Ozone ZPS accuracy criteria to ±7 percent Ozone calibration criteria to within 2 percent of best-fit line with 5 percent linearity Text, tables and figures to reflect cessation of meteorological monitoring at all but four EPA-sponsored sites Text, tables and figures to reflect that ozone monitoring is compliant with 40CFR pt 58 and data are submitted to the EPA Air Quality System web application
Section 1		
1.1	Update	
1.3	Update	
1.3.1.1	Update	
1.7.6.1	Update	
Table		
1-1	Update	CON186, CA and LYK123, OH removed
1-3	Update	Above sites added
1-5	Update	List RTI International as independent auditor
Figures		
1-1 – 1-4	Update	
1-12	Update	
Section 2		
2.1.1.2	Update	
2.1.2	Update	
2.1.5	Update	
2.2.2.2.1	Update	
2.4	Update	
2.4.1	Update	
2.4.3.1	Update	
2.4.3.2	Update	
2.4.4.2.1.1	Update	
2.4.4.2.1.2	Update	
Tables		
2-3	Update	
2-4	Update	
2-5	Update	
2-6	Update	
2-10	Update	
2-11	Update	
2-12	Update	
Figures		
2-1 – 2-4	Update	
2-7	Update	
2-9	Update	
2-10	Update	
2-12 – 2-18	Update	
Section 3		
Figure		
3-2	Updated	

Revision 8.0 **(Delivered 11-2011)**	***Action***	***Change Description***
Section 4		
4.1.2.1	Insert	Text to describe fire security for tape archives
4.2.1.1	Update	*castnet_cloud* database corrected to *mountain_cloud*
4.3.3	Update	Report generators and recipients clarified
4.3.4	Update	
4.3.4.1	Update	
4.3.4.1.2.4	Update	Example of flow problem clarified
4.3.4.1.3	Update	Section title changed to Temperature/Shelter Temperature
4.3.7.2	Update	Users of report updated
4.6	Update	
Table 4-5	Update	
Table 4-10	Update	
Figures		
4-2	Update	
4-3	Update	
4-4	Update	
4-6	Update	
4-7	Update	
4-8	Update	
Section 5		
5.3.1	Update	
5.3.3	Delete	Last sentence of section
5.3.6	Update	
5.5.4.1.2	Update	
5.5.4.1.7	Update	
Table 5-7		
Section 6		
6.0	Insert	Reference for Bowker, *et al.* 2011 paper on data substitution
Appendix 1	Update	
Appendix 1	Replace	Assistant Field Operations Manager with Field Operations Manager
Appendix 2	Update	
Appendix 3	Update	
Appendix 4	Update	
Appendix 4	Add	SOPs for pipette calibration, standards labeling and control chart generation
Appendix 5	Update	
Appendix 6	Update	
Appendix 6	Add	Description of AQS file preparation and SOP for use of iCASTNET in reviewing ozone data
Appendix 9	Update	Updated per recent nomenclature requirements.
Appendix 10	Update	
Appendix 10	Remove	FedEx billing number removed from field analyses SOP

Revision 8.1 **(Delivered 11-2012)**	***Action***	***Change Description***
All Main Body Sections	Replace	AMEC E&I, Inc with AMEC Environment and Infrastructure
	Update	Update network snapshot, site counts, and dates Add trace level/gas monitoring to site description and parameter lists for Bondville, IL (BVL130), Beaufort, NC (BFT142), Huntington Wildlife Forest, NY (HWF187) Add Bureau of Land Management sites to network description and site lists Added small footprint sites, Underhill, VT (UND002), White Face Mountain, NY, (WFM105), Nicks Lake, NY (NIC001) Added BLM sites: Basin, WY (BAS601), New Castle, WY (NEC602), Buffalo, WY 9BUF603), Sheridan, WY (SHE604), Fortification Creek, WY 9FOR605)
Section 1		
1.1	Update	Primary objectives list updated
1.3	Update	Measurement description in paragraph 1
1.3.1.5	Insert	Text to describe third party audits
1.7.7	Correction	Reconcile all references to retention to five years
1.1	Insert	Measurements were discontinued at HOW132, ME in October 2012.
1.7.1	Delete	~~and are provided as hard copy and via e-mail as electronic portable document format (PDF).~~
	Update	O3 ~~data collected from the 2011 ozone season forward will be~~ are
	Delete	~~An improved version of the MLM (Schwede, 2006) includes changes to the soil moisture factor, which affects the stomatal and soil resistances, and to the radiation algorithm, which also affects the stomatal resistance.~~
1.3.1.1	Insert	BFT142, NC was discontinued in March.
	Insert	at most sites
	Insert	During 2013, delta temperature was measured at the five EPA sites plus the NPS sites at Acadia National Park, ME (ACA416); Great Smoky Mountains National Park, TN (GRS420); and Rocky Mountain National Park, CO (ROM406). Surface wetness was measured at the five EPA sites plus GRS420, TN.
	Move	Move callout on CASTNET Meteorological Measurements from p. 23
	Insert	The AMEC laboratory is certified (April 2013) under the International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025:2005 accreditation by the American Association for Laboratory Accreditation (A2LA) for a scope of test methods that includes those utilized for exposed CASTNET filters.
1.3.1.4	Insert	SQL Server and Oracle 11g
1.5.2.1	Insert	The precision of measured ozone concentrations is estimated using the procedures listed in Table 4-13.
1.7.4	Delete	~~as hard copy,~~ via e-mail as PDF and~~, and~~
1.7.5	Delete	Annual reports are provided ~~as hard copy and~~
Table 1-1	Update	Table 1-1
Figures		
1-3 – 1-9	Update	Updated
1-11 – 1-20	Update	Updated
Section 2		
2.1.5	Insert	BLM began operating four CASTNET sites in Wyoming in November 2012 and on site in April 2013. The BLM sites are designated at 600-series sites in Figure 1-3.
2.3	Insert	both ~~EPA~~, NPS and ~~NPS~~BLM
2.3.2	Insert	Training and Management: NPS- and BLM-Sponsored Sites
	Insert	NPS and BLM
	Insert	units and BLM public land ~~as described in Section 2.3~~ NPS/BLM ~~Fifty-five EPA-sponsored sites and 24 NPS-sponsored~~ All 83 O3

Revision 8.1 **(Delivered 11-2012)**	***Action***	***Change Description***
Section 2		
2.4	Update	(Figure 2-5) Add photos of API 100U, 200U, and 300U.
	Insert	Measurements of Trace-Level Gaseous Pollutants Appendix 11, QAP for Procuring, Installing, and Operating NCore Monitoring Equipment at CASTNET Sites, provides detailed information on the methods for measuring CO, SO2, and NO/NOy, a discussion of the specific API analyzers, and the approach to quality control.
2.5	Insert	three sites
2.5.2	Insert	(ftp:/upload.epa.gov/incoming/CASTNET/data)
2.5.6	Update	Add shipping box
Tables		
2-1	Update	Add requirements for filter-pack-only sites
Figure 2-5 title	Replace	(1 of ~~3~~4), (2 of ~~3~~4), (3 of ~~3~~4)
	Insert	EPA-Sponsored CASTNET Site Components (4 of 4)
Section 3		
3.1.2	Update	Add shipping box
	Insert	Laboratory personnel follow the SOP in Appendix 4. The QA Manager ensures distribution of updated SOPs and checklists to the AMEC laboratory. The QA Manager also ensures the removal of obsolete documents from the laboratory.
3.1.4	Update	Add shipping box
3.2.2	Delete	~~material~~ safety data sheets (~~M~~SDS)
3.5	Insert	The data are stored on the network and are uploaded using a rewritable disk or flash drive.
3.6	Insert	A2LA Certification
	Insert	The AMEC laboratory is certified (April 2013) under the International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025:2005 accreditation by the American Association for Laboratory Accreditation (A2LA) for a scope of test methods that includes those utilized for exposed CASTNET filters.
Figure 3-1	Adjustment	Last box ("Data transmitted monthly") of flow chart moved to accommodate formatting
Section 4		
4.4.2	Insert	Text to describe data substitution
4.3.4.1.1	Insert	Text to describe annual ozone data review
4.1.1	Replace	appropriate Windows-based computer systems. The current standard computer configuration is adequate to support a 64-bit operating system and includes software such as Microsoft Office and antivirus programs for computer security. ~~Intel Pentium (Pentium 4, Pentium D, and Pentium Dual Core) based computer systems. The current standard computer configuration for new a acquisitions is a 1.6 GHz Pentium Dual Core, with 1GB memory, 80GB hard drive, integrated gigabit network interface card, DVD RW drive, integrated sound card, speakers, and a flat screen monitor capable of a minimum resolution of 1024 x 768 pixels.~~
4.6.2		~~Hard copy~~ Reports to EPA
Figures		
4-8	Insert	Example of Annual Data Plot (for site-year ROM406-2007)
4-8 – 4-9	Update	Update figure numbering to 4-9 and 4-10
Section 5		
5.5.8	Insert	New section describing third party audit protocols
5.3.2	Insert	or subcontractor
5.5.4.1.7	Insert	by injecting known air quality concentrations through the sampling
5.5.4.2.5.1	Delete	~~buckets,~~
5.5.6.1	Insert	Precision of O3 measurements is summarized in Table 4-13.

Revision 8.1 **(Delivered 11-2012)**	***Action***	***Change Description***
Appendices		
Appendix 1	Update	Temperature, flow and AQS-protocol ozone sections of field calibration manual
Appendix 1	Add	SOPs for Teledyne API precursor gas analyzers
Appendix 2	Update	
Appendix 3	Update	
Appendix 5	Update	
Appendix 6	Update	Data Deliverables SOP – AQS ozone and daily data delivery subsections added
Appendix 9	Update	Updated condition codes
Appendix 11	New	Quality Assurance Plan (QAP) for Procuring, Installing, and Operating NCore Air Monitoring Equipment at CASTNET Sites Model 701H Zero Air Generator SOP Handling And Storage of Compressed Gases SOP Remote Calibration SOP Model T100U Sulfur Dioxide (SO2) Analyzer Standard Operating Procedure SOP Model T200U NO/NOy Analyzer SOP Model T300U CO Analyzer SOP Model T700U Dynamic Dilution Calibrator SOP

Revision 8.2 **(Delivered 10-2014)**	***Action***	***Change Description***
All Main Body Sections	Replace	ICP-AES with ICP-OES and data-logger with data logger
	Update	Update network snapshot, site counts, and dates. These include two additional small footprint sites – KIC003, KS and RED004, MN; two additional NO/NOy sites – PNF126, NC and ROM206, CO; and cessation of ozone monitoring at KNZ184, KS.
	Change	Ozone range, span and precision values from 500 ppb, 400 ppb and 90 ppb respectively to 250 ppb, 200 ppb and 60 ppb. Zero check criterion lowered from 5 ppb to 3 ppb.
Section 1		
1.1	Bullet added	To provide scientifically defensible data to gauge the effectiveness of EPA emission reduction programs;
	Added	The five Wyoming sites are sponsored by BLM and are operated to support the Wyoming Air Resources Monitoring System (WARMS). The two New York sites are sponsored by the New York State Department of Environmental Conservation (NYSDEC) and New York State Energy Research and Development Authority (NYSERDA). The site in Vermont is sponsored by EPA. The WARMS sites measure temperature, barometric pressure, precipitation, relative humidity, scalar wind speed and direction, and solar radiation. The New York and Vermont sites operate filter packs but do not measure meteorological conditions.
	Added	The new hybrid approach (EPA, 2014a), which incorporates CMAQ output with air quality monitoring data, will be used for future spatial analyses of dry and total deposition. The hybrid approach is summarized in the 2012 CASTNET Annual Report (AMEC, 2014) and on the EPA total deposition web page (ftp://ftp.epa.gov/castnet/tdep/Total_Deposition_Documentation_2014v01.pdf).
1.2	Change	Figure 1-12 previously numbered as Figure 1-11. **QA Officer** ~~L. Kertcher~~ K. Orehowsky, ~~**Principal-In-Charge**~~ **Director of Governmental Programs**
	Change	Figure 1-14 previously numbered as Figure 1-13. **Contracting Officer's Technical Representative** ~~Ellen Porter (Acting)~~ Barkley Sive
	Added	Figure 1-14, Box for **ARS Field Operations Manager** Mike Slate
1.3	Changes	In Figure 1-~~3~~4 and Table 1-1, CASTNET sites are designated as 100-series sites for EPA-sponsored sites, 400-series for NPS-sponsored sites, and 600-series for BLM sites in Wyoming.

Revision 8.2 **(Delivered 10-2014)**	***Action***	***Change Description***
1.3.1.2.1	Added	The five-step site selection process illustrated in Figure 1-16 was followed for eastern sites established before 2002. Currently, monitoring locations are often offered/recommended by tribal or governmental agencies. For example, the new sites in Wyoming were recommended by BLM. In these cases the on-site evaluations were limited to the environs of the recommended site locations. Limited site evaluations are more typical today. On the other hand, most of the CASTNET sites that were operated during NDDN and prior to 2002 underwent the full site selection process.
1.3.1.4.1	Added	Level 1 includes preparing a complete database. The screened data are delivered via Oracle to EPA daily. Hourly continuous measurements are delivered to EPA AIRNow (www.airnow.gov) to support forecasts of the Air Quality Index (AQI).
	Added	The purpose of Level 2 validation is archiving the completed (but not validated) database.
1.7.2	Added	Screened continuous measurements are delivered to EPA daily via Oracle. Hourly continuous measurements are delivered to AIRNow.
1.7.3	Added	These data are subsequently made available to the user community by EPA via the CASTNET Web site (www.epa.gov/castnet). O3 data are delivered to the EPA Air Quality System monthly.
Section 1 Tables		
1-7	Additions	No standards or standard methods are available to determine the accuracy of the CASTNET deposition model. However, model evaluation and intercomparison studies indicate that the model generally underestimates SO2 and HNO3 dry deposition. However, the extent and scope of the field measurements were insufficient to gauge the degree of underestimation. In order to better assess model performance the model output will have to be compared to recent, independent, multi-year flux measurements.
Section 2		
2.1.1	Added	The CASTNET design is based on measurement of rural, regionally representative concentrations of sulfur and nitrogen species and O3 in order to estimate dry deposition fluxes, detect and quantify trends, define the spatial distribution of pollutants, and gauge the effectiveness of current and future emission control programs.
	Added	Currently, four EPA-sponsored, five BLM-sponsored and all NPS-sponsored CASTNET sites collect hourly meteorological measurements (Section 1.1).
2.1.2	Added	CASTNET continuous measurements are delivered to AIRNow (www.airnow.gov) hourly and to EPA daily.
2.1.3	Added	LAI data for sites installed after 1997 were estimated from the 1991−1997 LAI database, from aerial photographs of vegetative cover within one kilometer of the new site, and from any related information on completed SSRF.
2.2.1	Added	The siting criteria for filter pack only sites are listed at the bottom of Table 2-1.
2.2.2.1	Added	Prior to engaging in on-site field surveys, advance work is accomplished by AMEC. This includes review of information (e.g., site summaries, site descriptions, and any air quality and meteorological data) available from other networks about existing sites they are currently using that could provide candidate sites for CASTNET.
2.2.2.2.2	Added	Some tasks listed in Table 2-2 have not been needed for many newly installed sites because site infrastructure had already existed and a local site operator was available from the cooperating organization. A typical site configuration for a standard CASTNET site is shown in Figure 2-1. A typical site configuration for a small footprint, filter pack only site is given in Figure 2-2.
	Insert	New figure/photo Figure 2-2
	Added	Figure 2-4 shows an inventory form for a small footprint site.
2.2.2.3	Added	The two new sites in upstate New York (NIC001 and WFM105) are operated by DEC and NYSERDA, respectively. The new site in Vermont (UND002) is operated by EPA on a NADP site.
	Insert	Insert new Fig 2-6, Site Information Form for FP Only Sites

Revision 8.2 **(Delivered 10-2014)**	***Action***	***Change Description***
2.2.2.4	Added	AMEC expects future sites will be proposed by government agencies, universities, or tribes. Consequently, site evaluation will be performed primarily on a local basis and not regionally.
	Added	Again, candidate sites will often be proposed by participating agencies; and in these situations AMEC's role will be to gauge site acceptability.
2.2.2.5	Added	Again, AMEC anticipates future site selection activities will focus on a local area rather than candidate sites spread over a wide region.
	Deleted	During the on-site evaluation, AMEC personnel interview the prospective site operators ~~identified during the presurvey activities~~.
2.3	Added	Note that only four EPA sites operate the meteorological instruments listed in Table 2-3.
	Added	If the site includes O3 measurements, as most do, operation of the ozone analyzer is also emphasized.
	Delete and insert	Site operators received additional support and training during the Tuesday call to the FOM, during each biannual calibration visit, and ~~through technical tips and informative articles provided by the CASTNET site operator newsletter, which is delivered electronically two to three times per year~~ any site visits.
2.3.1	Added	CR3000 or CR850 data logger
	Delete	~~Verify that the site operator has viewed the operator training video on site laptop computer.~~
2.4	Added	Meteorological instruments (Table 1-1) are operated at four EPA, five BLM, the SJRWMD site at IRL141, FL and all NPS sites. In addition, NPS operates the meteorological instruments at the EPA PND165, WY site.
2.4.5.3.1	Added	Delta temperature was calculated previously by subtracting the 2 m temperature from the 9 m temperature. The 2 m temperature is no longer measured. Campbell Scientific Model 107 temperature probes are used to measure temperature inside the shelters.
2.5.2	Added	All of the continuous measurements described in the previous sections are recorded by the Campbell Scientific CR3000, CR850 or ESC 8816 data loggers.
Section 2 Tables		
2-3 (1 of 2)	Added	Trace Gas Samplers • Review automated z/s/p checks with span and precision checks at 10% of full scale and zero checks at 3% of full scale (CO at 2%); see QAPP Appendix 11 — Every Tuesday • Perform manual z/s/p checks — As requested by FOM or field coordinator • Check internal diagnostics — Every Tuesday • Check sample tubing integrity — Every Tuesday
2-3 (2 of 2)	Added	**Operation**[1, 2, 3]
	Added	[3] See Appendix 11 for details on trace-gas analyzers
2-5	Added	Calibration of trace gas instruments is discussed in QAPP Appendix 11.
2-6 (2 of 2)	Added	Campbell Scientific[2], Model CR3000 or CR350
	Deleted	~~[2] A second in-station photometer is utilized at 20 EPA-sponsored and all NPS-sponsored sites for verification of test atmosphere.~~
Section 3		
3.1.2	Replaced	Figure 3-2 replaced with a more recently completed SSRF
	Change	The filter pack ID label and corresponding S label are turned into the laboratory technician who ~~handles sample log in~~ performs the peer review of the logins and stores/enters SSRF data into the CASTNET CDMSA.

Revision 8.2 **(Delivered 10-2014)**	***Action***	***Change Description***
Section 4		
4.0	Change	The AMEC DMC is the repository for CASTNET data, including raw data that have been collected but not validated, and data that have been ~~validated~~ accepted using various validation schemes (e.g., Levels 1, 2, and 3).
4.1.1	Insert	The data logger program, which was developed by AMEC, allows site operators and site calibrators access to CR3000 data or CR850 data from small footprint sites.
4.2.1	Insert	The software currently used to process CASTNET data is MS SQL Server Version ~~7.0~~ 2008. Version 2012 will be installed by October 2014.
4.2.1.2	Insert	Section: 4.2.1.2 Client-access software
4.2.1.3	Insert	When deposition velocities are unavailable due to data completeness or validity issues, historical deposition velocities [Bowker *et al*. (2011)] are used as substitutes. A new hybrid approach (EPA, 2014), which incorporates air quality monitoring data with Community Multiscale Air Quality Modeling System (CMAQ) output, will be used for future spatial analyses of total deposition.
4.2.4.2	Change	~~CentricProject~~ SharePoint
4.3	Change	~~MS SQL Server 7.0~~ Version 2008
4.3.1	Change	As of ~~April 2013~~June 2014, meteorological measurements are collected at four EPA sites: BEL116, MD; BVL130, IL; PAL190, TX; and CHE185, OK.
	Addition	♦ Screened, but not validated, data archived into a single processing table; and all data that can be collected have been collected; and
4.3.1.1	Insert	Level 1 data validation also consists of a data analyst reviewing data at the end of a month and retrieving missing data using LoggerNet. Essentially, this step represents a double check of the daily review process. This new protocol for eliminating missing data entry is based on the implementation of the LoggerNet software and development of associated supporting programs. These activities were completed previously under Level 2. Monthly, the data analyst responsible for Level 1 validation generates a missing field data report (Figure 4-4). The report, produced for all sites for which continuous data are validated, shows every hour during the month for which there is a missing value for at least one parameter. The data analyst repolls the site data using LoggerNet. Occasionally, data from site print-out's will be used to replace missing data at CHE185, OK. Manual entry is used in this situation. In order to successfully update the database, the data analyst must document the reason the data are being updated and the origin of the data used for the update. Changes are recorded, along with the reason and source, in the TRANSACTION_LOG table in the *castnet_working* database, which then provides electronic documentation for all corrective actions performed during the Level 1 process. When manual entry is complete, new daily reports are printed as needed. In addition to verifying and validating accuracy through double entry, replaced values are routinely checked against the original source of the backup values to ensure accuracy during the manual entry process.
4.3.3	Section replaced with	**Level 2 Data Processing** The purpose of Level 2 validation is archiving the completed (but not validated) database. Level 2 archives all collected data into a single processing table. At this point, all data that can be collected have been collected. Previously, Level 2 included assembling all missing data that were subsequently available. Now, the collection of missing data is completed during Level 1.
4.3.4	Insert	All changes to the CASTNET database during Level 3 procedures are recorded on hard copy forms using a combination of continuous data review form (CDRF) (Figure 4-5) and/or continuous data validation summary (CDVS) (Figure 4-6) forms. Move Figures 4-5 and 4-6 here.
	Insert	Adjustments to ozone values are not permitted.

Revision 8.2 **(Delivered 10-2014)**	***Action***	***Change Description***
		Level 3 validation for the trace-level gas measurements (Appendix 11) is similar to the process for the standard CASTNET measurements.
4.4.2	Insert	As of April 2013 and currently, meteorological data are collected at four sites. This approach results in nearly 100% data completeness. A new hybrid approach (EPA, 2014a), which incorporates air quality monitoring data with Community Multiscale Air Quality Modeling System (CMAQ) output, will be used for future spatial analyses of dry and total deposition.
4.4.5.2	Insert	In order to replace missing values for V_d caused by missing and discontinued meteorological parameters and improve data completeness, EPA selected a method based on the process developed by Bowker *et al*. (2011) to substitute hour-specific historical averages for missing V_d values at specific sites. Previously, the rules used for calculation of V_d ~~are~~were as follows:
Section 4 Tables		
4-1	Table deleted	Table 4-1. Database Tables in SQL Server, Oracle, or Both (1 of 6)
4-1	Insert and Delete	Level 1 • Apply automated screening protocols. • Locate all missing data points using MS SQL Server queries. • Poll CR3000 data loggers with LoggerNet and update database. ~~Locate all missing data points using MS SQL Server queries.~~ ~~Poll CR3000 data loggers with LoggerNet and update database.~~ Level 2 Archives all collected data into a single processing table. At this point, all data that can be collected have been collected.
Section 5		
All	Replace Added	Figure 5-2 Expanded discussion of readiness reviews in section 5.4.2.4
Section 5 Tables		
5-7	Updated	Instrumentation column deleted
5-9	Updated	Instrument listings updated
Appendices		
Appendix 1	Update	All sections updated ozone range, span and precision values from 500 ppb, 400 ppb and 90 ppb respectively to 250 ppb, 200 ppb and 60 ppb. Zero check criterion lowered from 5 ppb to 3 ppb. Shelter temperature requirements from 18-32°C to 20- 30°C. All sections updated to account for limited meteorological sampling, six trace gas monitoring site locations, Bureau of Land Management sponsorship of some sites, and communications using Raven cellular modems.
Appendix 4	Update	GLM-3180-001 and GLO-3180-035 updated to refer to Chromeleon 7.2 software. References to PeakNet software deleted.
Appendix 6	Update	iCASTNET SOP updated to include updated ozone measurement criteria.
Appendix 9	Update	SBIC Supply Room Sign-Out SOP.
Appendix 11	Added	Description of procedure to track NPN conversion efficiency through gas cylinder changes when the system is otherwise not adjusted.
Revision 8.3 **(Delivered 10-2015)**	***Action***	***Change Description***
Front	Update Added Update	Signature page AA3 AutoAnalyzer 3 Kathy Barry, Laboratory Operations Manager Bureau of Land Management: Ryan McCammon, Air Resource Specialist

All Sections	Update	Update O_3, NO/NO_y, SO_2 zero check criterion to 1.5ppb and CO zero check criterion to 30ppb.
All Main Body Sections	Replace	AMEC with Amec Foster Wheeler
	Update	Update network snapshot, site counts, dates; form figures and dated embedded maps and data figures. Including the addition of WFM007, NY.
	Add	"BLM" - to all project partner discussion
	Add	"gauge compliance with O_3 National Ambient Air Quality Standards (NAAQS)" – to discussion of project objectives
	Update	Model discussions updated to note TDEP method as primary for estimates of deposition.
	Delete	All discussion of the discontinued Mountain Acid Deposition Program including tables.
Section 1		
1.1	Bullet updated	To evaluate and improve atmospheric air quality/deposition models;
	Added	The Amec Foster Wheeler CASTNET laboratory (analytical and field) is certified under the International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025:2005 accreditation by the American Association for Laboratory Accreditation (A2LA) for a scope that includes test methods performed at its primary facility and remote monitoring stations.
	Added	…four EPA-sponsored and all NPS-sponsored CASTNET sites collect hourly meteorological measurements, which are used to understand atmospheric pollutant dispersion and, specifically, as input to the MLM… Nine-meter temperature is measured at all sites in the network to support filter pack concentration measurements.
	Added	The photograph was taken on March 3, 2010, when Climatronics instruments were operated at BVL130.
	Added	However, CASTNET O3 monitoring systems at EPA-sponsored sites, except for the site at HOW191, ME, now comply with regulatory monitoring requirements described in 40 CFR Part 58, Appendix A (EPA 2014)...
	Added	Figure 1-9 Fourth Highest DM8A O3 Concentrations (ppb) for 2014
	Insert	Figure 1-1 CASTNET Sites Operational During 2015
	Insert	However, BLM collects meteorological measurements at PND165, WY and SJRWMD collects meteorological data at IRL141, FL.
1.2	Added	Amec Foster Wheeler QA personnel added to Figure 1-11.
	Insert	While all program partners cooperate in managing and operating the network, EPA is the primary program sponsor and, therefore, establishes the program requirements. Each sponsoring agency has established their own monitoring objectives; however, there are common network objectives (Section 1.1) across the agencies. The contractor for each agency collects and validates network data according to the QA program described in this QAPP and its appendices. Amec Foster Wheeler is responsible for common database management, data reporting, and all filter pack analyses. The program sponsors and their contractors communicate routinely through regularly scheduled meetings.
	Replace	Figure 1-12 replace C. Greer with A. Bernhardt and D. Tillison with R. Gray
	Update	Figure 1-13
	Insert	Site selection includes completing any special arrangements required for a site.
1.3.2.1	Change	Monitoring sites also need to be available for extended periods (40 years) in order to assess dry deposition trends.
	Added	Site selection procedures differ somewhat for different types of sites (traditional, filter pack only or gaseous pollutant monitoring) ...
1.3.1.3	Added	The CASTNET laboratory (analytical and field) is certified under the ISO/IEC accreditation by A2LA for a scope of test methods, which include those utilized for exposed CASTNET filters, at its primary facility and at remote monitoring stations.
1.3.1.4.1	Added	All EPA-sponsored sites, except for CHE185, OK, use Campbell Scientific CR3000 or CR850 Micrologger data loggers...

1.7.5	Updated	An annual report typically includes • an overview of CASTNET operations and a discussion of any changes in sampling and analytical methods, together with an analysis of the potential implications on reported concentrations • current year maps of annual mean concentrations of sulfur and nitrogen species and fourth highest DM8A O3 levels and their trends • modeled dry deposition rates, measured wet deposition rates, and estimates of total sulfur and nitrogen deposition for the current year and trends in deposition rates • analyses of trace-level pollutant concentrations measured at CASTNET sites • special topics of interest, e.g., air quality in regions of the United States with energy development and effect • Maps of critical loads of sulfur and nitrogen pollutants across United States • QC data for the network used to estimate the precision, accuracy, completeness, and other indicators for each measurement system.
Section 1 Tables		
1-1	Insert	"Trace Gas Measurements" column
Section 2		
2.1.1.1	Added	NPS measures NO/NOy concentrations at Mammoth Cave National Park, KY (MAC426) and Great Smoky Mountains National Park, TN (GRS420).
2.1.2	Added	CASTNET was not originally designed to operate as a regulatory network. However, all except one (HOW191, ME) monitoring system at EPA-sponsored sites complies with regulatory monitoring requirements described in 40 CFR Part 58, Appendix A (EPA 2014), and measured O3 data are submitted monthly to AQS. The trace-level pollutant instruments, which are operated at BVL130, IL, BEL116, MD, HWF187, NY, ROM206, CO, PNF126, NC, MAC426, KY and GRS420, TN support NCore monitoring requirements.
	Insert	The EPA-sponsored deposition research site, HOW191, ME, does not comply with the regulatory siting requirements and is therefore not used for NAAQS determinations.
	Insert	CASTNET continuous measurements are delivered to AIRNow (www.airnow.gov) hourly and to EPA daily.
2.2.1	Updated	Guidance for site selection is based on agency requirements, e.g., 40 CFR Part 58 Appendix E Tables E-1 and E-2 and Figure E-1, and CASTNET site-selection criteria. Site selection procedures differ somewhat for different types of sites (traditional, filter pack only or gaseous pollutant monitoring). A list of the site-specific siting criteria used in the site selection process for classic CASTNET sites is shown in Table 2-1. The siting criteria for filter pack only sites are listed in Table 2-2. Siting criteria for trace gas measurements are provided in Table 2-3.
2.2.2	Updated	Review of emissions inventory, population, traffic, and ...
2.2.2.3	Added	Underhill is sponsored by VT DEC (in-kind operations). It is collocated with NTN, AIRMoN, NCore, and IMPROVE.
2.3	Updated	If the site includes O3 measurements and/or trace gas measurements, operation of the continuous analyzers is also emphasized.
2.3.2	Replaced	Entire section revised using information from Section 4.2.8 of the ARS SOP "Procedures for Semiannual Maintenance Visits to a NPS Ambient Air Monitoring Station."
2.4	Update	Figure 2-9
2.5	Delete	The data logger employs three levels of security, which are password protected.
2.5.1	Update	Figure 2-21
Section 2 Tables		
Table 2-1	Updated	Converted table to address traditional CASTNET monitoring sites only. Added average daily traffic criteria.
Table 2-2	Added	Added table to describe "Siting Criteria for CASTNET Filter Pack Only Monitoring Sites"

Table 2-3	Added	Added table to describe "CASTNET Siting Criteria for Gas Monitoring"
Table 2-11	Update	Table 2-11 Field Maintenance Schedule
Table 2-13	Update	Table 2-13 Field Calibration Schedule
Table 2-14	Insert	(row 2) or another EPA region (row 3) or an EPA regional laboratory
Section 3		
3.6	Added Insert	...a scope of laboratory and field test methods... The current A2LA certification runs through May 31, 2017. The schedule for recertification is every two years.
Section 4		
All	Update	Tense agreement to present
4.0	Insert	Microsoft
Figure 4-1	Update	Figure 4-1 Flow of Data
4.1.1	Update Update	…collected hourly to a centralized server and automatically uploaded into the Amec Foster Wheeler database using Campbell's LoggerNet polling software (see Figure 4-2). …entered directly into the MS SQL Server Level 0 database
4.1.2	Update	Amec Foster Wheeler uses the Promium Element LIMS (Element) ... The Element program is illustrated in Figure 3-5.
4.1.2.1	Insert	The Element data management system is handled using the same server where SQL Server resides. Weekly scheduled backups of the SQL Server and Oracle 11g databases are created for all CASTNET-related data. For information that is updated several times per day, daily incremental backups are also performed. The CASTNET database system is comprised of a physical server that hosts two virtual servers, and is located in the Gainesville, FL office. After the backups are complete, the files created by the database backup process are stored locally on the servers and on three external hard drives used in rotation to permit onsite and offsite backups. Onsite backups are stored in a fire proof safe in a room equipped with an automated fire control system. Gainesville and Jacksonville office servers, used to store project related files, are backed up daily to the cloud, a process that is managed by Amec Foster Wheeler IT staff.
4.2.2.1		Software updates generally affect any one of four components
4.2.4.1	Delete	Additionally, the CASTNET database server is located on a separate sub-network of the main Amec Foster Wheeler network. This means that the CASTNET database server cannot be accessed without first obtaining access to the Amec Foster Wheeler main network and then obtaining rights to access that sub network.
4.2.4.2	Insert	After the backups are complete, the files created by the backup process are archived to external hard drives located in Amec Foster Wheeler's Gainesville, FL office. Three external hard drives per server are used in rotation so that one external hard drive is in use, one is onsite and available, and the third is offsite. Critical software and electronic documents are backed up to the Gainesville or Jacksonville office servers, which are backed up daily to the cloud in a system managed by Amec Foster Wheeler's IT staff. Should a disaster occur that renders the CASTNET server inoperable, the database management software will be rapidly re-loaded…
4.3	Add	Tables 2-6, 2-12, 3-3, 4-4 and 4-12
4.3.1.1	Delete	These activities were completed previously under Level 2.
4.3.4	Insert	All changes to the CASTNET database during Level 3 are reviewed using forms designed to assist the data analyst. The forms include a data review form (CDRF) (Figure 4-5) and/or a continuous data validation summary (CDVS) (Figure 4-6) form.
4.3.4.1.1	Update	(Figure 2-13). The daily z/s/p checks (Figure 2-15)
4.3.4.1.3	Insert	If the shelter temperature differs from the test temperature by more than ±2°C, then shelter temperature data are flagged as invalid for exceeding 2°C.
4.3.4.2	Update	see Table 2-6
4.3.5	Update	All section headings from "Dry Deposition" to "Filter Pack"
4.4.1	Update	Table 4-9, Table 4-10
4.4.5.2	Added	Although TDEP is now the primary model for estimating deposition, MLM/Bowker results are likewise produced and delivered to EPA annually.

4.6.1.2.2	Insert	Site information for sites submitting data to AQS is reviewed annually and updated when warranted by site changes.
Section 4 Tables		
Table 4-7	Added	R status flag definition – "Used for flagging ozone or trace-level gas QC check results. The R flag indicates that the QC check is valid but that associated ambient measurements are not valid and the check should not be submitted as a1-point QC check to AQS."
Section 5		
5.1.1	Changed	ARS QA Manager to QA Officer
5.4.2.2.1	Insert	Independent field assessments are generally not performed for this contract. However, field laboratory and field management systems are assessed by A2LA. A2LA assesses laboratory operations every two years
5.4.2.4.2	Insert	• QA plan (if required by task order)
Appendices		
Appendix 1	Updated – All sections of IIIA	AMEC with Amec Foster Wheeler. Updated figures depicting example forms. Move figures from appended sections and embed in text. Added additional figures (4,5 8-11,16,17,24-27,34 depicting equipment connections.
IIIA § 3.1	Updated	Network description updated to include trace gas monitoring.
IIIA § 3.2	Added	Field calibration schedule as Table 1.
IIIA § 4.0	Added	A compact disc with the HASP and Site Operator Handbook (QAPP Appendix 1, Section II) is provided in the shelter. Completed iForms with transfer certifications for the last three years are stored on the site laptop. Vendor instrument manuals are available to the calibrators either as hard copies or electronic copies on the laptop. Blank iForms are located on the calibrator thumb drive, which is shipped in the calibration kits for each calibration visit. Thumb drives store completed iForms and transfer certifications at small footprint sites.
IIIA § 6.0	Moved	Ozone and flow procedures moved to the beginning of the section.
IIIA § 6.0 (all subsections for each piece of transfer equipment)	Added	Identify the correct transfer electronic certification form found on the root directory of the calibration flash drive. Make sure the certification form is complete and that the transfer ID number matches the ID number on the certification form. Place a copy of the electronic certification form in the site calibration folder on the calibration flash drive to be copied to the site laptop at the completion of the site audit.
IIIA § 6.5	Added	6.5 Trace Gas Concentrations QAPP Appendix 11 describes trace gas concentration instruments, their specifications, data processing and QC requirements, and SOP for each instrument
IIIA § 7.0	Updated	Reference citations updated.
IIIA § 8.0	Updated	Figure citations updated.
Appendix 2	Updated	
Appendix 4	Updated	GLM-3180-001, GLM-3180-002, GLM-3180-004, GLM-3180-005, GLM-3180-007, GLM-3180-008, and GLO-3180-035 all updated. Please see the revisions table in each SOP for a description of changes.
Appendix 5	Updated	
Appendix 8	Deleted	The Amec Foster Wheeler QMP is a corporate document submitted separately.
Appendix 10	Deleted	The Mountain Acid Deposition Program has been discontinued.