Clean Air Status and Trends Network (CASTNet)

Quality Assurance Project Plan (QAPP) Revision 2.0

Prepared For:

U.S. Environmental Protection Agency

Prepared By:

MACTEC
Engineering and Consulting, Inc.

October 2003

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Quality Assurance Project Plan

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Office of Air and Radiation
Research Triangle Park, NC
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Prepared by:

MACTEC Engineering and Consulting, Inc.

October 2003

A.1 Title and Approval Sheet

Clean Air Status and Trends Network
Quality Assurance Project Plan

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List of Acronyms and Abbreviations

AACE™	Automated Analyzer Control and Evaluation
AC	alternating current
AQDBMS	Air Quality Database Management System
ARPD	absolute relative percent difference
ARS	Air Resource Specialists, Inc.
ASTM	American Society for Testing and Materials
B_{scat}	light scattering coefficient
BLM	Bureau of Land Management
°C	degrees Celsius
Ca^{2+}	calcium ion
CAAA	Clean Air Act Amendments of 1990
CAPMoN	Canadian Air and Precipitation Monitoring Network
CASTNet	Clean Air Status and Trends Network
CD	compact disc
CDMSA	CASTNet Data Management System Application
CDRF	Continuous Data Review Form
CDVS	Continuous Data Validation Summary
CFR	Code of Federal Regulations
Chester	Chester LabNet
CH_4	methane
Cl^-	chloride ion
CLASS™	Chemical Laboratory Analysis and Scheduling System
cm^2	square centimeter
CO_2	carbon dioxide
COTR	Contracting Officer's Technical Representative
CVS	continuing verification samples
DAS	data acquisition system
DC	direct current
DI	deionized
DMC	Data Management Center
DOM	Data Operations Manager
DQI	Data Quality Indicator
DQO	Data Quality Objective
EC	elemental carbon
ECAN	Environment Canada
EDTA	ethylenediamine-tetraacetic acid
EEPROM	electronically erasable programmable read only memory
EPA	U.S. Environmental Protection Agency
ESC	Environmental Systems Corporation
°F	degrees Fahrenheit

List of Acronyms and Abbreviations (continued)

FAR	Federal Acquisition Regulations
FID	flame ionization detector
FOM	Field Operations Manager
GB	gigabyte
Harding ESE	Harding ESE, Inc., now known as MACTEC Engineering and Consulting, Inc.
HCl	hydrochloric acid
Hg	mercury
HNO_3	nitric acid
IC	ion chromatography
ICP-AES	inductively coupled plasma - atomic emission spectrometry
ID	identification
IMC	Information Management Center
IMPROVE	Interagency Monitoring of Protected Visual Environments
IT	information technology
K^+	potassium ion
KΩ	kilo Ohm
K_2CO_3	potassium carbonate
km	kilometer
KOH	potassium hydroxide
L	liter
LAI	leaf area index
LAN	local area network
LED	light-emitting diode
Li-Cor	Li-Cor, Inc.
LIS	Laboratory Information Specialists
LOM	Laboratory Operations Manager
Lpm	liters per minute
m	meter
MACTEC	MACTEC Engineering and Consulting, Inc.
MHz	mega Hertz
m/sec	meters per second
MAD	mean absolute difference
MARPD	mean absolute relative percent difference
MB	megabytes
MFC	mass flow controller
mg	milligram
Mg^{2+}	magnesium ion
mL	milliliter
MLM	Multi-Layer Model

List of Acronyms and Abbreviations (continued)

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
NCAF	Non-Conformance/Corrective Action Form
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_3^-	particulate nitrate
NO_x	nitrogen oxides
NPS	National Park Service
NTN	National Trends Network
NWRI	National Water Research Institute
O_3	ozone
OC	organic carbon
Odessa	Odessa Engineering, Inc.
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
PSRF	Precipitation Sample Report Form
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

List of Acronyms and Abbreviations (continued)

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
sigma theta	standard deviation of horizontal wind direction
SLAMS	State and Local Monitoring Stations
SLIC	sample line integrity checks
SO_4^{2-}	particulate sulfate
SO_2	sulfur dioxide
SOP	standard operating procedures
SPO	site printout
SQL	structured query language
SRM	standard reference material
SSRF	Site Status Report Form
SJRWMD	St. Johns River Water Management District
STORET	storage and retrieval
STP	standard temperature and pressure
Sunset	Sunset Laboratory, Inc.
TFE	tetra fluoroethylene
TOA	thermal-optical analysis
TRAACS®	Technicon Random Access Automated Chemistry System
TSA	technical systems audit
µg	microgram
$\mu g/cm^3$	micrograms per square centimeter
$\mu g/m^3$	micrograms per cubic meter
µm	micrometer
µmho/cm	micro mhos per centimeter
UL	Underwriter's Laboratories
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UV	ultra violet
V	volt
V_d	deposition velocities
VDC	volt direct current
VOC	volatile organic compound
VSRF	Visibility Status Report Form
W/m^2	Watts per square meter
z/s/p	zero /span/precision
XRF	x-ray fluorescence

A.3 Distribution List

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A.4 Project/Task Organization

A general description of the organizations responsible for operating the Clean Air Status and Trends Network (CASTNet) together with an overview of the responsibilities of each organization and the roles, responsibilities, and authorities of the key positions are described in the following subsections.

A.4.1 Purpose/Background

CASTNet was established by the U.S. Environmental Protection Agency (EPA) in response to the requirements of the 1990 Clean Air Act Amendments (CAAA). Passage of the CAAA required implementation of a national network to:

1. Monitor the status and trends of air emissions, pollutant deposition, and air quality;
2. Determine the effects of emissions on water quality, forests, and other sensitive ecosystems; and
3. Assess the effectiveness of emission reduction requirements through operation of a long-term monitoring program.

CASTNet's primary goal is to function effectively as a national, long-term deposition monitoring network that provides information for assessing the effectiveness of current and future emission reductions mandated under the Clean Air Act. To meet this goal, the CASTNet program was designed to fulfill the following objectives:

1. To monitor the status and trends in air quality and atmospheric deposition;
2. 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; and
3. To assess and report on geographic patterns and long-term, temporal trends in ambient air pollutant concentrations and acid deposition.

The principal component of CASTNet is the measurement of atmospheric sulfur and nitrogen pollutants at rural sites throughout the United States. In addition to sulfur and nitrogen pollutants, each CASTNet site also includes measurements of particulate potassium (K^+), sodium (Na^+), chloride (Cl^-), magnesium (Mg^{2+}), and calcium (Ca^{2+}), continuous measurements of O_3 concentrations and meteorological conditions together with supporting information on vegetation and land use. The meteorological, vegetation, and land use data are used as input to the Multi-Layer Model (MLM), a mathematical model that simulates atmospheric dry deposition velocities (V_d). The modeled V_d are combined with the concentration measurements to estimate dry deposition of pollutants. Prior to May 2001, the network additionally included a visibility component that measured fine mass ($PM_{2.5}$) and its chemical constituents at eight sites. For the remainder of 2001, CASTNet measured aerosol $PM_{2.5}$ at only one site.

The National Park Service (NPS) has developed an air quality program that involves a wide range of activities including air quality monitoring and modeling and participation in CASTNet. In 1994, under a partnership agreement with EPA, NPS merged 17 previously operating sites into the network and assumed operation of two other park sites. New sites have been added subsequently. In 2002, NPS operated 30 sites at various national parks and monuments, mostly in western locations.

This Quality Assurance Project Plan (QAPP) satisfies the requirements of EPA QA/R-5, EPA Requirements for Quality Assurance Project Plans (2001b). An important tool for EPA personnel, CASTNet participants, and data users, this QAPP documents and promotes understanding of the types and quality of data generated by the network.

Information on all aspects of CASTNet field and laboratory measurements and the associated quality assurance (QA) and quality control (QC) procedures is provided in four principal sections:

1. Project management, Section A;
2. Project operations (measurement/data acquisition), Section B;
3. Assessment/oversight, Section C; and
4. Data validation and usability, Section D.

This QAPP documents that the CASTNet QA program is designed to ensure that all reported data are of known and documented quality, and that the data are reproducible and comparable with data from other programs.

A.4.2 Project Organization

The organizations responsible for the operation of CASTNet include EPA; NPS; MACTEC Engineering and Consulting, Inc. (MACTEC); and Air Resource Specialists, Inc. (ARS). A diagram of the relationships among the organizations involved in CASTNet is shown in Figure A.4.1. Key positions are designated in the appropriate boxes on the organization chart.

As the sponsoring organization, EPA personnel have specific roles within the CASTNet program. The roles of the key EPA personnel shown in Figure A.4.1 include:

- **EPA Project Officer**
  Reviews and approves the QAPP and subsequent revisions in terms of project scope and objectives. Ensures QAPP implementation.

- **EPA QA Officer**
  Reviews and approves the QAPP and subsequent revisions in terms of QA aspects. Conducts assessments of project activities.

- **EPA Technical Monitors**
  Review and approve all reports, documents, and databases. Provide guidance on all CASTNet technical issues.

As a co-sponsor under the partnership agreement with EPA, NPS personnel also have specific roles within the CASTNet program. Key NPS personnel are shown in Figure A.4.2. Their roles within the CASTNet organization include:

- **Contracting Officer's Technical Representative (COTR)**
  Directs the technical aspects of the NPS network operations contract and reviews contractor performance; reviews, approves, analyzes, interprets, and reports data from the CASTNet NPS sites; reviews and approves QA procedures; and represents NPS in technical issues related to CASTNet monitoring.

- **Contracting Officer's Representative**
  Reviews network data and provides other technical support as requested by the COTR.

Contractor organizations responsibilities include:

- **MACTEC**
  As prime contractor, MACTEC is responsible for network operations and QA; chemical analysis of samples as lead analytical chemistry laboratory; data management and delivery; data analysis and reporting; and all deliverables. The MACTEC Project QA Manager is responsible for maintaining the official, approved CASTNet QAPP. Specific roles, responsibilities and authorities of MACTEC positions within the CASTNet program are described in Table A.4.1, and a diagram of the MACTEC organization is shown in Figure A.4.1.

- **ARS**
  As contractor to NPS, ARS is responsible for operation of the 30-station NPS component of CASTNet. ARS has various responsibilities as a CASTNet team member, and a diagram of the ARS organization is shown in Figure A.4.2.

Figures A.4.1 and A.4.2 depict the project line organizations and their relationships to the two sponsors. In addition to internal QA activities performed by the respective project organizations, the CASTNet QA Management Team performs assessments of key project activities that affect the achievement of project objectives. This team is comprised of the MACTEC Project Manager, Project QA Supervisor, QA Manager, and operations managers; the EPA QA Officer; ARS Program Manager and QA Manager; and other agencies and organizations, as needed. As discussed in Section C, the QA Management Team members are responsible for assessing the effectiveness of implementation of the CASTNet QA program and for initiating corrective action if an assessment indicates such a response is required. The team meets twice a month via conference call and as needed, based on the assessment results. Members of the QA Management Team also interact frequently on an individual basis to discuss and resolve any quality issues.

A.5 Problem Definition/Background

In 1990, when Congress amended the Clean Air Act, Title IV (Acid Deposition Control Program) mandated a significant reduction in the emissions of sulfur and nitrogen oxides (NO_x), primarily from the electric utility industry. Titles IV and IX of the CAAA required that the environmental effectiveness of the Acid Deposition Control Program be assessed through environmental monitoring. This monitoring is required to gauge the impact of emission reductions on air pollution, atmospheric deposition, and the health of affected human populations and ecosystems. In 1991, EPA established CASTNet to provide an effective monitoring and assessment network necessary for determining the status and trends in air quality and pollutant deposition, as well as relationships among emissions, air quality, deposition, and ecological effects. Currently, CASTNet is considered the nation's primary source and repository of atmospheric data for use in estimating dry acidic deposition and rural O_3 levels.

An additional tenet of CASTNet is to implement monitoring in cooperation with other agencies and organizations and to fill gaps in monitoring coverage. Over the history of the network, in addition to dry deposition and O_3 measurements, CASTNet has taken wet deposition measurements at sites for which there were no long-term wet deposition sites within 50 kilometers (km) of a CASTNet site. Likewise, EPA established visibility monitoring sites at several CASTNet sites to supplement measurements taken by the Interagency Monitoring of Protected Visual Environments (IMPROVE). See Section A.6.1 for more information on the wet deposition and visibility monitoring aspects of the network.

A.6 Project Description and Schedule

This section provides an overview of CASTNet. Details are provided in the subsequent sections and appendices.

A.6.1 Network Description

To fulfill the primary goal of operating an effective monitoring and assessment network for development of a scientific database to evaluate the results of emission control strategies, an important objective of CASTNet is to establish patterns and trends of dry deposition. CASTNet measures concentrations of sulfur and nitrogen species and estimates V_d from meteorological conditions and supporting information on vegetation and land use in order to estimate dry deposition. CASTNet also includes measurements of O_3 concentrations at most sites and, prior to May 2001, had included measurements of $PM_{2.5}$ aerosols and visibility-related parameters at some sites.

CASTNet is comprised of 54 sites sponsored by EPA, 30 sites operated by NPS at various national parks and monuments, and one site in southeast Florida operated by the St. Johns River Water Management District (SJRWMD) under an EPA National Estuary Program grant. The EPA, NPS, and SJRWMD 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 SJRWMD sites are merged into a single database and delivered to EPA quarterly.

CASTNet site locations, as of October 2003, are shown in Figure A.6.1. Eighty-five sites are operational. All 85 sites are equipped with filter packs for measurement of pollutant concentrations and estimation of deposition rates. Eighty-three sites measure O_3. Two sites include collocated sampling systems for determining network precision. Table A.6.1 lists by state all of the CASTNet sites along with the operational characteristics for each site. The operational information includes site location, start date, latitude, longitude, elevation, and types of measurements. 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 SJRWMD). Table A.6.2 provides similar information for the discontinued sites.

In Figure A.6.1 and Table A.6.1, CASTNet sites are designated as 100-series sites for EPA sponsored sites and 400-series for NPS sponsored sites. The SJRWMD site at Indian River Lagoon, FL is also designated as a 100-series site (IRL141). 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. The first digit designates sponsorship (1 or 4) or if the site had included visibility/aerosol sampling equipment (5) in Tables A.6.1 and A.6.2. 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, day and night samples are collected weekly along with a standard weekly composite CASTNet filter pack. This set-up provides the means to compare results from CASTNet with the Canadian Air and Precipitation Monitoring Network (CAPMoN). O_3 is not measured at EGB181.

In 1993, EPA established visibility monitoring sites at several CASTNet sites to supplement measurements taken by IMPROVE. The visibility network investigated trends in fine particle concentrations and related measures of visual air quality. An eight-station network that measured aerosol concentrations and their chemical constituents and other parameters was operated from 1993 through May 2001. Six of the visibility sites were collocated with

standard dry deposition sites. Figure A.6.2 shows the locations of the eight visibility sites, only. The visibility sites were transferred to the IMPROVE network in May 2001. The Bondville, IL site (BVL130, IL) operated both IMPROVE and CASTNet sampling systems until 2002. Tables A.6.1 and A.6.2 also include the locations and descriptions of the visibility sites. More information on IMPROVE may be found on their web site: http://vista.cira.colostate.edu/improve.

In January 1999, all wet deposition monitoring activities were transferred to the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) protocol to promote nationwide consistency in wet deposition monitoring. NADP/NTN assumed responsibility for the administration of wet deposition activities at 15 CASTNet sites including analysis and reporting of precipitation chemistry samples. These activities were previously carried out at 19 CASTNet sites that had been established to fill gaps in NADP/NTN's geographic coverage. In transferring activities to NADP/NTN, operations at four of the CASTNet wet deposition sites were discontinued. NADP/NTN operates wet deposition sampling systems at other locations near virtually every CASTNet site. The NADP/NTN database represents the primary source of information on wet deposition across the United States. Tables A.6.1 and A.6.2 also include the locations and descriptions of the CASTNet wet deposition sites. The combination of CASTNet and NADP/NTN data provides information on total (dry + wet) deposition. More information about NADP/NTN may be found on their web site: http://nadp.sws.uiuc.edu.

A.6.2 Task Descriptions

The operation of CASTNet and the work required to meet project objectives can be separated into six basic tasks. These tasks and their key elements are presented in Figure A.6.3. The following subsections provide a brief description of each task.

A.6.2.1 Equipment Procurement and Inventory

CASTNet deploys a standard set of air pollutant sampling and meteorological monitoring equipment to each site for the purpose of estimating dry deposition. This equipment includes an open-face, three-stage filter pack to measure particulate and gaseous sulfur and nitrogen species and cations. A mass flow controller (MFC) is used to maintain a constant flow rate through the filter pack. O_3 concentrations are measured at EPA sites using analyzers based on ultraviolet (UV) absorbance. The NPS sites utilize UV and other O_3 analyzers. Each site employs meteorological sensors to measure temperature, temperature difference, relative humidity, solar radiation, scalar and vector wind speed, the standard deviation of horizontal wind direction (sigma theta), surface wetness, and precipitation. Equipment that is purchased for the project meets the following requirements:

- Meets established criteria [e.g., Prevention of Significant Deterioration (PSD) Guidelines (EPA, 1998a) and EPA equivalency] or project objectives;
- Compatible with network objectives, other networks, and system components;
- Proven durability for project use;
- Proven performance; and
- Cost effectiveness (including maintenance).

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

The CASTNet Property Control Manager (PCM) is responsible for the ordering and receipt of equipment. The following procedures are employed for all equipment received by MACTEC:

- Physical inspection of shipping container for damage;
- Verification of packing list by matching quantity and serial numbers of shipped items;
- Assignment of EPA bar code sticker and cross-reference with serial number;
- Update of the CASTNet EPA equipment bar code list; and
- Entry of bar code numbers and equipment information into the designated table in the CASTNet database.

After receipt and log in, 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. A monthly equipment report including itemized nonexpendable and expendable government equipment is sent monthly to EPA.

A.6.2.2 Field Operations

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

A.6.2.2.1 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/depositions. The eastern sites are selected by considering:

1. Regional representativeness,
2. Avoidance of nearby pollution sources,
3. Long-term availability,
4. Accessibility, and
5. 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 sulfur dioxide (SO_2) and/or 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 (15 to 20 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 limited number of sites and higher diversity of the region precludes rigorous determination of spatial patterns. Therefore, site selection focuses primarily on locations where specific research issues can be addressed, and where natural resources are at risk (e.g., national parks). These locations include calibrated watersheds such as Centennial, Wyoming (CNT169, WY), in which dry deposition information is needed to close geochemical cycles for sulfur, nitrogen and alkalinity.

Site-specific criteria also play a part in the site selection process. These criteria relate to 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.

The CASTNet site-selection process follows the five-step procedure listed below:

1. Meetings with EPA to discuss site-selection criteria and objectives for new monitoring sites.
2. Presurvey evaluations to identify candidate locations for subsequent local survey and on-site evaluation.
3. Meetings with EPA to review presurvey evaluations and to obtain approval for subsequent local survey and on-site evaluation.
4. Comprehensive on-site evaluations. Typically, two or three locations are evaluated for each new site.
5. Meetings with EPA to review site evaluations and to obtain approval for site installation.

A.6.2.2.2 Site Operations for Ambient Concentration (Dry Deposition) and Meteorological Monitoring

Ambient measurements for SO_2, particulate sulfate (SO_4^{2-}), particulate nitrate (NO_3^-), nitric acid (HNO_3), particulate ammonium (NH_4^+), particulate Cl^-, particulate K^+, particulate Na^+, particulate Mg^{2+}, and particulate Ca^{2+}, and meteorological variables required for dry deposition calculations are performed at each CASTNet site. O_3 concentrations are measured at 83 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 Whatman filters. The Teflon® filter collects particulate SO_4^{2-}, NO_3^-, NH_3, Cl^-, K^+, Na^+, Mg^{2+}, and Ca^{2+}; the nylon filter collects HNO_3. The Whatman filter is a cellulose fiber base that is impregnated with potassium carbonate (K_2CO_3) and is used for collection of SO_2. Two Whatman filters are used. In practice, a fraction (usually < 20%) of ambient SO_2 is captured on the nylon filter. The nylon filter SO_2 and Whatman 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 MACTEC analytical laboratory and shipped to the field weekly. The filter packs are exchanged at each 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 (i.e., trip blanks) are collected quarterly to evaluate 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 liters per minute (Lpm) at eastern sites and 3.00 Lpm at western sites, for standard conditions of 25 degrees Celsius (°C) and 760 millimeters (mm) of mercury (Hg) with a MFC.

Ambient O_3 concentrations are measured at EPA sites via UV absorbance with a Thermo-Environmental Model 49-103 analyzer; NPS sites use a variety of analyzers. Zero, span, and precision (z/s/p) checks of the O_3 analyzer at EPA sites are performed every Sunday. Checks of z/s/p for the O_3 analyzers at NPS sites are variable, ranging from daily to weekly. CASTNet QA procedures for O_3 do not strictly conform to the EPA requirements for State and Local Monitoring Stations (SLAMS) monitoring (EPA, 1998b) except at the Cherokee Nation site in Stilwell, OK (CHE185, OK). All aspects of ambient O_3 monitoring at CHE185 are the responsibility of the

Cherokee Nation. MACTEC acquires, stores, and reports the data for CASTNet. The NPS QA procedures also follow the SLAMS requirements.

Site operators are scheduled to visit each CASTNet site every Tuesday at approximately 0900 local time. 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. All supporting paperwork is completed. Site operators also participate in Tuesday telephone calls with the Field Operations Manager (FOM) or designated field operations personnel. Site operators record surface conditions (e.g., dew, frost, snow) and vegetation status weekly. Vegetation status and land-use information are archived in the CASTNet database and are used to define 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).

Leaf area index (LAI) measurements were taken at all 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 was measured using an LAI-2000 Plant Canopy Analyzer manufactured by Li-Cor, Inc. (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).

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.

A.6.2.2.3 Site Operations for Visibility Monitoring

Visibility monitoring included three measurement types as defined by the IMPROVE program:

- Aerosol-Aerosol characteristics (concentration, composition, and size) were determined in order to relate atmospheric optical properties with $PM_{2.5}$ mass and its chemical constituents.
- Optical-Optical properties (e.g., light scattering) of the atmosphere were monitored for a scene-independent measure of air quality.
- Scene-Visual characteristics (e.g., through photos) of a scene were monitored to document scene-specific visibility.

IMPROVE protocols were used to guide the CASTNet monitoring instrument specifications, siting criteria, sample frequency, QA, and analytical techniques.

The visibility network consisted of eight sites in the eastern United States (Figure A.6.2). The 500-series site identification numbers of the sites listed in Tables A.6.1 and A.6.2 denote the visibility sites. These sites operated from October 1993 to May 2001. BVL130, IL continued to operate a CASTNet sampling system until 2002.

Aerosol sampling was conducted using time-integrated systems in which 24-hour samples were collected every six days. Each aerosol sampling system consisted of three separate single-stage filter packs designated as

denuder/nylon, Teflo®, and quartz. These designations refer to the type of filter media deployed in each respective filter pack. Visibility sites were visited every six days coinciding with the six-day sampling schedule. During the site visit, the site operator changed the filters; shipped them to the MACTEC, Gainesville, FL laboratory; evaluated system performance; and completed the required forms and paperwork.

A.6.2.2.4 Site Operations for Precipitation (Wet Deposition) Monitoring

At 15 CASTNet sites, wet deposition samples are collected weekly by NADP/NTN and shipped to the NADP/NTN laboratory for chemical analysis. 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. The precipitation amount is also monitored at wet deposition sites.

A.6.2.3 Laboratory Operations

Laboratory operations for CASTNet are performed by the CASTNet laboratory at MACTEC. The CASTNet laboratory is responsible for the 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.

CASTNet Laboratory operations involve tasks that 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 data and QC summaries. CASTNet laboratory operations also encompass sample storage. 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. All sample extracts may be discarded two years after extraction.

MACTEC's Chemical Laboratory Analysis and Scheduling System (CLASS™) provides a strong framework on which scientists manage, control, report, and provide feedback on project performance. CLASS™ is used to organize and schedule the analyses performed by the CASTNet laboratory.

Laboratory operations encompassed all three sampling components of the network: dry and wet deposition analysis and visibility aerosol analysis. The following subsections provide descriptions of these tasks.

A.6.2.3.1 Dry Deposition Analysis

Open-face, three-stage filter packs are prepared, loaded, shipped, received, extracted, and analyzed by MACTEC 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 ion chromatography (IC). Teflon® filter extracts are also analyzed for NH_4^+ by the automated indophenol method with the Technicon Random Access Automated Chemistry System (TRAACS®) using the TRAACS®-800 Autoanalyzer™. The filter extracts are additionally analyzed for Na^+, K^+, Mg^{2+}, and Ca^{2+} by inductively coupled plasma-atomic emission spectrometer (ICP-AES) using a Perkin Elmer Optima 3000 spectrometer. Results of all valid analyses are stored in CLASS™.

A.6.2.3.2 Visibility Aerosol Analysis

After every third sampling event, the denuders, nylon, Teflo®, and quartz filters were shipped to the MACTEC laboratory from each visibility site. After receipt and log in at the MACTEC laboratory, valid Teflo® and quartz samples were separated and shipped on a monthly basis to Chester LabNet (Chester) and Sunset Laboratory (Sunset), respectively.

The nylon filters that remained at the MACTEC laboratory were extracted and analyzed for NO_3^- and SO_4^{2-} by IC. The Teflo® filters were analyzed by Chester for mass (gravimetry) and the elements sodium through lead by x-ray fluorescence (XRF). The analysis of elements by XRF uses a Kevex Model 771 spectrometer with electronic and computer software upgrades. The quartz filters were analyzed by Sunset for elemental carbon (EC) and organic carbon (OC) using thermal-optical analysis (TOA). The TOA method is based on the principle that organic and EC react under different temperature and oxidation conditions. Results of all valid analyses are stored in CLASS™.

A.6.2.3.3 Wet Deposition Analysis

Historically, wet deposition samples were filtered and then analyzed for pH (acid-base scale), conductivity, acidity (base buffering capacity), SO_4^{2-}, nitrite (NO_2^-), NO_3^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, and Cl^-. Analyses of NH_4^+ and anions were performed, as described for the dry deposition filter pack samples, by using IC and TRAACS®. Likewise, analysis of Na^+, K^+, Ca^{2+}, and Mg^{2+}, was performed using ICP-AES. Acidity was determined via titration to pH 8.3 with a Mettler autotitrator. Conductivity was determined by a Wheatstone bridge-type conductivity meter. The results of all valid analyses are stored in CLASS™.

A.6.2.4 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. The CASTNet data are managed and archived using Microsoft® (MS) structured query language (SQL) Server™ 7.0, a fully relational database management system (RDBMS). Defined SQL tables are used to archive all measurements and supporting data. The database contains archives of concentrations measured on exposed filters; continuous meteorological, O_3, and flow data; and MLM output of hourly, weekly, quarterly, and annual dry deposition fluxes over the period beginning in 1987.

A.6.2.4.1 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.

The data acquisition process stresses multiple levels of redundancy to minimize data loss. The primary mode of data acquisition from the field sampling sites is via telephone modem. All sites are automatically polled daily. If daily polling results in incomplete data capture from any site, then diskettes of data from the primary and backup data acquisition system (DAS) are read into the database management system. If data are still incomplete, the missing data are entered manually, using independent double entry, either from site printouts (SPO) or recovered from diskettes.

CASTNet data acquisition utilizes a customized version of Odessa's Environmental Aide software for sites with Odessa Engineering, Inc. (Odessa) data loggers. The Environmental Aide system consists of two programs, ENVICOM and ENVAID that reside on a local area network (LAN) in the DMC. ENVICOM is a communications

and data transmittal package that polls each site daily and incorporates the previous day's hourly averages into the raw database. Data retrieved through ENVICOM are stored as binary data and include status files. ENVAID was used until recently only in the validation process for the flow data from the eight visibility sites and is no longer used.

For sites with Environmental Systems Corporation (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.

After daily polling of all stations, Level I validation procedures are initiated. The purpose of Level I validation is to develop a complete database. The process involves generating reports to establish data completeness and define periods of missing data. The process continues by recovering missing data from the diskette containing data from the primary DAS, the diskette from the backup DAS, and/or data from SPO. Level I validation is complete when the data for all time periods for all of the sampling sites have been accounted for, data have been manually entered when possible, using independent double entry, and sources of missing data are documented.

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.

Level II validation involves a more detailed screening of the data. The Site Status Report Forms (SSRF), operator logsheets, calibration data, and audit results are reviewed for each site. In addition, data are screened using the CASTNet Data Management System Application (CDMSA) that identifies 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 Operations Manager (DOM), approximately 10 percent of the database is audited for traceability. Upon completion of the QA review, the database is verified as Level II.

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

A.6.2.4.2 Laboratory Data

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

1. Data are determined to be reasonable based on the analyst's evaluation of the data batch QC sample results.

2. Data transfer by electronic or manual entry into CLASS™ 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.
3. The appropriate analytical batches are processed through an automated QC checking routine performed by CLASS™ and are determined to be acceptable. For each analytical batch, a data flag is generated if any of the following occurs:
   - Insufficient QC data were run for the batch;
   - Correlation coefficient of standard curve was less than 0.995;
   - The 95 percent confidence limit of the Y-intercept exceeded the limit of quantification;
   - 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 verification samples (CVS) exceeded the recovery limits;
   - Reference samples exceeded accuracy acceptance limit; or
   - Replicate samples exceeded percent difference limits.

A batch with one or more flags is accepted only if written justification is provided by the LOM.

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

1. All Level I data meeting QC criteria are reviewed by the LOM;
2. A review and evaluation of any alarm flags is completed by the LOM;
3. Written justification for acceptance of data that did not meet QC criteria is reviewed and approved by the QA Manager; and
4. Supporting field and laboratory documentation is 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 concentration data as invalid. Level II concentration data are archived in the CASTNet MS SQL Server™ 7.0.

A.6.2.5 Quality Assurance

The CASTNet QA program encompasses all major QC procedures depicted in Figure A.6.3 and Table A.6.3. The core of the QA program is the internal audit system. Independent and external audit systems also are utilized. These audit systems are used to assess the components of the project and their compliance with the QA program. The following project assessments are used in the CASTNet QA program:

- Management systems reviews
- Readiness reviews
- Surveillance
- Technical systems audits (TSA)
- Performance evaluations (PE)
- Assessments of data quality indicators (DQI)
- Data quality assessments

- Peer review of project deliverables
- Review, revision, and approval of CASTNet QAPP

In addition to assessment, the audit systems incorporate corrective action and implementation systems and reporting procedures. The internal audit program addresses all aspects of project operations. PE and TSA of the field, laboratory, and data operations components are conducted by qualified, independent auditors. The independent and external audit programs are managed and executed by EPA, at its discretion.

A.6.2.5.1 Internal and Independent Audits

Internal audits are conducted routinely to assess all aspects of the project (Table A.6.3). Additional audits are performed at the QA Manager's discretion and/or at the request of other project personnel. The routine audits trace a minimum of 10 percent of the 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 are conducted of the following categories of project operations:

- **Project-Wide Assessments**

  Project–wide assessments address all components of the project. Internal project-wide assessments are used to:

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

  Internal audits such as surveillance and data quality assessments provide continuous monitoring of project status. Assessments of DQI are conducted quarterly. Changes to this QAPP and SOP, the guiding QA documents of the project, are reviewed, revised, and approved as necessary, or at 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.

- **Field Operations Assessments**

In addition to the project-wide assessments, internal TSA and PE are conducted every six months during the routine calibration visits at each of the sampling sites. These calibration visits are performed by the FOM, field coordinators, and trained field operations personnel.

- **Laboratory Operations Assessments**
  The laboratory operations component is also subject to the project-wide assessments. Additional internal assessments include TSA conducted annually by the QA Manager that consist of separate audits of data and procedures, which when combined, yield an overview of the entire process. 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 CVS. Laboratory precision is estimated via analysis of replicate samples.

  Independent TSA are conducted annually by a qualified auditor. Laboratory performance is evaluated on an ongoing basis by way of participation in intercomparison studies conducted by Environment Canada (ECAN) and 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.

- **Data Operations Assessments**
  Data generated by project activities must be as precise, accurate, complete, and usable as possible. 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 data validation process, the DOM 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 DOM and QA Manager.

  A thorough TSA that reviews data management activities from data ingestion through reporting to EPA is conducted every two years by an independent auditor. 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 conformance with this QAPP. Results are evaluated by the DOM and QA Manager and reported to the Project Manager.

A.6.2.5.2 External Audits

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

A.6.2.6 Management and Reporting

Reports and/or deliverables that are produced to meet project requirements and their submittal schedules are discussed in Section A.6.4. 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 staff 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.

A.6.3 Schedules

The schedules of routine CASTNet activities are depicted in Figures A.6.4, Routine Annual Activity Schedule; Figure A.6.5, Routine Visibility and Wet Deposition Schedule; and Figure A.6.6, Routine Monthly Activity Schedule, using March 2001 as an example. The life history of a filter pack datum is depicted in Figure A.6.7.

A.6.4 Deliverables

Reports and data are routinely delivered to the EPA. Table A.6.4 describes the routine data reporting schedules for CASTNet internal and external deliverables. In addition to monthly and quarterly data submittals, the three types of reports provided to the EPA each year include:

1. Monthly reports,
2. Quarterly reports, and
3. Annual reports.

A.6.4.1 Monthly Progress Reports

The Monthly Progress Reports consist of detailed financial reports and descriptions of technical activities. Each report discusses management issues and deliverables, field operations, laboratory operations, data management, and the status of reports for the current and upcoming months. QA/QC tasks are also described. Problems encountered during the reporting period and any corrective actions taken to resolve the problems are discussed. Any unresolved items from the previous monthly report are included. These reports are submitted to EPA by the 15th of each month and are provided as hard copy and via e-mail as electronic portable document format (PDF).

A.6.4.2 Monthly Data Delivery

A six-month data set consisting of validated Level II site data from a completed site calibration group is delivered to EPA on a compact disc (CD) at the end of each calendar month. Each data set is accompanied by sums of numerical fields and counts of character fields to assess completeness and accuracy of the transmittal. These data are subsequently made available to the user community by EPA via the CASTNet web site (www.epa.gov/castnet).

A.6.4.3 Quarterly Data Submittals and Reports

Quarterly data are submitted to EPA in ASCII format (MySQL™ insert statements or comma delimited) on a CD along with a hard copy. Also provided to EPA as QC are reports listing a summation of all parameters and aggregated counts of status flags. Quarterly reports summarize network activities for the period and present results of all field and laboratory QC checks. The quarterly reports include maps of concentration data and aerosol data. Trends analysis and time series plots are also presented. O_3 concentrations are presented in terms of 1-hour and 8-

hour 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 as hard copy and via e-mail as PDF.

A.6.4.4 Annual Reports

Annual reports are provided as hard copy and electronically as a CD. 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 the year just completed and includes intercomparisons of data across the years that the network has operated. An annual report is typically divided into 6 chapters and appendices. Chapter 1 provides an overview of CASTNet operations and discusses all changes in sampling and analytical methodology, together with a discussion of the potential implications on reported concentrations. Chapter 2 presents maps of concentrations of sulfur and nitrogen species and their 10-year trends. Chapter 3 discusses modeled dry deposition rates, measured wet deposition rates, and estimates of total sulfur and nitrogen deposition. Trends in deposition rates are presented. Chapter 4 presents O_3 concentrations. Chapter 5 is reserved for discussion of other aspects of the network. QC data for the network that are used to estimate the overall precision, accuracy, completeness, and other indicators for each measurement system are summarized in Chapter 6.

The fourth of the quarterly QA reports for each year will also serve as the annual QA report. It will 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 together with a summary of the previous three quarters and control charts for each quarter (24 per quarter including blanks).

A.7 Data Quality Objectives and Criteria

Data Quality Objectives (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; and
- To assess and report on geographic patterns and long-term, temporal trends in ambient air pollutant concentrations and acid deposition.

The network design was developed based on the assumption that dry deposition can be estimated mathematically using ambient concentration and meteorological inputs.

CASTNet DQO are summarized in Table A.7.1 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. Measurement criteria have been 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 deposition monitoring.

A.7.1 Data Quality Indicators

The DQI are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of the data collected. The DQI for CASTNet are precision, accuracy, bias, completeness, representativeness, and comparability. These DQI are discussed in the following subsections. The current precision and accuracy measurement criteria for the CASTNet field and laboratory measurements are listed in Tables A.7.2 and A.7.3. Completeness measurement criteria and a summary of completeness criteria for data aggregations are listed in Table A.7.4.

The application of the DQI to the hourly, weekly, and annual data that are required to satisfy CASTNet DQO is summarized in Tables A.7.5 through A.7.7.

A.7.1.1 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 (i.e., duplicate) sets of equipment at two selected sites. Filter concentration measurements and continuous field measurements are compared using the same protocol. In addition, all laboratory measurements require an assessment of analytical precision via replicate analysis.

The overall precision of meteorological variables, flow rate, and O_3 is assessed quarterly 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 for filter concentrations, O_3, and meteorological measurements include Mackville, KY (MCK131, KY) and Rocky Mountain National Park, CO (ROM206, CO/ROM406, CO). 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 mean ARPD (MARPD).

Analytical precision within sample batches is assessed by replicating five percent of the samples within a run and by calculating the relative percent difference (RPD). Samples to be replicated are selected at random.

A.7.1.2 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 MACTEC personnel. Accuracy objectives for field measurements are listed in Table A.7.2.

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 A.7.3 and B.6.2. 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 CVS in a batch. CVS are independently produced standards, which approximate the midpoint of the analytical range for an analyte and are run after every tenth environmental sample.

A.7.1.3 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 has always been monitored within the CASTNet program in the following ways:

- Assessment of analytical bias through monitoring of reference sample recoveries over time via graphics 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.
- Performance of filter acceptance tests to ensure that only batches of filters that meet the acceptance criteria are used for sample collection. In the filter acceptance testing process, five percent of Teflon® and nylon filters and two percent of Whatman impregnated 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. The data are analyzed for trends.
- Analysis of laboratory filter blank controls 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. Bias is assessed annually using data from specified parameters collected over a minimum of two years at selected sites.

A.7.1.4 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 is reported as an invalid sampling period. This information is summarized in Table A.7.4. The table also summarizes completeness criteria for data aggregations.

A.7.1.5 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, visibility, and O_3 concentrations. Major 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. Local sources of air contaminants are also of major concern because regional trends may be confounded by local sources of emissions. Maps and tabular listings of SO_2, NO_x, VOC, and particulate matter emissions within 100 km are produced for each candidate site. These emission data are part of the permanent site file for selected sites. See Section A.6.2.2.1 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, and season.

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 below), and sample integrity are the indicators in the representativeness of laboratory analyses.

A.7.1.6 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; and
- Comparability with other similar monitoring networks.

O_3 measurements at CHE185, OK and all NPS operated sites are operated in accordance with 40 Code of Federal Regulations (CFR) Part 58, Appendix A (EPA, 1998b), utilizing an on-site transfer standard. All other sites utilize an internal working standard in lieu of an on-site transfer standard. Precision and accuracy measurements at collocated CASTNet sites demonstrate the stability of the O_3 analyzers utilizing an internal working standard.

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 studies to document laboratory performance.

A.8 Special Training and Certification

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.

A.8.1 Training

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

A.8.1.1 Site Operator Training

The FOM or a designated, experienced field coordinator or field technician provides training for new site operators. All site operators are trained on-site. Training 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. The DAS is also presented in detail. Field SOP are distributed and trainees are required to familiarize themselves with the contents. Documentation procedures, such as filling out chain-of-custody and SSRF, are reviewed and practiced. In addition, the NPS site operators are provided a training CD and a site operator newsletter twice each year. The CD was produced to demonstrate all activities associated with a weekly station visit. The newsletter ("The Monitor") is delivered at the beginning and end of the O_3 season. This publication conveys general network information, brief technical procedures, and news items.

Before training is concluded, trainees perform site operator duties while observed by the trainer. 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. Site operators also fill out the appropriate forms while demonstrating their duties. A record of the training is established in the site logbook. If needed, refresher training is given during the twice-annual calibration and maintenance visits.

Following the completion of all scheduled calibration and maintenance, the field technician will spend as much time as required with the site operator to ensure 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 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, 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; update, if necessary, the SOP to reflect any changes in instrumentation, procedures, or protocols; and thoroughly review any changes with the site operator.
- Verify that the operator has an adequate inventory of all required forms and 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; encourage and fully answer any questions; and note any operator comments and suggestions.

A.8.1.2 Remote Training of Newly Assigned NPS Site Operators

Network park units experience turnover in site operator positions due to personnel transfers, reassignments, or other employment actions. While attempts are made to arrange site visits to accommodate site operator turnover, this may not always be possible. However, enhanced communication and network documentation allows for effective remote site operator training. The combination of remote and eventual on-site training procedures for a newly assigned site operator are summarized below:

- If a change in personnel occurs at a site, the existing site operator or his/her backup has the primary responsibility to perform on-site training of the newly assigned operator. As noted above, each site is equipped with a complete set of SOP and site visit checklists.
- Preliminary on-site training of a newly assigned operator by the existing operator is most effectively performed by following the checklist procedures. If the training operator carefully takes the new operator through each of these steps, the new operator will gain a good understanding of his/her duties. These checklist instructions are fully explained in the SOP. New operators are directed to read and follow these documents. Each site also has a training CD that provides additional detail.
- The ARS FOM makes and maintains immediate remote contact with the new operator. Communications options are explained to the new operator and the FOM again reviews the available on-site training resources and encourages the operator to read and review these resources. Most importantly, ARS stresses that the operator should contact ARS with any questions. Most often, an ARS field technician will lead the operator through every phase of his/her first independent site visit by telephone.
- When a new operator is assigned, ARS reviews its twice-annual calibration visit schedule and rearranges the schedule (with COTR approval) to visit the site as soon as possible within the approximately six-month window.

- When an ARS field technician is able to make a site visit, the newly assigned operator is thoroughly trained on-site by the field technician as described in the previous subsections.

A.8.1.3 Training of Field Technicians

Newly hired personnel are initially trained at either the MACTEC certification laboratory in Gainesville, FL (EPA sponsored sites) or at the ARS facility in Fort Collins, CO (NPS sponsored sites). Newly hired field technicians undergo a proprietary training program prior to independent field assignment. The MACTEC FOM, experienced field coordinator, or field technician or experienced ARS field technicians provide this training. Trainees receive an overview of CASTNet and the project objectives along with information on air sampling principles, basic meteorology, and instrumentation. Additionally, the program includes training on:

- Administrative procedures
- Travel procedures
- Safety training
- Network-specific SOP
- Network goals, objectives, performance criteria, and history
- Data logger training
- Monitoring and calibration equipment training
- Troubleshooting procedures
- Site visit procedures including site operator training
- Calibration and maintenance documentation
- Other documentation procedures

Experienced field technicians demonstrate calibration procedures and completion of the necessary documentation. Following these demonstrations, the trainees, under supervision, perform calibrations on the instruments and equipment that are provided for training purposes at either the Florida or Colorado training location and fill out the appropriate forms.

The next phase of training involves a calibration trip with an experienced, field technician trainer. By having each trainee travel with a trainer, the trainee can become familiar with on-site field procedures and be evaluated on his/her performance. The trip provides the trainee additional calibration experience under actual conditions at different site locations, and also provides the trainer with an indication of how well the trainee handles the long hours and rigors of travel. All calibrations are performed under the supervision of the trainer.

After the calibration trip with the trainer, the trainees return to MACTEC or ARS with their calibration standards and spend approximately one day recertifying their standards. Training is concluded with review and additional instruction as needed. When the trainer is satisfied with the trainee's performance, the training is complete and the trainee will begin to perform independent site visits. The specific details and timing of the training program depend on the experience and capabilities of the trainee as assessed by the FOM or designated trainer. The trainer will continue to verify the performance of the new field technician at least once each remaining quarter of his/her first year.

A.8.1.4 Laboratory Analyst/Technician Training

Laboratory personnel are trained in specific analyses by the LOM and/or designated group leader prior to analyzing samples for CASTNet. Analysts are trained in EPA methodology using in-house SOP and recommended QA/QC procedures specific to the project. Laboratory analysts also undergo training in health and safety and chemical hygiene.

Analytical instrument training includes one-on-one work with the group leader. The trainee observes the group leader perform analytical runs and follows along from the SOP. The basic principles of operation, preventive maintenance, and database procedures are reviewed. The trainee performs analytical runs under supervision using training or dummy samples with known concentrations. The trainee completes all documentation. The CASTNet Laboratory QA/QC program is presented with emphasis on QC samples, their purpose and preparation, acceptance criteria for QC samples, and actions taken when criteria are not met.

A.8.1.5 Data Analyst Training

Data analysts working on validation of the continuous data are trained by the DOM, or designee, at the DMC. Training includes presentations on CASTNet and project objectives, meteorological sensors, and field instrumentation including the DAS, the DMC computer system, and data management tools. An overview of all operations at a field site is presented by an experienced field technician with emphasis on the DAS. Trainees also visit the certification laboratory for a demonstration of certification procedures and review of the documentation used in data validation (e.g., field logs and narratives, SSRF, and calibration and certification forms).

A.8.2 Certification

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

A.9 Documents and Records

The following sections provide information on QAPP updates and revisions and also on archiving procedures for all records, reports, and data.

A.9.1 Quality Assurance Project Plan

This QAPP identifies reporting and feedback channels to ensure early detection of problems and implementation of corrective actions if DQO are not met. 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.

A.9.1.1 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 pages, incorporating the approved changes, will be

disseminated to the personnel on the QAPP distribution list along with a request to remove and discard the outdated portion(s) according to the procedure described below.

Each year, the QAPP and associated SOP will be reviewed and revised by the QA Manager, Project Manager, and selected project personnel. 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 drastic 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 mailed to all names on the QAPP distribution list along with a receipt verification form. The receipt verification forms will be returned to MACTEC 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.

A.9.1.2 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 F. The description will note the subsection number and the revision number associated with the change.

A.9.2 Archiving Procedures

Hard copy records are indexed and stored in sequentially numbered banker's boxes. A database of all the records is updated as necessary with the contents and location of the archived records. Satellite archives are set up at the MACTEC office in Gainesville, FL for up to seven years. Records may be transferred to secure off-site storage, if necessary, any time after the annual report has been finalized. Archived records are discarded after a total of seven 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 seven years or older has been designated for disposal, a notice of impending disposal will be sent to the EPA describing the basic types of documents and their approximate date range. If no response is received within 4 weeks of notice, it will be assumed that the documents may be discarded.

Electronic copies of the data are archived on the MACTEC computer network in Jacksonville, FL. The MACTEC database is considered the primary source of all the CASTNet data. All requests for data from EPA are generated from the primary database. Tables A.9.1 through A.9.4 provide a brief description of the CASTNet data, databases, records, and reports that are produced by the project. These tables also identify location, format, update frequency, archive location and details, and whether or not the item has been submitted to EPA.

Table A.4.1 Roles, Responsibilities, and Authorities of MACTEC CASTNet Team Members (Page 1 of 4)

Position	Duties and Responsibilities	Authorities
Principal-In-Charge	• 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	• 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 Work Assignments • 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 work assignment progress	• Accepts work assignments 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
Work Assignment Managers	• Alternate point-of-contact with EPA for respective work assignment • Provide senior technical guidance and review • Communicate frequently with Project Manager with regard to day-to-day progress and activities • Assist the Project Manager with developing Work Plans • Implement approved Work Plans for respective work assignments • Identify appropriate technical staff/resources for work assignments • Approve or disapprove any labor, materials, or subcontractor charges • Review work assignment progress and performance with Project Manager • Assure completion of quality deliverables • Direct and monitor performance of subcontractors on work assignments • Conduct periodic status reviews of work assignment progress	• Approve reports and deliverables for assigned tasks • Organize and chair weekly review meetings • Assign duties, roles, and related budget to work assignment team members • Recommend final acceptance and closeout of work assignments

Table A.4.1 Roles, Responsibilities, and Authorities of MACTEC CASTNet Team Members (Page 2 of 4)

Position	Duties and Responsibilities	Authorities
Corporate Project QA Supervisor	• Monitors and periodically audits to ensure that QA procedures as identified in the QAPP, Laboratory Operations Manual, Field Operations Manual, and Data Management Manual are followed by the project team • Ensures 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	• Independently reports to the Principal-in-Charge • Approves QAPP • Issues stop work for non-compliance with QA procedures
QA Manager for Field, Laboratory, and Data Management	• 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 as described in QAPP	• Stops delivery of all products and reports that do not meet QA requirements • Issues corrective actions • Approves implemented corrective actions • Approves QAPP
Field Operations Manager	• Coordinates and monitors all aspects of field operations • Schedules calibration and preventative maintenance visits • Installs new monitoring sites • Trains site operators • Conducts special visits for repairs • Prepares SOP for field operations, equipment calibration and 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 •
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	• Assigns analysis • Scheduling • Procures laboratory supplies • Approves analytical batches

Table A.4.1 Roles, Responsibilities, and Authorities of MACTEC CASTNet Team Members (Page 3 of 4)

Position	Duties and Responsibilities	Authorities
Data Operations Managers	• Acquire continuous field measurements • Validate all CASTNet measurements • Calculate filter concentration data • Design upgrades and improvements to database management system • Maintain CASTNet database • Deliver database to EPA • Oversee management of DMC	• Assign DMC personnel • Approve all software used in DMC • Approve all data
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 work assignment negotiation • Monitors performance of submittal of contract deliverables • Reviews and approves subcontractor invoices • Interfaces with EPA Contracting Officer and Work Assignment 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 system	• Approves purchasing • Manages all vendors
Data Analysts	• Validate continuous data stored in the DMC database • Verify that stored data have met project data collection requirements • Report to the DOM	• 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 CLASS™ • Report to the Gainesville Laboratory Supervisor	• Add comment codes to reported laboratory data • Stop or repeat analysis as required by the QAPP

Table A.4.1 Roles, Responsibilities, and Authorities of MACTEC CASTNet Team Members (Page 4 of 4)

Position	Duties and Responsibilities	Authorities
Field Coordinators	• 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	• Directing field technicians to unscheduled sites for repair • Procurement of supplies • Scheduling special efforts for field certification laboratory
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 • Report to the FOM	• Replace instrumentation or other site equipment when necessary
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, data printouts, disks, and all site documentation to MACTEC • 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 A.6.1 Locational and Operational Characteristics of Existing (January 2003) CASTNet Sites

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Alabama												
SND152	Sand Mountain	12/27/88	34.2894	85.9704	352	•	•		Agri.	Rolling	Y	EPA
Alaska												
DEN417	Denali National Park	10/06/98	63.7258	148.9633	661	•	•		Forested	Complex	N	NPS
POF425	Poker Flats Research Range	07/31/01	65.1178	147.4333	495	•	•[4]		Forested	Complex	M	NPS
Arizona												
CHA467	Chiricahua National Monument	04/25/89	32.0092	109.3892	1570	•	•	◊	Range	Complex	N	NPS
GRC474	Grand Canyon National Park	05/16/89	36.0597	112.1822	2073	•	•		Forested	Complex	M	NPS
PET427	Petrified Forest National Park	09/24/02	34.8750	109.9694	1723	•	•		Desert	Flat	Y	NPS
Arkansas												
CAD150	Caddo Valley	10/04/88	34.1792	93.0989	71	•	•		Forested	Rolling	N	EPA
California												
CON186	Converse Station	06/17/03	34.1041	116.9130	1837	•	•		Forest/Arid	Complex	N	EPA
DEV412	Death Valley National Monument	02/21/95	36.5092	116.8481	125	•	•		Desert	Complex	Y	NPS
JOT403	Joshua Tree National Monument	02/16/95	34.0714	116.3906	1244	•	•		Desert	Complex	M	NPS
LAV410	Lassen Volcanic National Park	07/25/95	40.5403	121.5764	1756	•	•		Forested	Complex	M	NPS
PIN414	Pinnacles National Monument	05/16/95	36.4850	121.1556	335	•	•		Forested	Complex	M	NPS
SEK402	Sequoia National Park	02/04/97	36.4292	118.7625	1225	•	•		Forested	Mountaintop	N	NPS
YOS404	Yosemite National Park	09/25/95	37.7133	119.7061	1605	•	•		Forested	Complex	N	NPS

Table A.6.1 Locational and Operational Characteristics of Existing (January 2003) CASTNet Sites

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Colorado												
GTH161	Gothic	05/16/89	38.9573	106.9854	2926	•	•	◊	Range	Complex	N	EPA
MEV405	Mesa Verde National Park	01/10/95	37.1983	108.4903	2165	•	•		Forested	Complex	M	NPS
ROM206	Rocky Mountain National Park	07/03/01	40.2778	105.5453	2743	•	•		Forested	Complex	M	EPA
ROM406	Rocky Mountain National Park	12/20/94	40.2778	105.5453	2743	•	•		Forested	Complex	M	NPS
Connecticut												
ABT147	Abington	12/28/93	41.8402	72.0111	209	•	•	◊	Urban-Agri.	Rolling	M	EPA
Florida												
EVE419	Everglades National Park	10/06/98	25.3911	80.6806	2	•	•		Swamp	Flat	Y	NPS
IRL141	Indian River Lagoon	07/09/01	30.1065	80.4554	2	•	•		Beach	Flat	Y	SJRWMD
SUM156	Sumatra	12/28/88	30.1065	84.9938	14	•	•	◊	Forested	Flat	Y	EPA
Georgia												
GAS153	Georgia Station	06/28/88	33.1812	84.4100	270	•	•		Agri.	Rolling	M	EPA
Hawaii												
HVT424	Hawaii Volcanoes National Park	09/15/99	19.4197	155.2400	1199	•	•		Forested	Complex	N	NPS
Illinois												
ALH157	Alhambra	06/28/88	38.8690	89.6229	164	•	•	◊	Agri.	Flat	Y	EPA
BVL130	Bondville	02/09/88	40.0520	88.3725	212	•	•		Agri.	Flat	Y	EPA
STK138	Stockton	12/28/93	42.2872	89.9998	274	•	•		Agri.	Rolling	M	EPA

Table A.6.1 Locational and Operational Characteristics of Existing (January 2003) CASTNet Sites

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Indiana												
LIV573	Livonia	10/07/93	38.5347	86.2608	299		◊		Agri.	Rolling	N/A	EPA
SAL133	Salamonie Reservoir	06/28/88	40.8164	85.6608	250	•	•		Agri.	Flat	Y	EPA
VIN140	Vincennes	08/04/87	38.7406	87.4844	134	•	•		Agri.	Rolling	M	EPA
Kansas												
KNZ184	Konza Prairie	03/26/02	39.1021	96.6096	348	•	•		Prairie	Flat	Y	EPA
Kentucky												
CDZ171	Cadiz	10/01/93	36.7841	87.8500	189	•	•		Agri.	Rolling	M	EPA
CKT136	Crockett	08/24/93	37.9211	83.0658	455	•	•		Agri.	Rolling	Y	EPA
MAC426	Mammoth Cave National Park	07/24/02	37.2806	86.2639	236	•	•		Agri./Forested	Rolling	M	NPS
MCK131	Mackville	07/31/90	37.7044	85.0483	353	•	•		Agri.	Rolling	M	EPA
Louisiana												
SIK570	Sikes	10/01/93	32.0585	92.4334	68		◊		Agri.	Flat	N/A	EPA
Maine												
ACA416	Acadia National Park	12/01/98	44.3770	68.2610	158	•	•		Forested	Complex	M	NPS
ASH135	Ashland	12/20/88	46.6039	68.4142	235	•	•		Agri.	Flat	Y	EPA
HOW132	Howland	11/24/92	45.2158	68.7085	69	•	•		Forested	Rolling	Y	EPA
Maryland												
BEL116	Beltsville	11/01/88	39.0283	76.8175	46	•	•		Urban-Agri.	Flat	N	EPA
BWR139	Blackwater National Wildlife Refuge	07/04/95	38.4448	76.1115	4	•	•		Forest-Marsh	Coastal	M	EPA

Table A.6.1 Locational and Operational Characteristics of Existing (January 2003) CASTNet Sites

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Michigan												
ANA115	Ann Arbor	06/28/88	42.4164	83.9019	267	•	•	◊	Forested	Flat	M	EPA
HOX148	Hoxeyville	10/31/00	44.1809	85.7390	298	•	•		Forested	Flat	Y	EPA
UVL124	Unionville	06/28/88	43.6139	83.3597	201	•	•	◊	Agri.	Flat	Y	EPA
Minnesota												
VOY413	Voyageurs National Park	06/13/96	48.4128	92.8292	429	•	•		Forested	Rolling	M	NPS
Mississippi												
CVL151	Coffeeville	12/27/88	34.0028	89.7989	134	•	•		Forested	Rolling	M	EPA
Montana												
GLR468	Glacier National Park	12/27/88	48.5103	113.9956	976	•	•		Forested	Complex	N	NPS
Nevada												
GRB411	Great Basin National Park	05/16/95	39.0053	114.2158	2060	•	•		Forested	Complex	M	NPS
New Hampshire												
WST109	Woodstock	12/27/88	43.9446	71.7008	258	•	•		Forested	Complex	N	EPA
New Jersey												
WSP144	Washington's Crossing	12/27/88	40.3133	74.8726	61	•	•		Urban-Agri.	Rolling	M	EPA

Table A.6.1 Locational and Operational Characteristics of Existing (January 2003) CASTNet Sites

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
New York												
CAT175	Claryville	05/10/94	41.9423	74.5519	765	•	•[5]		Forested	Complex	N	EPA
CTH110	Connecticut Hill	09/28/87	42.4010	76.6535	515	•	•	◊	Forested	Rolling	N	EPA
HWF187	Huntington Wildlife Forest	05/28/02	43.9732	74.2232	502	•	•		Forested	Complex	N	EPA
North Carolina												
BFT142	Beaufort	12/28/93	34.8843	76.6213	2	•	•	◊	Agri.	Flat	Y	EPA
CND125	Candor	09/25/90	35.2643	79.8382	198	•	•	◊	Forested	Rolling	M	EPA
COW137	Coweeta	11/04/87	35.0605	83.4302	686	•	•		Forested	Complex	N	EPA
PNF126	Cranberry	12/27/88	36.1040	82.0448	1250	•	•	◊	Forested	Mountaintop	M	EPA
North Dakota												
THR422	Theodore Roosevelt National Park	10/06/98	46.8947	103.3778	850	•	•		Range	Rolling	Y	NPS
Ohio												
DCP114	Deer Creek State Park	09/28/88	39.6358	83.2600	267	•	•	◊	Agri.	Rolling	Y	EPA
LYK123	Lykens	01/10/89	40.9169	82.9981	303	•	•	◊	Agri.	Flat	M	EPA
OXF122	Oxford	08/18/87	39.5314	84.7231	284	•	•		Agri.	Rolling	N	EPA
QAK172	Quaker City	09/28/93	39.9431	81.3378	372	•	•		Agri.	Rolling	M	EPA
Oklahoma												
CHE185	Cherokee Nation	04/02/02	35.7507	94.6700	299	•	•		Agri.	Rolling	Y	EPA
Ontario												
EGB181	Egbert, Ontario	12/27/94	44.2317	79.7840	251	•[6]	•[4]		Agri.	Rolling	Y	EPA

Table A.6.1 Locational and Operational Characteristics of Existing (January 2003) CASTNet Sites

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Pennsylvania												
ARE128	Arendtsville	06/28/88	39.9231	77.3078	269	•	•	◊	Agri.	Rolling	M	EPA
KEF112	Kane Experimental Forest	01/03/89	41.5981	78.7683	622	•	•		Forested	Rolling	Y	EPA
LRL117	Laurel Hill State Park	12/15/87	39.9883	79.2522	615	•	•		Forested	Complex	N	EPA
MKG113	M.K. Goddard State Park	01/12/88	41.4250	80.1447	384	•	•		Forested	Rolling	N	EPA
PSU106	Penn. State University	01/06/87	40.7209	77.9316	376	•	•		Agri.	Rolling	M	EPA
Tennessee												
ESP127	Edgar Evins State Park	03/22/88	36.0389	85.7330	302	•	•		Forested	Rolling	N	EPA
GRS420	Great Smoky Mountains National Park	10/06/98	35.6331	83.9422	793	•	•		Forested	Complex	N	NPS
SPD111	Speedwell	06/12/89	36.4698	83.8265	361	•	•	◊	Agri.	Rolling	Y	EPA
Texas												
BBE401	Big Bend National Park	07/18/95	29.3022	103.1772	1052	•	•		Forested	Complex	M	NPS
Utah												
CAN407	Canyonlands National Park	01/24/95	38.4583	109.8211	1814	•	•		Desert	Complex	M	NPS
Vermont												
LYE145	Lye Brook	03/30/94	43.0510	73.0613	730	•	•[5]	◊	Forested	Mountaintop	N	EPA
Virgin Islands												
VII423	Virgin Islands National Park	10/06/98	18.3364	64.7964	80	•	•		Jungle	Coastal	N	NPS

Table A.6.1 Locational and Operational Characteristics of Existing (January 2003) CASTNet Sites

Site ID	Site Name	Start date	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[3]	Sponsor
Virginia												
PED108	Prince Edward	11/03/87	37.1653	78.3070	150	•	•	◊	Forested	Rolling	M	EPA
SHN418	Shenandoah National Park	06/28/88	38.5231	78.4347	1073	•	•		Forested	Mountaintop	M	NPS
VPI120	Horton Station	06/02/87	37.3300	80.5573	920	•	•		Forested	Mountaintop	N	EPA
Washington												
MOR409	Mount Rainier National Park	08/29/95	46.7583	122.1222	421	•	•		Forested	Complex	N	NPS
NCS415	North Cascades National Park	02/14/96	48.5397	121.4389	109	•	•		Forested	Complex	M	NPS
OLY421	Olympic National Park	10/06/98	48.0975	123.4256	125	•	•		Forested	Complex	N	NPS
West Virginia												
CDR119	Cedar Creek State Park	11/10/87	38.8794	80.8478	234	•	•	◊	Forested	Complex	N	EPA
PAR107	Parsons	01/19/88	39.0906	79.6614	510	•	•		Forested	Complex	N	EPA
Wisconsin												
PRK134	Perkinstown	09/27/88	45.2066	90.5972	472	•	•	◊	Agri.	Rolling	M	EPA
Wyoming												
CNT169	Centennial	08/19/91	41.3722	106.2422	3178	•	•		Range	Complex	M	EPA
PND165	Pinedale	12/27/88	42.9214	109.7900	2388	•	•		Range	Rolling	M	EPA
YEL408	Yellowstone National Park	06/26/96	44.5597	110.4006	2400	•	•		Forested	Rolling	N	NPS

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

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

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

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

2. Meteorological sensors: 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; N/A = Not Applicable.

4. O_3 not measured.

5. Solar-powered sites.

6. Composite filter pack, day filter pack, and night filter pack.

- • Indicates current monitoring.
- ◊ Indicates discontinued monitoring.
  Measurements were discontinued at the various sites because of several reasons including:
  (1) rotate limited number of instruments;
  (2) redundant measurements (e.g., with IMPROVE and NADP/NTN); and
  (3) funding limitations.

100 and 200 series = EPA – Operated Sites
400 series = NPS – Operated Sites
141 site = St. Johns River Water Management District (SJRWMD)

Table A.6.2 Discontinued CASTNet Sites (Page 1 of 2)

Site ID	Site Name	Reporting Dates	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Aerosol Filter Pack[3]	Optical Scattering[4]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[5]	Sponsor
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			•	•[6]		Agri.	Flat	N/A	EPA
Nevada														
SAV164	Saval Ranch	05/89-09/93	41.29	115.86	1873	•	•				Range	Flat	Y	EPA
New Hampshire														
WST183	Woodstock (ridge site)	12/92-03/93	43.95	71.70	258	•	•				Forested	Complex	N	EPA
New York														
WFM105	Whiteface Mountain	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

Table A.6.2 Discontinued CASTNet Sties (Page 2 of 2)

Site ID	Site Name	Reporting Dates	Latitude (°N)	Longitude (°W)	Elevation (m)	Deposition Filter Pack[1]	Ozone and Meteorology[2]	Aerosol Filter Pack[3]	Optical Scattering[4]	Wet Deposition	Primary Land Use	Terrain	Representative to the MLM[5]	Sponsor`
Pennsylvania														
SCR180	Scotia Range	02/93-02/99	40.79	77.92	378	•[7]	•[7]			•	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

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

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

2 Meteorological sensors: 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:

Teflo® = 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 operated by ARS.

5 N = No; Y = Yes; M = Marginal; N/A = Not Applicable.

6 Reporting dates are from 10/93-11/95

7 Reporting dates are from 10/89-06/90

Table A.6.3 Project Assessments

Assessment Type	Frequency	Assessment Personnel
Management Systems Review	As needed	Project Manager, QA Manager, or QA Supervisor
Readiness Review	As needed	Project Manager, QA Manager, FOM, LOM, DOM, Work Assignment Managers, Field Coordinators
Surveillance • Field Operations • Laboratory Operations • Data Operations	 Weekly Weekly Weekly	 Site Operators, FOM, Field Coordinators Laboratory Supervisor, LOM DOM, QA Manager
Technical Systems Audits • Field Operations Internal Independent External	 Biannually As determined by EPA As determined by EPA	 MACTEC, ARS, or AQS Field Technicians As determined by EPA As determined by EPA
Technical Systems Audits • Laboratory Operations Internal Independent External	 Annually Every 2 years As determined by EPA	 QA Manager TBD* As determined by EPA
Technical Systems Audits • Data Operations Internal Independent External	 Depends on audit type Every 2 years As determined by EPA	 DOM, QA Manager TBD* As determined by EPA
Performance Evaluations • Field Operations Internal Independent External	 Biannually As determined by EPA As determined by EPA	 MACTEC, ARS, or AQS Field Technicians As determined by EPA As determined by EPA
Performance Evaluations • Laboratory Operations Internal Independent External	 Per analytical batch Approximately bimonthly As determined by EPA	 Laboratory Analysts ECAN, USGS As determined by EPA
Performance Evaluations • Data Operations Internal Independent External	 Annually Every 2 years As determined by EPA	 DOM, QA Manager TBD* As determined by EPA
Assessment of DQI	Quarterly	DOM, FOM, LOM, QA Manager, Project Manager
Data Quality Assessments	On going	DOM, FOM, LOM, QA Supervisor, QA Manager, Project Manager
Peer Review and Presentation of Data	Minimum of once per year	Qualified Reviewers
Review, Revision, and Approval of CASTNet QAPP	Annually or as needed	QA Manager

* To be determined

Table A.6.4 CASTNet Routine Data Reporting (page 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; field report; QA report; DMC report; laboratory report; priority table; projected activities
		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. Fourth quarter report doubles as Annual QA Report
		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 3 quarters, control charts (24 per quarter including blanks), 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 data
		Visibility Quarterly Report	Within 120 days of quarter's end	Electronic and hard copy data results
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	End of each month	One month of daily polled site data
		Site documents and printouts	Every Tuesday	SSRF; narrative log; SPO
		Diskette download	End of each month	One month of continuous data recorded by the DAS
		Field calibration results	As completed	Completed field calibration forms; assembled calibration folder with laboratory certifications
		Problem Report	End of each month	All available problem information
	Laboratory Operations	Filter Pack Late List Report	Weekly	Filter pack(s) not returned on schedule

Table A.6.4 CASTNet Routine Data Reporting (page 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
	Data Operations	Filter pack data	Weekly	Total mass filter pack 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 METDATA 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; visibility data; METDATA changes
		Annual data tables	By 8/15 of following year By 11/30 of following year	Dry deposition values; OZONE values Equipment inventory
	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 II validated and audited six month data sets from the appropriate site group(s); Level I data set; NPS data; filter pack data; visibility data
		Figures, maps, and tables for Annual Report	Draft by 8/15 of following year. Final 30 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

Table A.6.4 CASTNet Routine Data Reporting (page 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. Fourth quarter report doubles as Annual QA Report
		Annual QA Report	Within 30 days of the end of the 4th quarter	Summary of previous 3 quarters, control charts (24 per quarter plus blanks), 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; as needed	Metered audit results
		Quarterly field calibration data audit	Within 30 days of quarter's end	Field calibration data audit results (10 percent of data)
		Annual Systems Audit	By mid-November	Systems audit results for Analytical Laboratory, Field Calibration Laboratory, and the DMC
	Data Operations	Continuous data validation audit report	1 week after completion of monthly validation	Data validation audit results

Table A.7.1 CASTNet DQO: 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, evaluation studies indicate that the model generally underestimates SO_2 dry deposition with a -10 percent bias for crops and grass, up to -50 percent bias for forests. The model shows an approximate 10 percent overestimation for HNO_3.
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 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 distribution data for O_3, SO_4^{2-} and N concentrations have yet to be evaluated. Western site data has not been evaluated. It is unlikely that sufficient geographic coverage currently exists in the west. MLM estimates should not be extrapolated geographically.

Table A.7.2 Data Quality Indicators for CASTNet Field Measurements

Measurement Parameter	Method	Criteria*	
		Precision	Accuracy
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
Relative Humidity	Thin Film Capacitor	± 10% (of full scale)	± 5%, rel. hum. > 85% ± 20%, rel. hum. ≤ 85%
Solar Radiation	Pyranometer	± 10% (of reading taken at local noon)	± 10%
Precipitation	Tipping Bucket Rain Gauge Weighing Rain Gauge	± 10% (of reading) ± 5%	± 0.05 inch† ± 0.06 inch (5% of full scale)
Ambient Temperature	Platinum RTD	± 1.0°C	± 0.5°C
Delta Temperature	Platinum RTD	± 0.5°C	± 0.5°C
Surface Wetness	Conductivity Bridge	Undefined	Undefined
O_3	UV Absorbance	± 10% (of reading)	± 10%
Filter Pack Flow	Mass Flow Controller	± 10%	± 5%
Light Scattering	Nephelometer	± 15%	Undefined§

Note:

°C = degrees Celsius
m/s = meters per second
rel. hum. = relative humidity
RTD = resistance-temperature device
UV = ultraviolet

* Precision criteria apply to collocated instrument and accuracy criteria apply to calibration of instruments.
† For target value of 0.50 inch.
§ Nephelometer was replaced annually with a laboratory certified instrument

Table A.7.3 Data Quality Indicators for CASTNet Collocated Filter and Laboratory Replicate Measurements*

Analyte	Medium	Method	Acceptance Criteria			
			Precision (RPD)**	Accuracy (%)	Nominal Reporting Limits†	Method Detection Limit
Ammonium (NH_4^+)	F/W	Automated colorimetry	10	90 - 110	0.020 mg-N/L	0.009 mg-N/L
Sodium (Na^+)	F/W	ICP-AES	5	95 - 105	0.005 mg/L	0.002 mg/L
Potassium (K^+)	F/W	ICP-AES	5	95 - 105	0.005 mg/L	0.002 mg/L
Magnesium (Mg^{2+})	F/W	ICP-AES	5	95 - 105	0.003 mg/L	0.001 mg/L
Calcium (Ca^{2+})	F/W	ICP-AES	5	95 - 105	0.003 mg/L	0.002 mg/L
Chloride (Cl^-)	F/W	Ion chromatography	5	95 - 105	0.020 mg/L	0.002 mg/L
Nitrate (NO_3^-)	F/W	Ion for nitrate chromatography	5	95 - 105	0.008 mg-N/L	0.003 mg-N/L
Sulfate (SO_4^{2-})	F/W	Ion chromatography	5	95 - 105	0.040 mg/L	0.015 mg/L
Nitrite (NO_2^-)	W	Ion chromatography	5	NA	0.01mg-N/L	0.0005 mg-N/L
pH	W	Electrometric	‡ 0.05	‡ ± 0.05	NA	NA
Conductivity$^\phi$	W	Electrometric	10	90 - 110	0.04 µmhos/cm	NA
Elemental Carbon$^\phi$	QF	TOA	10	90 - 110	0.04 µg-C/m^3	NA
Organic Carbon$^\phi$	QF	TOA	10	90 - 110	0.10 µg-C/m^3	NA
Total Carbon$^\phi$	QF	TOA	10	90 - 110	0.20 µg-C/m^3	NA
Mass$^\phi$	TF	Gravimetric	± 10 µg	± 3 µg	2.13 µg/m^3	NA
Trace/Crustal Elements$^\phi$	TF	XRF	20	90 - 110	§ 0.001-0.10 ng/m^3	NA

Note:

F = filter pack samples
ICP-AES = inductively coupled plasma-atomic emission spectrometry
W = wet deposition
RPD = relative percent difference
N = nitrogen
QF = quartz filter
TF = Teflo® filter
TOA = thermal-optical analysis
XRF = X-ray fluorescence
C = carbon
NA = not available

* The precision criteria apply to the laboratory analysis of field samples and laboratory replicates.

** This column lists the precision goals for both network precision calculated from collocated filter samples and laboratory precision based on replicate samples. The precision criterion is applied as described below:

QC conditions: (v1 = initial response; v2 = replicate response; RL = nominal reporting limit)

Condition 1: if (v1 or v2 < RL and the 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

† 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-AES, 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-AES methods that supports the current nominal reporting limits.

‡ Expressed in pH units (± 0.05 pH unit represents approximately ± 12.2 percent expressed as H^+)

ϕ Measurements of these analytes were performed through 2001, prior to the transfer of the visibility network to IMPROVE.

§ XRF reporting limits are dependent upon the uncertainty calculated for each sample and analyte per batch. The reporting limit is equal to 3 times the calculated uncertainty value. See CASTNet QAPP, Revision 1.0, January 2003, Appendix 5, SOP XR002 section 7.5.4.7 for a description of the uncertainty calculation.

Table A.7.4 Data Collection Completeness Criteria

Averaging Period	Data Collection Performance and Completeness Goals*	Completeness Criteria for Data Aggregations
Hour	90% by parameter per quarter	75% of 5-minute data
Week	< 75% is an invalid sampling quarter	70% of hourly data
Quarter		69% of valid weekly values
Annual		minimum of 3 quarterly values (75%)
Annual Trends		4 quarterly values

* Calculated by percent of valid data points relative to total possible data points

Table A.7.5 Data Quality Indicators as Applied to Measurements – 1-Hour

Data Increment: 1-Hour	Meteorological	Ozone
Precision	RPD values are calculated for quarterly averages of collocated data. Results are documented in the quarterly reports to the EPA.	Single point internal precision checks are performed weekly. RPD values are calculated for quarterly averages of collocated data. Results are documented in the quarterly reports to the 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 is indicated by the Level II continuous data validation process detailed in Section D.1.4 of this QAPP. Instrument generated data found outside of established calibration criteria are invalidated.	Bias in hourly continuous data is indicated by the Level II continuous data validation process detailed in Section D.1.4 of this QAPP. Instrument generated data are either adjusted or invalidated per established calibration and data validation criteria.
Completeness	75% - See Section D.4.5.1	75% - See Section D.4.5.1
Representativeness	Emission inventory, population, and land use within 100 km are evaluated. The site-specific criteria listed in Table B.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 B.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 above).	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 above).

* The current lack of continuous meteorological and ozone data from comparably equipped and sited networks prevents an evaluation of comparability or of bias as compared to an established norm.

† Ozone measurements at NPS operated sites are operated in accordance with 40 CFR Part 58, Appendix A (EPA, 1998b), utilizing an on-site transfer standard. All other sites utilize an internal working standard in lieu of an on-site transfer standard (see Section B.5.1.2).

Table A.7.6 Data Quality Indicators as Applied to Measurements – 1-Week

Data Increment: 1-Week	Flow	Ozone	Deposition Velocities and Fluxes	Ambient Concentration Data
Precision	RPD values are calculated for quarterly averages of collocated data. Results are documented in the quarterly reports to EPA.	Single point internal precision checks are performed weekly. RPD values are calculated for quarterly averages of collocated data. Results are documented in the quarterly reports to EPA.	MLM data generated from collocated sites are 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 the 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. See Table A.7.3 for acceptance criteria.
Bias*	Results from semiannual calibrations and the Level II continuous data validation process detailed in Section D.1.4 of this QAPP indicate bias in weekly continuous data. Instrument generated data are either adjusted or invalidated per established calibration and data validation criteria.	Results from semiannual calibrations and the Level II continuous data validation process detailed in Section D.1.4 of this QAPP indicate bias in weekly continuous data. Instrument generated data are either adjusted or invalidated per established calibration and data validation criteria.	Limits on bias may be inferred from bias (if any) in MLM data inputs and from MLM evaluation studies, which suggest no bias for flat terrain settings and under-estimation for forested settings.	Percent recoveries of reference and CVS are calculated for each analytical batch to ascertain if recoveries are within acceptable range. (Table A.7.3). Analysis of field and lab blanks is performed to measure any bias through background contamination on filters. For consideration of external bias, please see Comparability below.
Completeness	75% - See Section D.4.5.1	75% - See Section D.4.51	75% - See Section D.4.5.2	75% - See Section D.4.5.1
Representa-tiveness	75% of valid flow data for the sampling period.	Emission inventory, population, and land use within 100 km are evaluated. The site-specific criteria listed in Table B.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 representative-ness, data comparability (see below), and sample integrity (see Section B.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 above).	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 lab participates regularly in laboratory intercomparison studies. Study results are reported to EPA in quarterly and annual reports after they become available.

* The current lack of continuous meteorological and ozone data from comparably equipped and sited networks prevents an evaluation of comparability or of bias as compared to an established norm.

† Ozone measurements at NPS operated sites are operated in accordance with 40 CFR Part 58, Appendix A (EPA, 1998b), utilizing an on-site transfer standard. All other sites utilize an internal working standard in lieu of an on-site transfer standard (see Section B.5.1.2).

Table A.7.7 Data Quality Indicators as Applied to Measurements – 1-Year

Data Increment: 1 Year	Meteorological	Ozone	Deposition Velocities and Fluxes	Ambient Concentration Data
Precision	RPD values are calculated for annual averages of collocated data. Results are documented in the quarterly reports to the EPA.	Single point internal precision checks are performed weekly. RPD values are calculated for annual averages of collocated data. Results are documented in the annual reports to the EPA.	MLM data generated from collocated sites are compared via calculated RPD. This procedure utilizes only sites with complete meteorological data. Data from nearby sites are not utilized for this procedure.	Collocated filter pack data are compared via calculated RPD. Results are documented in the annual reports to the 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 the EPA.
Bias*	Results from semiannual calibrations and the Level II continuous data validation process detailed in Section D.1.4 of this QAPP indicate bias in continuous data. Instrument generated data found outside of established calibration criteria are invalidated.	Results from semiannual calibrations and the Level II continuous data validation process detailed in Section D.1.4 of this QAPP indicate bias in continuous data. Instrument generated data are either adjusted or invalidated per established calibration and data validation criteria.	Limits on bias may be inferred from bias (if any) in MLM data inputs and MLM evaluation studies. Bias may also result from data aggregation procedures. See the discussion in Section D.	Percent recoveries of reference and CVS are calculated for each analytical batch to ascertain if recoveries are within acceptable range. (Table A.7.3). Analysis of field and lab blanks is performed to measure any bias through background contamination on filters. For consideration of external bias, please see Comparability below. Bias may also result from data aggregation procedures. See the Discussion in Section D.
Completeness	75% - See Section D.4.5.1	75% - See Section D.4.5.1	75% - See Section D.4.5.2	75% - See Section D.4.5.1
Representa-tiveness	Emission inventory, population, and land use within 100 km are evaluated. The site-specific criteria listed in Table B.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 B.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 B.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 above).	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.

∗ The current lack of continuous meteorological and ozone data from comparably equipped and sited networks prevents an evaluation of comparability or of bias as compared to an established norm.

Table A.9.1 Records Generated at MACTEC, Gainesville, FL

Document/ Record	Format	Description	Frequency of Updates	Sent to EPA	Archive Location/Details
QAPP	Hard Copy	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. Also provides detailed descriptions of all project operations.	Annually, or as needed	Yes	Gainesville Office/ CASTNet Library
CASTNet SOP	Hard Copy	Provides detailed information on field and analytical measurements and other processes.	Annually, or as needed	Yes	Gainesville Office/ CASTNet Library
Monthly Progress Report	Hard Copy/ Electronic	Provides detailed financial reports, description of field activities for month, status of laboratory sample analyses, QA report, problems encountered, corrective actions, data management report, and upcoming events. Addresses unresolved items from previous monthly reports.	Monthly	Yes, due the 15th of each month	Gainesville Office/ CASTNet Library
Quarterly Report	Hard Copy/ 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 the base program and executed options. Also, includes comparisons of data to previous calendar year (previous quarter, same quarter in previous year) in terms of figures, maps, tables, and explanatory text.	Quarterly	Yes, due within 120 days of end of quarter	Gainesville Office/ CASTNet Library
Quarterly QA Report	Hard Copy/ Electronic	Contains DQI results (as graphs); count of QA samples by QA code; percentage of suspect and invalid samples by QA code (i.e., failure type); count of field problems/resolutions and length of time to resolution; and calibration failure by location and parameter.	Quarterly	Yes, due within 30 days of end of quarter	Gainesville Office/ CASTNet Library
Annual Report	Hard Copy/ 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	Gainesville Office/ CASTNet Library
Annual QA Report (fourth quarter QA Report serves as annual report)	Hard Copy/ Electronic	Contains summary of previous three quarters; control charts (24 per quarter including blanks); DQI results (as graphs); count of QA samples by QA code; percentage of suspect and invalid samples by QA code (i.e., failure type); count of field problems/resolutions and length of time of resolution; and calibration failure by location and parameter.	Annually	Yes, due within 30 days of end of 4th quarter	Gainesville Office/ CASTNet Library
Site Contact List	Hard Copy/ Electronic	Includes all pertinent information for each site within CASTNet (contacts, operators, shipping information, directions to site, latitude, longitude, elevation, etc.).	As needed	No	Gainesville Office 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/Iron Mt* On-site 3 years; Off-site 4 years
Continuous Data Receipt Log	Hard Copy	Contains receipt data for SSRF, diskettes, SPO, and narrative logs received from weekly site packages.	Quarterly	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years

* Iron Mt = Iron Mountain Record Storage (off-site)

Table A.9.2 Records Generated at CASTNet Field Sites

Document/ Record	Format	Description	Frequency of Updates	Sent to EPA	Archive Location/Details
Calibration Forms	Carbon Copy	Document checks performed by site calibrators. Includes Wind System Data Form, Temperature/Relative Humidity Data Form, Solar Radiation Data Form, Precipitation Data Form, Flow Pre-Calibration Data Form, Flow Calibration Data Form, Data Acquisition System Calibration Form, and Test Equipment Calibration and Maintenance Record.	By Calibration Period	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
Site Diskettes	Electronic	Contains primary and secondary files containing downloaded data from the primary and backup cartridges for each month.	Monthly	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
Narrative Log	Carbon Copy	Documents all activities and instrument responses during any site visit.	Weekly, as needed	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
SSRF	Carbon 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/Iron Mt* On-site 3 years; Off-site 4 years
SPO	Hard Copy	Hard copies of the primary data logger output generated automatically, or secondary data logger output content generated by field operations personnel	Weekly	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years

* Iron Mt = Iron Mountain Record Storage (off-site)

Table A.9.3 Records Generated at MACTEC, Gainesville, FL Laboratory

Document/ Record	Format	Description	Frequency of Updates	Sent to EPA	Archive Location/Details
Project Files	Hard Copy	Contains pre-field set-up form, SSRF, project changes and problems documentation.	As needed	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
Sample Preparation Records	Hard Copy	Documentation of filter preparation, shipping to field.	Daily	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
Sample Receipt Records	Hard Copy	Documentation of samples received and unpacked with problems noted.	Daily	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
Instrument Maintenance Log	Hard Copy	Documents all activities for each instrument. One log for each instrument.	As needed	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
Laboratory Notebooks	Hard Copy	Documents all preparation and analysis activities.	Daily	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
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; and comments of analyst and reviewers.	Only if needed once batch is final	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
Raw Data Files	Electronic	Instrument output for analyses.	N/A	No	Gainesville Computer Network See SOP GLO3180-019
CLASS™ Data Files	Electronic	Data files for project, samples, analyses, and QC.	Daily	No	Gainesville Computer Network See SOP GLO3180-019

* Iron Mt = Iron Mountain Record Storage (off-site)

Table A.9.4 Records Generated at MACTEC, Data Management Center (DMC)

Document/ Record	Format	Description	Frequency of Updates	Sent to EPA	Archive Location/Details
Missing Data Report	Electronic /Hard Copy	Lists all missing data in database for one-month period.	Monthly	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
CDVS Report	Hard Copy	Tracking form for Level II validation. Includes a checklist and procedural guide, which itemizes steps that must be followed for every site. Contains summaries of all information related to semiannual post calibration checks, independent audits, and standard changes applied to the data.	Semi-annually by calibration period	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years
Daily Report	Hard Copy	Printout of daily polled data.	Daily	No	Gainesville Office/Iron Mt* On-site 3 years; Off-site 4 years

* Iron Mt = Iron Mountain Record Storage (off-site)

Figure A.4.1 Project Organization

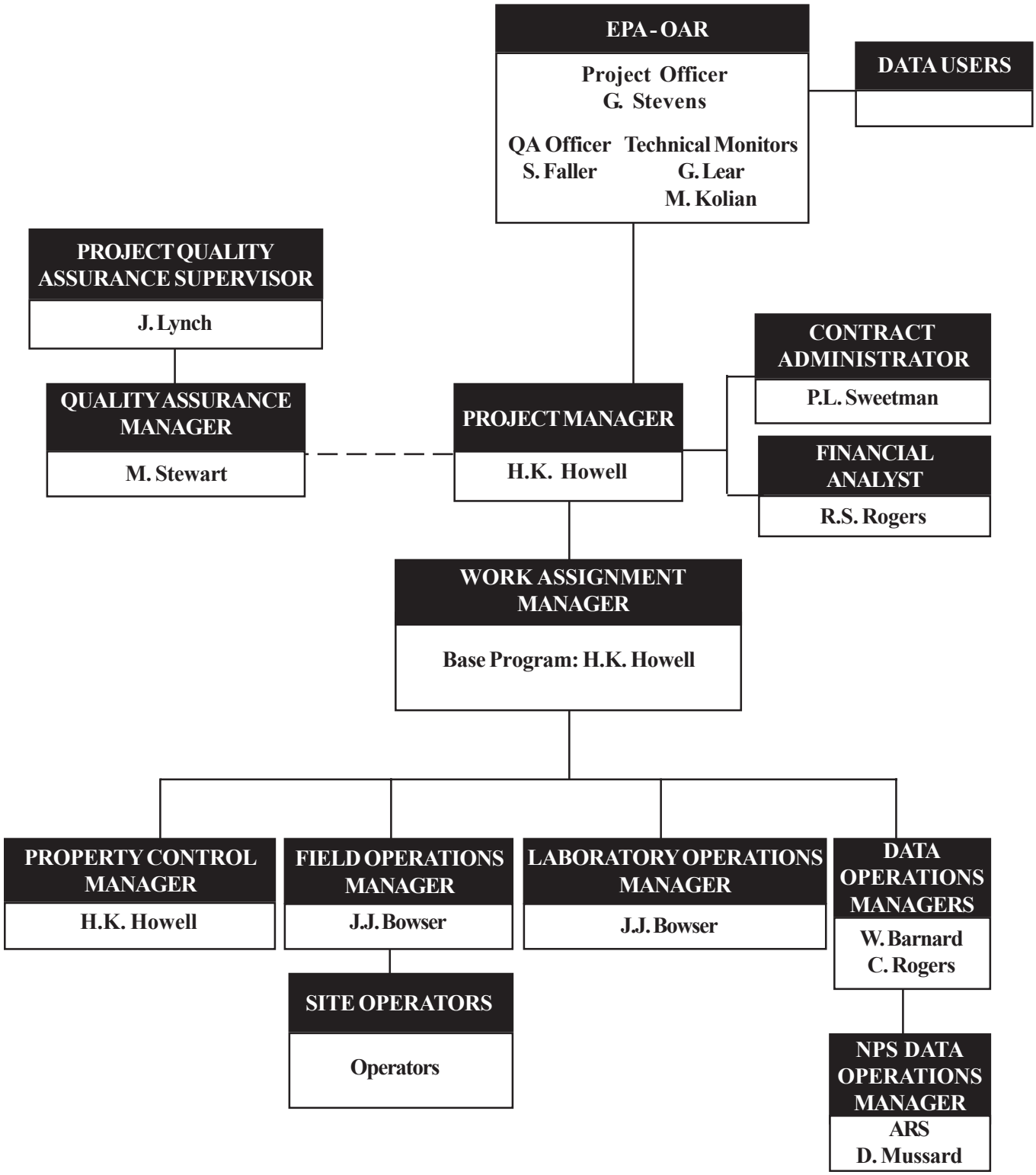


Figure A.4.2 NPS/ARS Project Organization

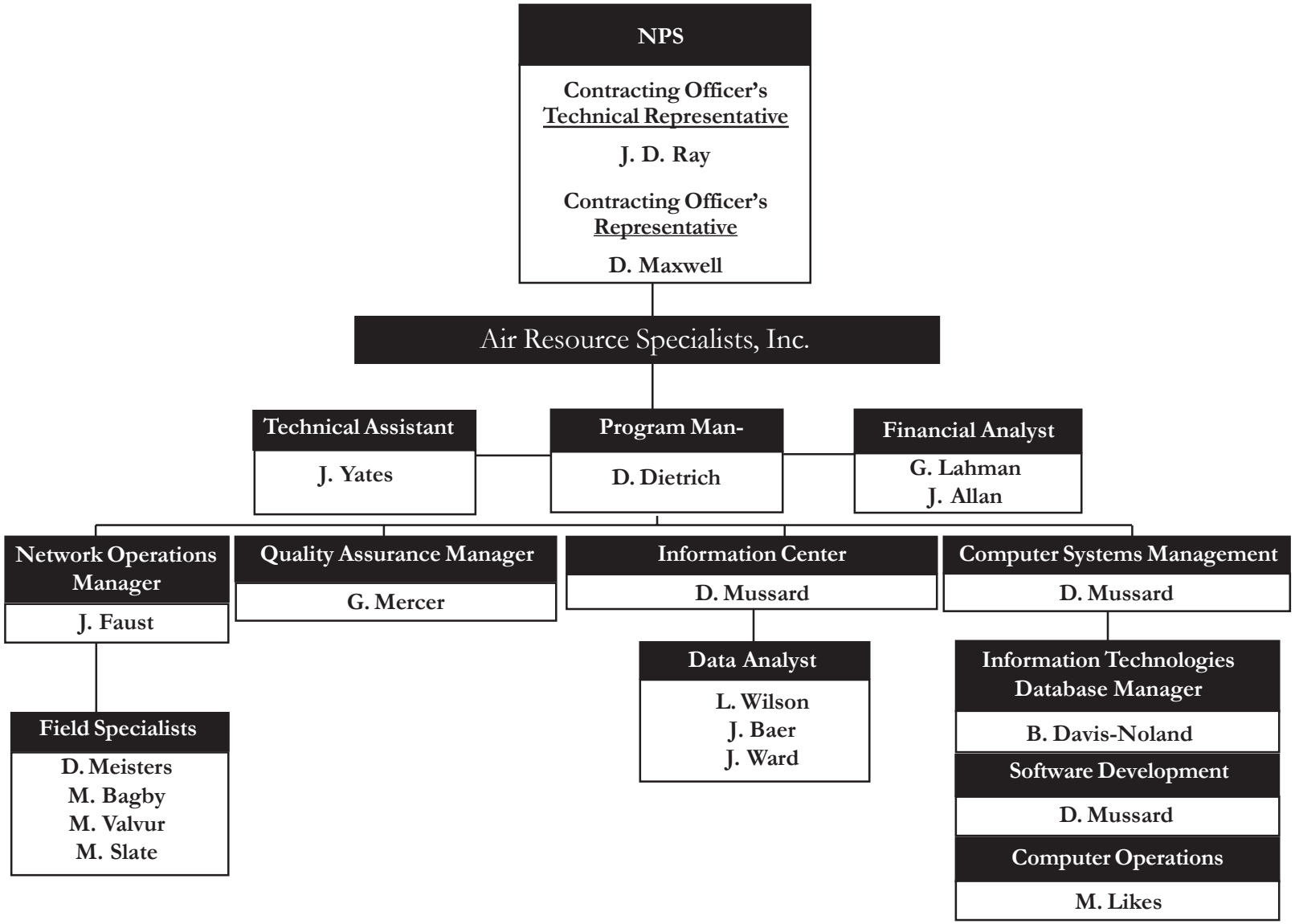


Figure A.6.1 Locations of CASTNet Sites as of October 2003

Figure A.6.2 Locations of CASTNet Visibility Monitoring Sites as of May 2001

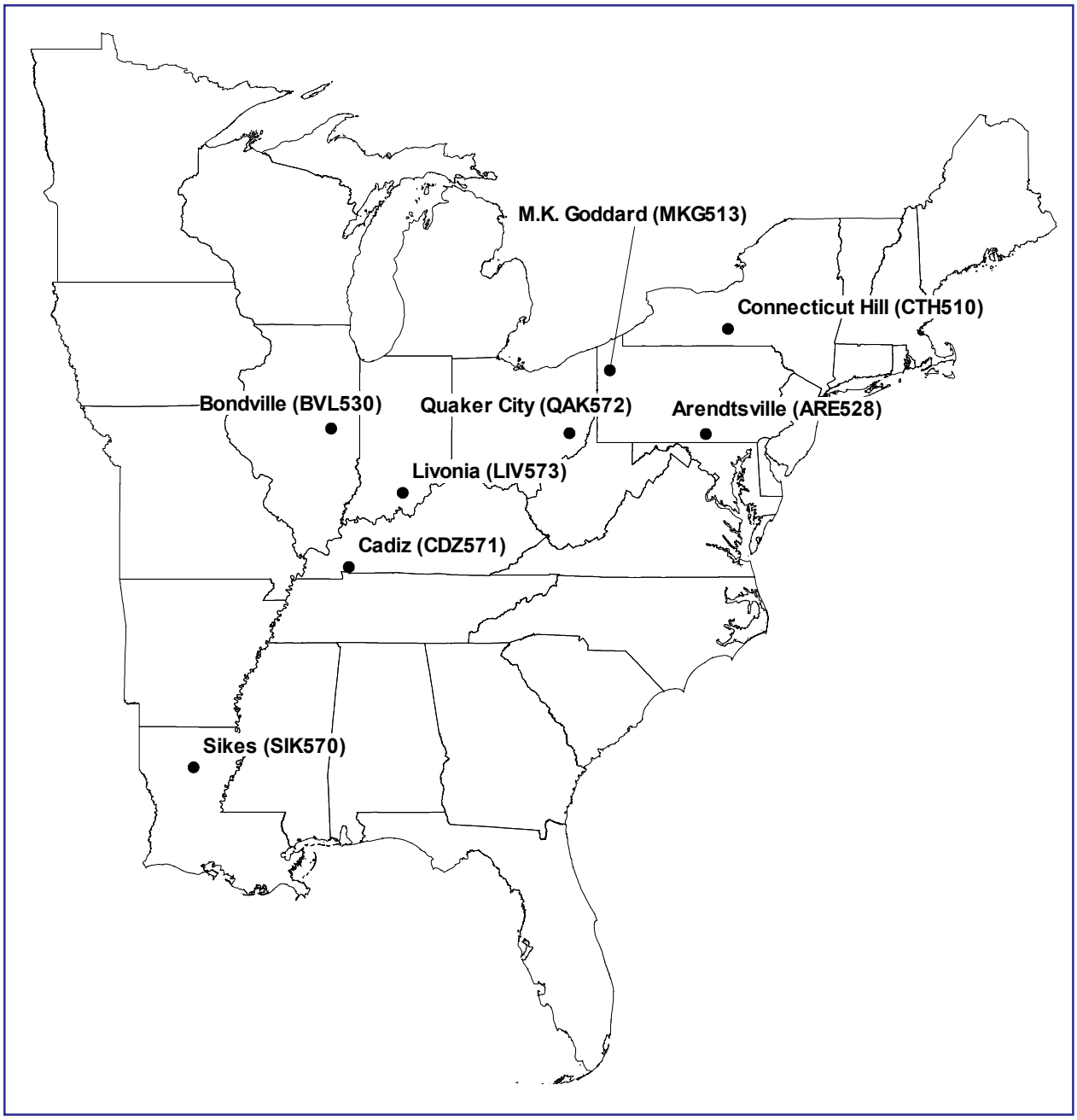


Figure A.6.3 Overview of CASTNet Tasks

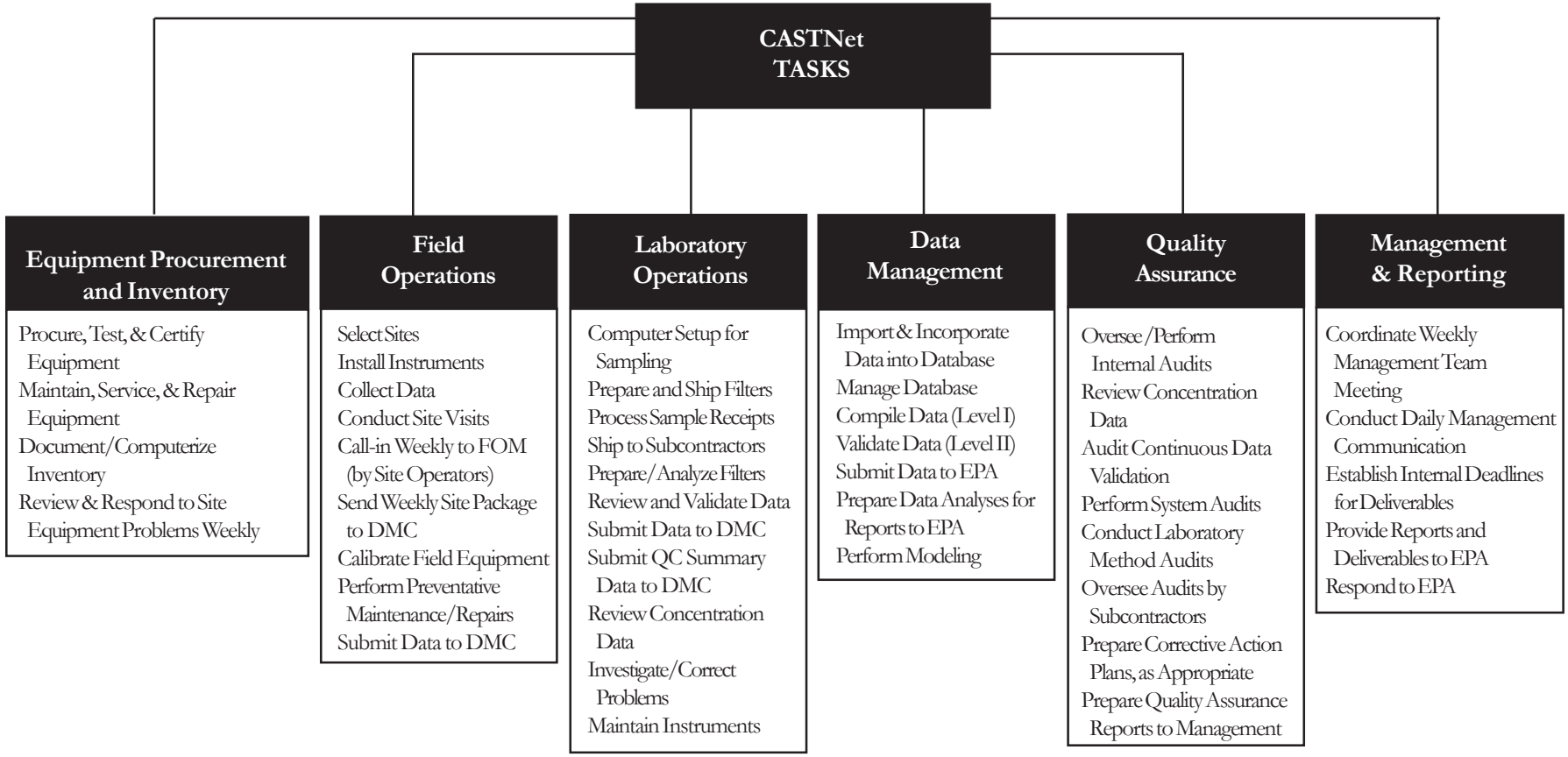
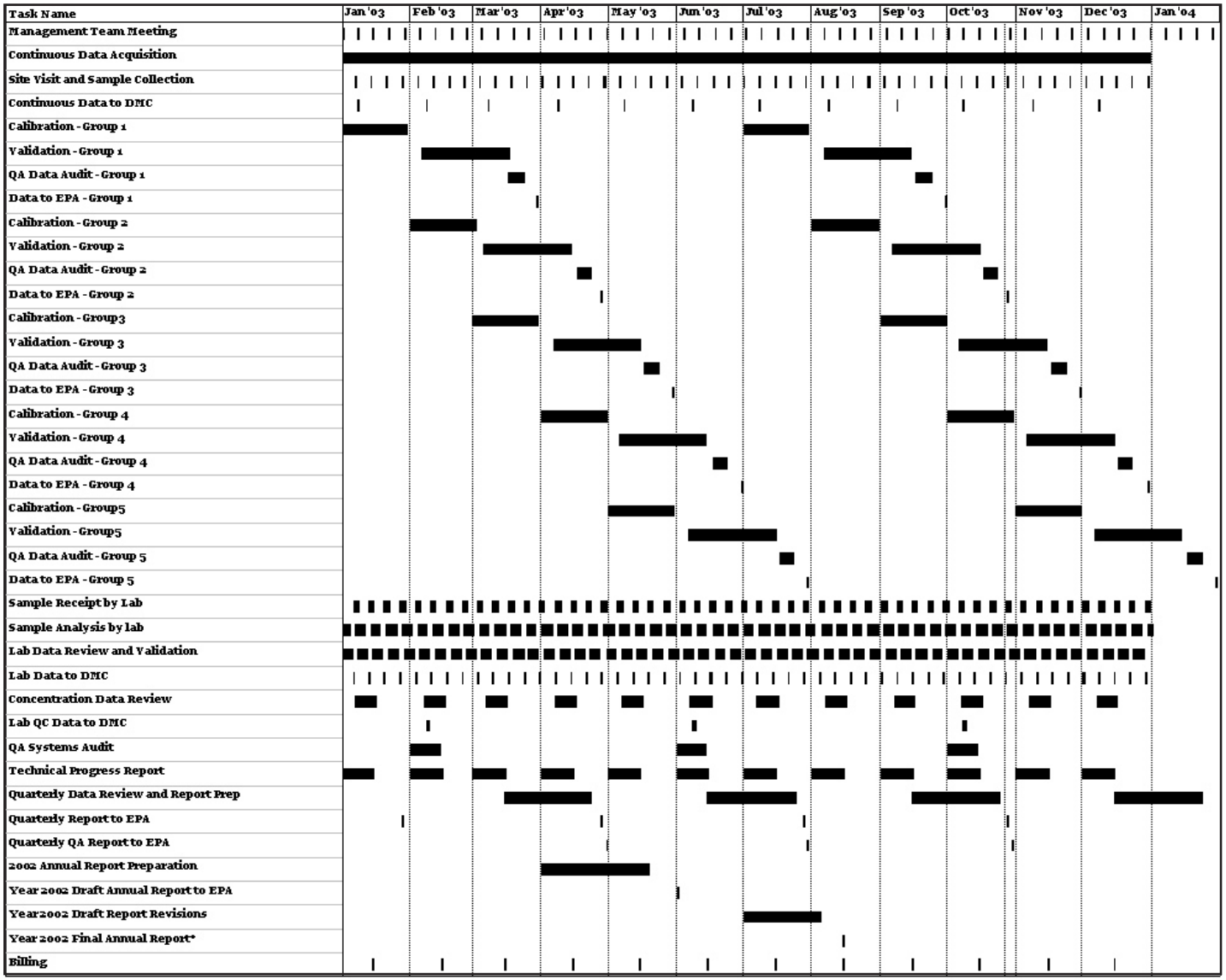


Figure A.6.4 Routine Annual Activity Schedule



* Estimated. Actual due date is 30 days after receipt of EPA comments on the draft report.

Figure A.6.5 Routine Visibility Schedule and Wet Deposition Schedule

In 2001, the visibility network was transferred to IMPROVE.

Figure A.6.6 Routine Monthly Activity Schedule

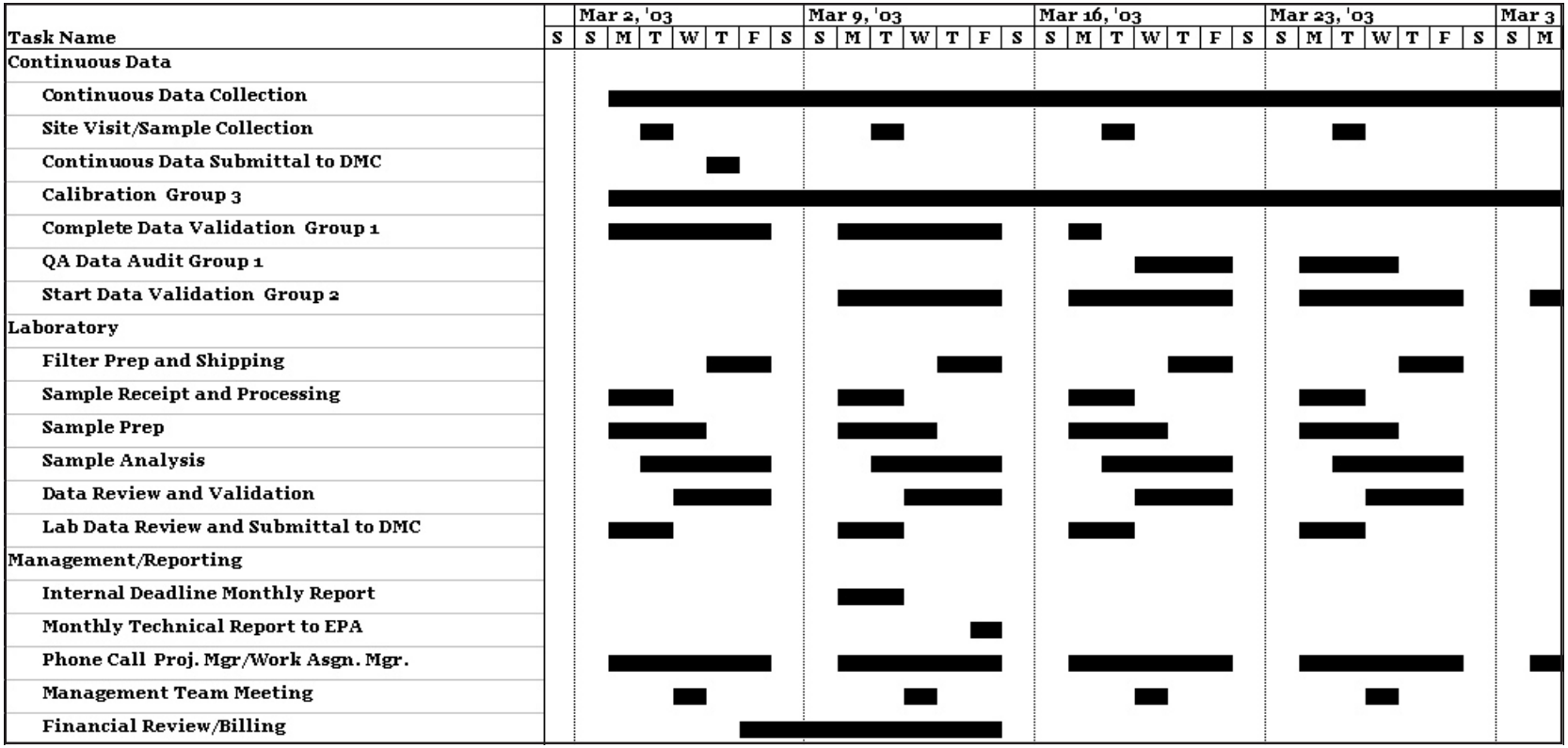
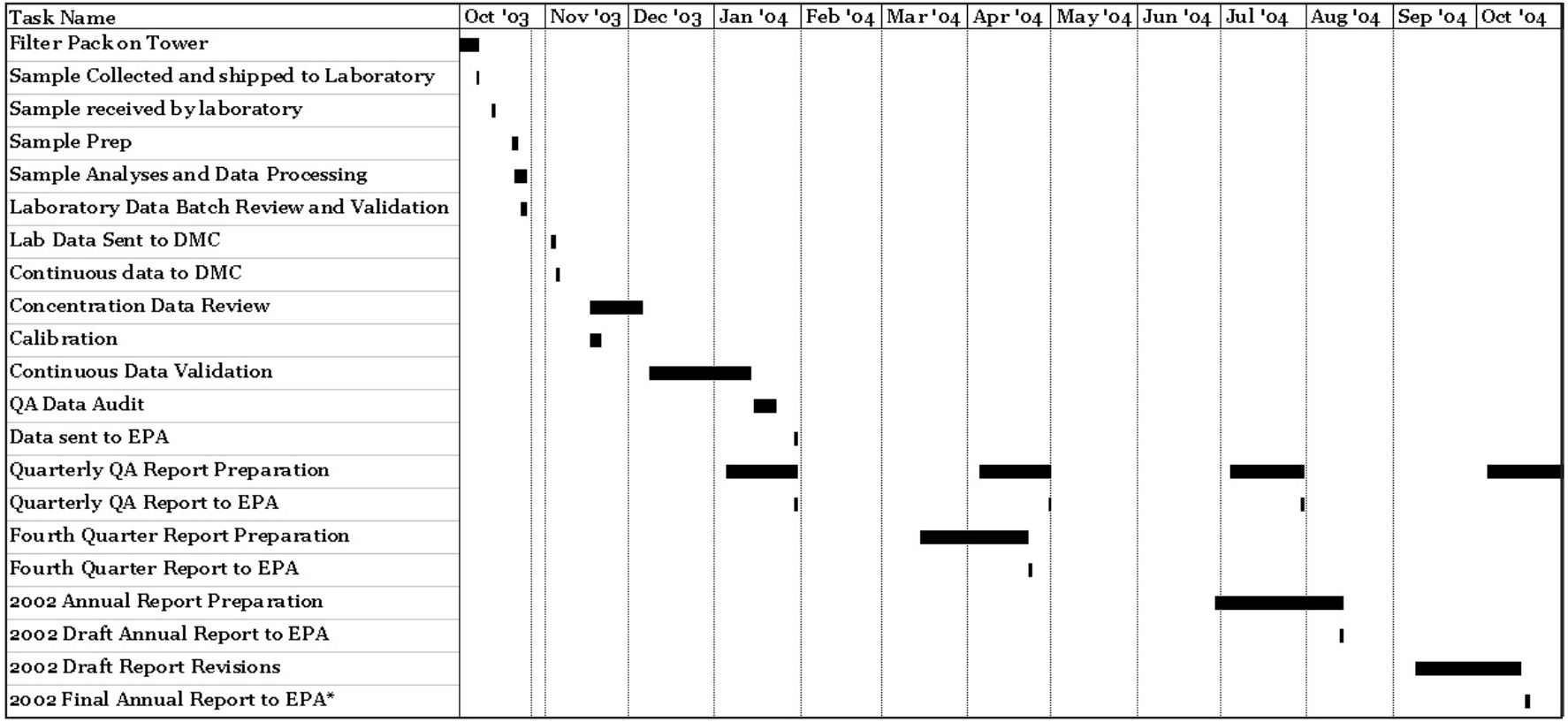


Figure A.6.7 Life History of a Filter Pack Datum - Example Using Filter Pack Sampled at Site CDR119 from 9/30/03 through 10/6/03



* Estimated. Actual due date is 30 days after receipt of EPA comments on the draft report.

B. Project Operations

B.1 Sampling Process Design

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. The goal of estimating dry deposition also requires the measurement of a variety of meteorological parameters used in the MLM. The background and goals of CASTNet are summarized in Sections A.5 and A.6.

B.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 sequential filters (Teflon®, nylon, and dual K_2CO_3-impregnated Whatman filters) to ambient air at a constant flow rate for a week is the basic sampling device. See the discussion in Sections A.6.1 and A.6.2.1.

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.

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.

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 IMPROVE protocols to guide instrument specifications, siting criteria, sampling frequency, and analytical techniques. Three single-stage filter packs with cyclones were selected to measure $PM_{2.5}$ and its chemical constituents. The visibility network consisted of an eight-station network that spanned the eastern United States (Figure A.6.2). Six of the sites were collocated with standard dry deposition sites. Seven of the visibility sites were transferred to IMPROVE as of May 2001. One site, BVL130, IL hosted IMPROVE and CASTNet sampling systems through 2001. Over the history of the CASTNet visibility network, sampling techniques have included measurement of visual quality through 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 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.

B.1.2 Sampling Locations and Frequency

The original concept behind CASTNet was to establish a network of approximately 100 sites throughout the United States. Eighty-five sites are operational. Figure A.6.1 shows the location of CASTNet sites as of October 2003. Table A.6.1 provides the location and operational characteristics of each CASTNet site by state. Table A.6.2 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 was installed and had started collecting data by July 1989. Fourteen sites were discontinued, 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 eleven sites for a total of 30. The NPS sites are designated as 400-series sites in Figure A.6.1. The visibility network was established in the fall of 1993. Sampling and analysis of measured aerosol $PM_{2.5}$ concentrations and its chemical constituents at eight sites were turned over to IMPROVE in May 2001. BVL130, IL operated both CASTNet and IMPROVE sampling systems through 2001. In 1999, wet deposition sampling, analysis, and reporting activities were transferred to NADP for operation under the NTN protocol to promote nationwide consistency in wet deposition monitoring. NADP/NTN is responsible for the collection, analysis, and recording of the wet deposition samples measured at CASTNet sites.

CASTNet currently includes the following major components:

1. Eighty-five sites, all of which collect weekly filter pack measurements and include meteorological measurements. Eighty-three sites measure O_3.
2. Two collocated sites. 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 site (MCK131, KY).
3. Fifteen sites collect precipitation chemistry (wet deposition) measurements and are operated according to NADP/NTN protocols. All 15 sites are collocated with dry deposition sites.
4. MLM calculations of V_d and dry deposition fluxes.
5. CASTNet database (EPA and NPS data) from 1987 through current quarter.

B.1.3 Current Measurements

See Table A.6.1 for the current types of measurements collected at each site.

B.1.4 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.

B.2 Station Siting and Installation

The addition of new CASTNet sites requires successful completion of four tasks: site selection, procurement of field equipment, site installation/initiation, and site operator training.

B.2.1 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. Results of all site evaluations are documented 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 and visibility monitoring sites was followed. The principal steps include:

1. Identification of general geographic areas for inclusion in the network;
2. Review of emissions inventory, population, and land-use data to identify areas that are regionally representative;
3. Visits to areas identified in Step 2 to identify and evaluate candidate sites; and
4. Discussion and selection of sites with EPA.

B.2.1.1 Siting Criteria

Both 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 A.6.2.1, the physical and chemical environment of each site must be consistent with objectives for that site (e.g., total deposition, visibility). Guidance for site selection is based on agency requirements and CASTNet site-selection criteria. A list of site-specific siting criteria used in the site selection process is shown in Table B.2.1. Additional siting criteria for visibility measurements are listed in Table B.2.2.

B.2.1.2 Station Siting, Identification, and Evaluation

Once EPA has designated general site locations, the initial siting task is to identify candidate locations that satisfy the general criteria for dry deposition monitoring.

B.2.1.3 Identification of New Candidate Sites

Prior to engaging in on-site field surveys, advance work is accomplished by MACTEC. This includes review of information (e.g., site summaries and site descriptions) 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 and federal agencies. CASTNet experience has shown that the U.S. Forest Service (USFS), Bureau of Land Management (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. 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 also overview 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.

The NPS sites are designated for national parks and monuments. Once a park or monument is selected, NPS/ARS follows the procedures discussed in Sections B.2.3 and B.2.4.

B.2.1.4 Evaluation of Candidate Sites in Existing Monitoring 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 what special requirements may be necessary to house the additional equipment required. The local site operator and the sponsoring agency are contacted to obtain the following information:

1. Availability of shelf or rack space in the existing shelter,
2. Adequacy of existing power and telephone connections,
3. Suitability of existing sample manifold and possibilities for retrofit,
4. Means of access (e.g., duplicate keys and security requirements), and
5. Protocols for cooperation with sponsoring agency.

B.2.1.5 Determination of Favorable Sites for Comprehensive Evaluation

Based on review of available documentation, emission inventories, and local land-use maps, MACTEC prepares listings of candidate sites along with recommendations for the EPA Project Officer to review. 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 emissions sources (SO_2 and NO_x) and population centers, land-use patterns, maps (USGS, other), 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.

B.2.1.6 Comprehensive On-Site Evaluation

Following receipt of approval from the EPA Project Officer, a schedule of site visits is developed. The schedule is designed to minimize travel by organizing candidate sites in logical geographic groups. Advance arrangements are made with the appropriate agency personnel and landowners, and background information on CASTNet is sent to them for review, prior to the arrival of MACTEC personnel.

MACTEC personnel conduct on-site evaluations of all prospective EPA sponsored CASTNet sites. The objectives of each trip are to accomplish the following:

1. Meet with the site manager or landowner to discuss monitoring objectives,
2. Evaluate the site with respect to site-specific siting criteria (Table B.2.1),
3. Obtain documentation of current site characteristics, and
4. Investigate availability of candidate site operators.

All 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, MACTEC personnel interview prospective site operators identified during the presurvey activities. MACTEC assembles information regarding the prospective site operator's experience, education, intent to remain in the area, and ability to assume additional duties for further consideration.

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:

1. Site identification,
2. Site administration,
3. Site representativeness (including regional and local influences),
4. Site suitability, and
5. Site logistics.

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

B.2.1.7 Contractual Arrangements

Following approval of a location for site installation, the appropriate contractual arrangements are initiated. Such activities vary from site to site because numerous agencies, organizations, offices, and individuals must 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.

B.2.2 Equipment Procurement

CASTNet deploys a standard set of air pollutant sampling and meteorological monitoring equipment. Equipment procurement is carried out according to the SOP described in the CASTNet Government Property Control SOP, which is included as Appendix 5.

Order and receipt of equipment are the responsibility of the CASTNet PCM. The following procedures are employed upon receipt of all equipment at MACTEC:

- Physical inspection of shipping container for damage;
- Verification of packing list by matching quantity and serial numbers of shipped items;
- Assignment of EPA bar code sticker and cross-reference with serial number;
- Update of the CASTNet EPA equipment bar code list;
- Entry of bar code numbers and equipment information into the designated table in 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. A monthly equipment report, which includes itemized, nonexpendable and expendable government equipment, is sent monthly to the EPA.

B.2.3 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 B.2.3 summarizes the activities involving site installation and initiation. A typical site configuration is shown in Figure B.2.1. 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 Requirements for PSD Air Monitoring Guidelines (EPA, 1998a), and the QA Handbook for Air Pollution Measurement Systems, Volumes I, II, and IV (EPA, 1986a and b, 1989). More detailed procedures are provided in the CASTNet Field SOP I, Site Selection Procedure (Appendix 1).

Site-specific inventory forms, generated prior to equipment mobilization (Figure B.2.2), document descriptions and assigned EPA barcodes for all instruments and equipment located on the site. The inventory forms are verified prior to the field technician's departure from the site. Upon return to the MACTEC office, the verified inventory document is used for cross checking with the computerized inventory table, which is maintained by the PCM. If discrepancies exist, the computerized table is corrected to reflect the actual, as installed, equipment inventory. The equipment inventory is a component of the CASTNet database.

B.2.3.1 LAI Measurements

LAI measurements are required to evaluate rates of transfer of material from the atmosphere to the plant canopy (i.e., V_d). 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.

B.2.4 Site Operator Training

Potential site operators are required to attend and successfully complete a training seminar provided on-site. The training topics include a CASTNet overview, equipment maintenance and operation, sampling procedures, and the importance of documentation. The training is performed by the FOM or a designated field coordinator or field technician. See also the discussion in Section A.8. Site operator duties are discussed later in Section B.5 and are summarized in Table B.5.2.

During the site initiation, the site operator observes instrument hookup and initial calibration. This is essential, as site operators must be able to change out equipment or components, if necessary.

Once the station is operational, the MACTEC FOM or designated field coordinator or technician trainer explains the operation of the site, as configured, to the site operator. Without assisting, the MACTEC trainer then observes the site operator's performance on all tasks that are required to operate a site. The MACTEC trainer will require the site operator to repeat tasks until the trainer deems the site operator proficient, and the site operator is comfortable with all procedures. Emphasis is placed on instrument maintenance, repair, and sample change-out procedures. Site operators are required to visit sites during semiannual calibration visits for additional training, as necessary.

B.2.4.1 Site Contacts

MACTEC maintains a CASTNet Site Contact List, which includes all pertinent information for each site within CASTNet. Each site list is kept current through semiannual updates based on field coordinator, field technician, site operator, and project staff input. Figure B.2.3 is an example of the CASTNet Site Contact List for VPI120, VA. Appendix 2 provides a complete CASTNet Site Contact List.

B.3 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:

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

B.3.1 Sample Custody

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

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

B.3.2 Sample Handling

B.3.2.1 Dry Deposition Filter Packs

An open-face, three-stage filter pack is used to measure sulfur and nitrogen species. Figure B.3.1 illustrates the filter pack. The measurement method is discussed in Section B.5.9.

Sample handling procedures are designed to minimize handling and transfers (i.e., opportunities for contamination and misdirection). The filter pack custody system begins with setting up the weekly field sampling groups in CLASS™. CLASS™ generates the filter pack lot number label, chain-of-custody label, shipping labels, and a laboratory sample label for each filter pack. Once the filter pack is loaded and capped, a filter pack lot number label is attached to the outer ring. This label contains the filter pack lot number and site number. A corresponding chain-of-custody label bearing the same filter pack lot number and site number, plus the employee number of the person who assembled the filter pack is attached to the SSRF (Figure B.3.2).

The prepared filter pack and labeled SSRF are placed in a polyvinyl chloride (PVC) tube for shipment to the designated site operator. The shipping label on the outside of the tube also includes the site number and filter pack lot 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 lot number of the filters used in the filter pack, and the date the tube was given to the shipping clerk.

The filter pack is then shipped to the site operator who will 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 PVC shipping tube, seal it, and attach the CLASS™-generated return shipping label addressed to the CASTNet laboratory in Gainesville, FL. 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 laboratory within two weeks of removal from the sampling tower.

The MACTEC 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 lot number 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 in the weekly Filter Pack Receipt Log. As part of the unpacking process, the filter pack lot number is matched to its corresponding CLASS™ generated laboratory sample number. The sample number is then activated and logged into the CLASS™ 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 holding time between sampling and extraction as long as the filters are stored in a cold (approximately 4ºC) and contaminant-free environment. The laboratory log sheet documents the samples received, the date received, and the signature of the person processing the samples. This information is then entered into CLASS™.

B.3.2.2 Fine Particulate Filter Packs

The procedures summarized below, and discussed in more detail in Section B.5.10, were followed by MACTEC until May 2001 when IMPROVE assumed responsibility for the visibility network measurements.

Aerosol sampling was conducted using time-integrated systems that collected 24-hour samples every six days. Each aerosol sampling system consisted of three separate, single-stage filter packs designated as denuder/nylon, Teflo®, and quartz (Figure B.3.3). As with the dry deposition filter packs, the custody system began with setting up the weekly field sampling groups in CLASS™. However, since a visibility sampling kit consisted of three single-stage filter packs, laboratory sample labels were generated for each filter type in addition to the chain-of-custody label and shipping labels. Only one pre-assembled filter pack was sent to the field for sampling. The Teflo® and quartz filters were loaded into their respective filter packs in the field. Once the single-stage filter pack was loaded with the unexposed nylon filter and attached to the denuder assembly, a laboratory sample number label was attached to the outer ring. This label contained the laboratory sample number and site number. The individual Petri dishes containing the unexposed Teflo® and quartz filters were labeled with identical laboratory sample numbers differentiated by a letter to designate the filter type (i.e., T for Teflo® and Q for quartz). A corresponding chain-of-custody label bearing the same laboratory sample numbers and site number plus the employee number of the person

who prepared the denuder/nylon filter pack was attached to the Visibility Status Report Form (VSRF) (Figure B.3.4).

The prepared denuder/nylon filter pack was sealed with end caps and placed in a resealable plastic bag. The bagged filter pack and the Petri dishes with the Teflo® and quartz filters were placed with the labeled VSRF in a customized, corrugated plastic container. Each shipping box contained three separate sampling kits, i.e., sample media for three 24-hour periods. The entire sampling kit was kept at ambient temperature. The same person who assembled the sampling kits and packed them in the shipping container completed the CASTNet Filter Pack Preparation Form for the filter preparation log.

The sampling kits were then shipped to the site operator who opened the shipment and verified that the laboratory sample numbers on the denuder/nylon filter pack and the Teflo® and quartz filters of each sampling kit matched the same numbers on the corresponding VSRF chain-of-custody label. The site operator signed and dated the chain-of-custody label and prepared the filter packs for sampling. The measurement method is discussed in Section B.5.10. After sampling, the Teflo® and quartz filters were placed back into their respective Petri dishes, sealed, and stored in the on-site freezer. The denuder/nylon assembly was sealed with end caps and placed back into the resealable plastic bag. After all three sample kits were exposed, the shipping container was returned to the CASTNet laboratory. The quartz and Teflo® filters were shipped with frozen gel packs to keep the filters cool. The VSRF for each sampling kit was completed by the site operator and included with the sample shipment.

The shipping containers were received and unpacked by the sample custodian according to CASTNet Laboratory SOP GLO3180-008 (Appendix 4). The sample custodian verified that the site operator completed the on and off sampling dates and checked the VSRF for comments or needed supplies. Samples were unpacked and recorded in the weekly Filter Pack Receipt Log. As part of the unpacking process, the filter sample number was activated and logged into the CLASS™ system for continued tracking.

The denuders were detached from the single-stage filter packs, and inspected for damage before being cleaned with deionized (DI) water, recoated with sodium carbonate (Na_2CO_3), and stored in a desiccator for future use. The nylon filters were removed from the filter packs, inspected for damage, placed in pre-cleaned, labeled extraction bottles and stored in a secure cold room at the CASTNet laboratory until extraction. The Teflo® filters were stored in individual Petri dishes at room temperature prior to shipment to Chester for analysis. The Teflo® filters were shipped to Chester at ambient temperature in monthly shipments. Once at Chester, the Teflo® filters were stored in a temperature-controlled room until analysis. The quartz filters were stored in individual Petri dishes in the CASTNet laboratory freezer prior to shipment to Sunset for analysis. The Petri dishes containing the quartz filters were packed in coolers with frozen Blue Ice™ and shipped to Sunset monthly. Upon arrival at Sunset, the quartz filters were stored in freezers until analysis.

B.3.2.3 Wet Deposition Samples

The procedures summarized below and discussed in more detail in Section B.5.11 were followed by MACTEC through 1998. NADP/NTN assumed responsibility for wet deposition measurements in 1999.

Sample handling procedures were virtually identical to those used for dry deposition filter packs. At each site, samples were collected, processed, packed for shipment to the CASTNet laboratory, sealed, and then transferred to the courier. A Precipitation Sample Report Form (PSRF) (Figure B.3.5) was completed and included with the sample shipment. The MACTEC receiving clerk delivered the sealed shipping container to the sample custodian, who received the sealed shipping container, inspected the integrity of the container and seal, opened the container, and checked the integrity of the contents. The PSRF was completed by the sample custodian. Wet deposition samples were filtered and then transferred to labeled sample containers and stored in a cold room at approximately 4°C. The laboratory log sheet documented the samples received, the date received, and the signature of the person processing the samples. The information was then entered into CLASS™.

B.3.3 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. Prior to 1999, sample integrity for wet deposition samples was maintained with bucket and filtration blanks. Section B.4.1 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 analyzed following the standard procedures described in Section B.3.6.

Laboratory blanks are prepared during the same time the filter packs are being prepared for the field. Two separate laboratory blank samples are prepared each week. Each blank contains a filter from the same lot as the 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 quarterly in-house data reports. Electronic data files for all of the blank samples are submitted to the DMC quarterly.

Prior to transfer of wet deposition sampling and analysis to NADP/NTN in 1999, MACTEC maintained sample integrity for wet deposition samples through use of bucket and filtration blanks. Bucket and filtration blanks were prepared weekly for analysis along with the weekly wet deposition samples. All analytical results through 1998 for the bucket and filtration blanks are stored in CLASS™.

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.

B.3.4 Preparation, Serialization and Shipment

B.3.4.1 Filter Packs

B.3.4.1.1 Dry Deposition

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 B.3.2.1. 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 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 B.3.1) is loaded with one Teflon® filter (first stage), one nylon filter (second stage), and two Whatman filters (third stage). First, the two Whatman filters are placed directly together on the bottom filter support screen. Two Whatman 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 screen above the Whatman filters. Finally, the Teflon® filter is installed on a filter support screen 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.

Sample handling procedures are designed to minimize handling and transfers (i.e., opportunities for contamination and misdirection). After assembly, the filter pack is sealed and capped, and a filter pack lot number label is attached to the outer ring. This label contains the filter pack lot number and site number. A corresponding chain-of-custody label bearing the same filter pack lot number and site number plus the employee number of the person who assembled the filter pack 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 laboratory blank samples are prepared for each field sampling week. The laboratory blanks are prepared from the same lot of filters used in preparing the weekly filter packs. Two Teflon® and two nylon filters are selected and placed in individual extraction bottles labeled with the corresponding filter lot number. A total of four Whatman 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 PVC tubes. The shipping tube contains a filter pack, SSRF, and a CLASS™-generated return 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 (e.g., FedEx Government) of filter packs to and from each site.

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 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:

DDxx-y*z
and
FBxx-y*z

where: DD = dry deposition
FB = field blank
xx = calendar year (last two digits)
y = week number (1-52)
z = site sequence number

B.3.4.1.2 Visibility

The procedures summarized below, and discussed in more detail in Section B.5.10, were followed by MACTEC until May 2001 when IMPROVE assumed responsibility for the visibility network measurements. More information about IMPROVE may be found on their web site: http://vista.cira.colostate.edu/improve.

Single-stage filter packs for the visibility network were prepared and shipped to site operators approximately every tenth day. Field blanks were shipped quarterly. Custody tracking began with preparation of the denuder/nylon assembly and filters for shipment as described in Section B.3.2.2. As with the dry deposition sampling, all handling of denuders, filters, and filter packs during preparation and packing for shipment was done with powder-free gloves in a limited-access room dedicated for this purpose.

The visibility sample kit contained three separate filter packs: the denuder/nylon filter pack, the Teflo® filter pack, and the quartz filter pack. The denuder/filter pack assembly used with the nylon filter contained only a nylon filter with a Na_2CO_3 coated denuder attached upstream. The Teflo® and quartz filters were shipped in individually labeled Petri dishes, separate from their designated filter packs. These filters were then each loaded into its own filter pack in the field. The Teflo® filter used in the visibility filter pack was a thin film of Teflon® supported by a plastic outer ring. Unlike the Teflon® filter used for the dry deposition filter pack, the Teflo® filter did not have any backing attached.

The visibility sampling kits were shipped to the field in large plastic containers. Each container held three sampling kits, each containing a filter pack/denuder assembly, a Teflo® filter in a Petri dish, a quartz filter in a Petri dish, and a VSRF. For the visibility network, the Teflo® and quartz filters were unloaded from the filter pack by the site operator, placed in the correct Petri dish, and then shipped to the laboratory with the nylon filter pack/denuder assembly. Site operators completed the VSRF after sampling and returned the exposed filters, denuder assembly, and VSRF for each of the three sampling kits to the CASTNet laboratory. A field-shipping log was used to document shipments (e.g., FedEx Government) of visibility sampling kits to and from each site.

When the exposed filter packs arrived back at the CASTNet laboratory, the shipment was inspected and unpacked by following the CASTNet Laboratory SOP for Receiving, Unpacking and Log in of Visibility Samples (GLO3180-008 in Appendix 4). The filters were assigned sample numbers in the same fashion as for dry deposition filter packs, except that V was used instead of DD to denote the visibility network (e.g., Vxx-yy*z).

B.3.4.2 Wet Deposition Buckets

The procedures listed below were followed by MACTEC through 1998. NADP/NTN assumed responsibility for wet deposition measurements in 1999. More information about NADP/NTN may be found on their web site: http://nadp.sws.uiuc.edu.

Prior to shipment, the internal surfaces of wet deposition buckets and lids were scrubbed with a natural sponge and rinsed three times with DI water. All buckets were handled with powder-free plastic gloves. The buckets and lids were drained upside down on absorbent paper. One hundred milliliters (mL) of DI water was added to one of the cleaned buckets selected at random, and the water was swirled in the bucket. A 20-mL sample was drawn from the bucket and analyzed for conductivity and pH. Conductivity of less than 2.0 micromhos per centimeter (µmho/cm), and pH greater than 5.0 was required before the batch of buckets was accepted for use.

Dry buckets and lids were weighed separately and the weights were recorded on a log sheet. Weights and unique identification (ID) numbers were written on buckets and lids with permanent marker. Buckets and lids were stored separately in sealed plastic bags until used.

Buckets and lids were shipped to the sites in reusable, heavy-duty boxes that were securely strapped closed. A bucket and lid assembly was assigned a sample number in the same fashion as for filter packs, except that W was used instead of DD to denote wet deposition (e.g., Wxx-yy*z). PSRF and Belfort rain gauge charts were provided as needed.

B.3.5 Receipt and Log in of Sample Media

B.3.5.1 Filter Packs

Filter packs are received at the MACTEC receiving area. Exposed filter pack samples from EPA-sponsored sites must be received by the CASTNet laboratory within two weeks 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 lot 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. Samples are unpacked and recorded in the weekly Filter Pack Receipt Log. As part of the unpacking process, the filter pack lot number is matched to its corresponding CLASS™-generated laboratory sample number. The sample number is then activated and logged into the CLASS™ system and tracking of the sample continues in CLASS™. Samples are stored for subsequent extraction and analyses.

Prior to May 2001 when the visibility network was transferred to IMPROVE, similar procedures were followed for the receipt and log in of the visibility sample kits and VSRF.

B.3.5.2 Wet Deposition Buckets

The procedures listed below were followed by MACTEC through 1998. NADP/NTN assumed responsibility for wet deposition measurements in 1999.

Wet deposition bucket shipping boxes were delivered to the MACTEC receiving area. The MACTEC receiving clerk checked the receiving area daily and transferred the samples to the sample custodian who examined the shipping boxes for damage and noted their condition. The number of buckets shipped to and received from each site was also noted. Buckets and forms were removed from the boxes, and the buckets were inspected for sample condition and leakage. The PSRF accompanying the buckets were checked for completeness, equipment problems, and supply requests. Samples were then logged in and matched to the corresponding CLASS™-generated laboratory sample number. The sample number was then activated and logged into the CLASS™ system and tracking of the sample continued in CLASS™.

B.3.6. Sample Preparation Prior to Analysis

B.3.6.1 Unloading and Extraction of Filters

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

Once in the laboratory, filter packs are unloaded individually using a disassembly stand (Figure B.3.6) 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 Whatman. 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 screen is removed and the nylon filter is carefully lifted off its support screen. As with the Teflon® filter, the nylon filter is inspected before being placed in the designated extraction bottle. Once the nylon filter support screen is removed, both Whatman filters are carefully lifted off the bottom support screen. The Whatman 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 Whatman filters are extracted according to the procedures described in the CASTNet Laboratory SOP (GLO3180-001 in Appendix 4).

Before transfer of visibility sampling and analysis to IMPROVE, the nylon, quartz, and Teflo® filters from the single-stage visibility filter packs were logged in and stored according to filter type. The denuders were detached from the single-stage filter packs and inspected for any damage. The denuders were cleaned with DI water and recoated with Na_2CO_3 and stored in a dessicator for future use. The nylon filters, which remained at the CASTNet laboratory, were removed from the filter packs, inspected for any damage and placed in pre-cleaned, labeled extraction bottles. Once the visibility nylon filters were placed into individual extraction bottles, they were subject

to the same procedures as the dry deposition nylon filters. The Teflo® and quartz filters were not extracted at the CASTNet laboratory, but were shipped on a monthly basis to Chester and Sunset, respectively, for analysis. The methods used by Chester and Sunset are described in the corresponding SOP in Appendix 5 of the CASTNet QAPP Revision 1.0 (January 2003).

B.3.6.2 Weighing and Filtration of Wet Deposition Samples

The procedures listed below were followed by MACTEC through 1998. NADP/NTN assumed responsibility for wet deposition measurements in 1999.

Precipitation samples were decanted from the wet deposition bucket on-site and sent to the CASTNet laboratory in sealed bottles. If the sample was less than 35 mL, it was discarded. If the sample was greater than 35 mL, it was analyzed for pH and conductivity. The remaining sample was then filtered through a rinsed 0.45 µm filter. Following filtration, if the sample was greater than 35 mL but less than 70 mL, analyses were performed for anions and cations. Samples with limited volume (less than 50 mL) were prioritized to ensure that the most critical ions were analyzed first. These ions, in order of priority, were SO_4^{2-}, NO_3^-, Cl^- , NO_2^-, Ca^{2+}, Mg^{2+}, Na^+ , K^+, and NH_4^+. If the sample was greater than 70 mL, a second 20-mL aliquot was drawn for additional analysis of dissolved pH and conductivity. Remaining samples were stored in the coldroom for further analysis. At the end of each week, after all samples were received, log sheets were submitted to CLASS™ for data entry.

B.4 Inspection and Acceptance of Supplies and Consumables

B.4.1 Teflon®, Nylon, and Whatman Filters

Teflon® and nylon filters require no preparation for use in filter packs. Whatman 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. Prior to being loaded into the filter packs, each lot of Teflon®, nylon, and Whatman filters is analyzed to ensure that background contamination from the manufacturing and impregnation processes is within acceptable limits. Acceptance testing is done on each box of Teflon® and nylon filters prior to preparation of the filter packs. Five filters (5 percent) from each box of 100 are extracted and analyzed following standard procedures. If any of the five filters show nitrate or sulfate contamination above the detection limit (Table B.3.1), the box is rejected and not used in filter packing. Acceptance test results are stored in CLASS™. The manufacturers' lot numbers from each box of Teflon® and nylon filters are recorded in the filter pack preparation logbook. A database is maintained to cross-reference MACTEC sample numbers with the Teflon® and nylon manufacturers' lot numbers.

The nylon filters used in the single-stage visibility filter packs also required no preparation before use and were subject to the same acceptance testing procedures as the nylon filters used in the dry deposition filter packs.

Whatman filters are acceptance tested after the impregnation procedure. Each set of impregnated filters is assigned an impregnation date. The impregnation date is considered the Whatman lot number. Acceptance testing is performed on two percent of the Whatman filters contained in each lot. The number of filters in a lot may range from 200 to 800 filters depending upon the demand. The acceptance test samples are prepared, extracted and analyzed. A Whatman filter lot is considered acceptable if no more than one acceptance sample shows sulfate contamination above 3.83 micrograms (µg) (equivalent to an approximate ambient concentration of 0.7 micrograms

per cubic meter [$\mu g/m^3$] as SO_2). All of the Whatman filter acceptance test results are stored in CLASS™. The Whatman filter lot number is recorded in the filter pack preparation logbook and in CLASS™. A database is maintained that cross-references the MACTEC sample numbers with the Whatman lot numbers.

Figures B.3.7 through B.3.9 are examples of quarterly acceptance testing on Teflon®, nylon, and Whatman 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.

B.4.2 Denuder Assembly

Before the May 2001 transfer to IMPROVE, denuders were used with nylon filters in the single-stage filter packs that were deployed for aerosol sampling by the visibility network. Denuders required coating with Na_2CO_3 before packing. See CASTNet Laboratory SOP GLO3180-011 (Appendix 4).

B.4.3 Teflo® Filters

Teflo® filters were used in single-stage filter packs by the visibility network. Before the network was transferred to IMPROVE, Chester supplied MACTEC with Teflo® filters. Chester selected a filter manufacturer who could provide consistently high quality Teflo® filters with minimal degassing characteristics. Filters were ordered when needed, and large individual lots were requested from the manufacturer. The Teflo® filters were kept in a climate-controlled weighing room maintained at a temperature of 70 degrees Fahrenheit (°F) ± 5°, and 40% relative humidity ± 5%. Upon receipt, the filters were recorded in the Filter Receiving Log, by lot number and filter type. The plastic shrink wrap packaging was removed from the filter boxes so the filters could begin degassing. During inspection, the filters were handled with forceps. Each filter was examined individually in a clean, laminar flow hood. The Teflo® filters were magnified and inspected against a lighted background for deep creases or grooves, tears, holes, discolorations, foreign particles, or an incompletely sealed support ring. Removal of foreign particles was attempted by blowing on the filters with a lens cleaner. If accepted, each filter was assigned a 5-digit ID number and then weighed. The ID number was written on the filter support ring as well as on a preprinted, self-adhesive sticker placed on a Petri dish. The Teflo® filters needed to equilibrate in the weighing room for a minimum of 24 hours prior to being weighed. Ten percent of the filters were reweighed the next day to verify that degassing was no longer occurring. Chester stored the tare-weighted filters in the temperature-controlled weighing room until shipment to MACTEC. The Teflo® filters were shipped to MACTEC in individual Petri dishes at ambient temperature when requested. When the Teflo® filters were received at MACTEC, they were kept at room temperature in the visibility sample kit preparation area.

B.4.4 Quartz Filters

Quartz filters were used in single-stage filter packs by the visibility network. Before the network was transferred to IMPROVE, MACTEC obtained quartz filters from Sunset. The 47 mm quartz fiber filters were ordered by Sunset in lots of 1,000. When received from the vendor, the packages of filters were inspected for physical defects and for uniformity in size. Sterile, single-use polystyrene 50 mm Petri dishes used for storage of the filters were inspected for physical defects or damage from shipping and were stored as received. The quartz fiber filters were cleaned in batches of 100 by placing them first in a clean crucible and then in a 600°C muffle furnace for 2 hours. After the filters were fired, the crucibles containing the filters were removed and then placed in a clean desiccator to cool. The filters were individually removed, placed in a Petri dish, and then closed and wrapped in aluminum foil in

groups of 10 filters. A lot number was assigned to the group of filters and logged in the logbook along with the filter supplier's information. Two filters out of the group of 100 were randomly selected from the lot for acceptance testing of total carbon. If greater than 0.2 micrograms per square centimeter ($\mu g/cm^2$) of total carbon was detected, the lot was rejected and the cleaning process was repeated. The accepted lot was mailed to MACTEC in the same manner as it was wrapped after firing: 10 aluminum foil wrapped groups of 10 individual filters in Petri dishes. Before shipment to MACTEC, the filters were placed in coolers with frozen Blue Ice™ to keep the filters cool. When the filters arrived at MACTEC, they were stored in the laboratory freezer until needed for use in the assembly of the visibility sampling kits.

B.4.5 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 must be traceable to a NIST (or EPA equivalent) source. Other chemicals must have a purity specification on their labels.

B.4.5.1 CASTNet Laboratory

As noted above, all laboratory standards (calibration standards, drift check standards, independent references) must be traceable to a NIST (or EPA equivalent) source, specifying purity on their labels. The safety requirements are checked with the material safety data sheets (MSDS) 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.

B.4.5.2 Sunset

Prior to transfer of the visibility network to IMPROVE, all of the standards used by Sunset were 99.9 percent pure or were reagent grade. Required purity levels were established for the gases used (e.g., Helium = 99.999 percent pure).

B.4.5.3 Chester

The laboratory used reagent grade ethanol, NIST-traceable SRM, and EPA organo-metallic acetate film standards for analyses of visibility samples until May 2001 when visibility sampling and analysis was transferred to IMPROVE.

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B.5 Field Sampling Methods

Field operation 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 following sections describe procedures that are implemented at each sampling site to ensure collection of data of the highest quality.

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. The meteorological instruments used by the two organizations are generally the same with some minor procedural differences that do not affect the resulting measurements. However, unlike MACTEC, ARS operates a variety of O_3 analyzers and utilizes a second in-station photometer to verify the ozone levels generated for the precision and span checks. In short, the ARS procedures conform to all EPA requirements for SLAMS monitoring as described in 40 CFR Part 58, Appendix A (EPA, 1998b). Because the MACTEC sites do not utilize an independent photometer, these sites do not strictly conform to SLAMS requirements.

The discussions in the following subsections apply to both EPA and NPS field instruments unless noted otherwise.

Site operators visit CASTNet sites each Tuesday and as directed by the FOM or field coordinator (e.g., for equipment repair). Visibility sites were visited at a minimum of once every six days coinciding with the 6-day sample schedule. This section presents the general sequence of activities performed during routine site visits, only. Detailed procedures for equipment checks, preventive and corrective maintenance, sample media collection, DAS operation, filter pack change-outs, documentation, and shipment of samples are described in the CASTNet Field SOP in Appendix 1. Table B.5.2 summarizes the site operator's responsibilities for routine site visits.

Subsections B.5.1 through B.5.7 discuss the operation of the ozone analyzers and the meteorological instruments. These subsections are followed by discussions of the nephelometers, dry deposition filter pack and flow, aerosol filter pack and flow, wet deposition sampling, data acquisition, and operation of the calibration and certification laboratory. Each subsection includes descriptions of the instrument method and its calibration procedures and schedule.

Each instrument is inspected and/or tested every Tuesday by the site operator as shown in Table B.5.2. In addition, field technicians perform preventative maintenance every six months according to the schedule listed in Table B.5.3. Table B.5.4 summarizes possible QC failures for all field and laboratory instruments and the respective corrective actions. The information in these three tables applies to all CASTNet instruments. Site operator activities are documented on various forms, such as the Site Narrative Log and SSRF. All originals are sent to the MACTEC, Gainesville, FL DMC and stored. Copies are also filed at the CASTNet site. Field calibrations are documented on the field calibration forms and filed in the same manner.

The accuracy of field measurements is determined by challenging instruments with standards that are traceable to NIST. Continuing accuracy is verified through biannual calibrations by MACTEC personnel. Accuracy objectives for field measurements are listed in Table A.7.2.

In practice, separate measurement criteria are used for field calibrations and for data validation. Table B.5.5 provides acceptance criteria for field calibrations. For example, an O_3 instrument is adjusted if any calibration result (any point) is outside the ± 5 percent criterion. On the other hand, O_3 data are considered valid if results are within 10 percent.

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.

To determine network precision of the CASTNet measurements, two sites in the network operate collocated sampling systems. MACTEC operates two sampling systems at MCK131, KY. 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 and is operated by MACTEC, while ROM406 is an NPS sponsored site and is operated by ARS. All instruments are installed in identical configurations and carefully calibrated. Sensors are located so that they will not interfere with each other's operation or response, yet are expected to provide identical results (i.e., wind speed and direction sensors separated so as not to create turbulent disturbances). The overall precision of continuous data is assessed quarterly and annually by calculating MARPD between simultaneous hourly averages from collocated sites. MARPD is calculated using Equation 1:

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

Where:

S1 = The value for the primary sampler,
S2 = The value for the collocated sampler, and
k = The number of pairs of valid data.

Collocated continuous data are analyzed on a quarterly basis, and quarterly ARPD 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. Please note that when a problem is identified it shall not be corrected until a network-wide solution is created or until regularly scheduled maintenance is performed, as appropriate, to preserve collocated results as a measure of network precision.

B.5.1 Ozone

B.5.1.1 Method Description

O_3 is measured via UV absorbance with a Thermo Environmental Model 49-103 analyzer operating on the 0 to 500 parts per billion (ppb) range. The principle of operation is based on the Beers Law technique of UV absorption. Ambient air is drawn from the 10-m air monitoring tower through 3/8-inch tetra fluoroethylene (TFE) Teflon® tubing. Savillex 47-mm filter holders are used to house 5-µm Teflon® filters at the tower inlet and the analyzer

sample port to help prevent particle deposition within the system. This maintains sample degradation to 3 percent or less. Table B.5.7 depicts the O_3 analyzer's operating specifications.

ARS operates O_3 analyzers based on UV absorbance and also chemluminescence. See Table B.5.1 and the ARS SOP in Appendix 3.

B.5.1.2 Equipment Calibration and Frequency

Field calibrations are critical to achieving and maintaining DQI. Therefore, training field technicians and developing calibration criteria (Table B.5.5) with stricter limits than project DQI (Table A.7.2) are given considerable attention. 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 B.5.5 summarizes the calibration methods and acceptance criteria for all of the CASTNet field equipment, including the O_3 analyzer. CHE185, OK and all NPS operated sites follow SLAMS O_3 monitoring requirements (see A.6.2.2.2).

Every six months, MACTEC technicians visit each site to perform routine calibration and maintenance of all sensors and instruments. The results of the individual calibration data forms are summarized on the Calibration Result Summaries Form (Figure B.5.2). The information on this form is then entered into the calibration summary database, which is maintained in the Gainesville, FL office, by the field operations staff. 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 on the Test Equipment Calibration and Maintenance Record (Figure B.5.3). The sites are calibrated every six months (Figure A.6.4). The sites are grouped geographically in blocks of approximately ten sites. Each block of ten is calibrated within one month. The calibrations are performed in two five-month blocks: January through May and July through November. The Calibration Result Summaries Forms are reviewed by the FOM and/or field coordinator. The calibration summary database entry is also checked.

Every six months, a multi-point calibration is performed to adjust the response of the on-site O_3 instrument to correspond to the output of an O_3 transfer standard. Each site analyzer 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 80 percent of the full-scale output of the ozone analyzer. The internal ozone generator is then set to perform automatic z/s/p checks of the ozone measurement system each week. The O_3 calibration results are recorded on an Ozone Data Form (see Figure B.5.4).

The transfer standard used for the multi-point calibration is certified at least twice per calendar quarter against a primary standard maintained in the MACTEC Equipment Calibration and Certification Laboratory, which is discussed in Section B.5.13. The primary standard is certified at least once annually against the NIST reference photometer at the EPA National Exposure Research Laboratory (NERL). Copies of the certification documentation are filed at each site and at MACTEC along with the calibration results for each site.

Every Sunday, automatic z/s/p checks are performed using the O_3 generating system integrated into the measurement system. ARS utilizes a second (independent) in-station photometer to verify the ozone levels used for the z/s/p checks. The frequency of z/s/p checks at NPS sites ranges from daily to weekly. The results of the z/s/p checks are documented by the site operator on a control chart maintained at each site, automatically recorded to the DAS, and automatically polled each week. The z/s/p binary files are named and managed similarly to the binary data files. Figure B.5.5 depicts an O_3 control chart from site ARE128, PA. The automatic test results are reviewed by the FOM or field coordinator prior to the site operator's weekly site visit. An example of a chart produced from the polled data from site ARE128, PA is provided (see Figure B.5.6). The results obtained by polling and those observed by the site operator are confirmed during the Tuesday call-in. The results presented in Figures B.5.5 and B.5.6 represent precision checks, which are stable and within control limits, indicating that no additional action is required.

If the control chart indicates responses greater than ± 10 percent for the span and precision checks, or greater than 5 ppb or less than 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 on both the site control chart and 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 of the ozone generator.

Figure B.5.7 represents a precision control chart from site LYK123, OH, where the results are consistently at or above the 10 percent limit. The test gas concentration remained stable, which indicated that there was no drift occurring with either the test gas or the analyzer. In this case, the corrective action occurred during the multi-point calibration when the unadjusted results confirmed that the O_3 measurements were accurate, and the precision gas concentration was set too high. The precision gas concentration was adjusted as shown by the control chart. Figure B.5.8 represents a precision control chart from site LRL117, PA. In this case, the operation of the internal O_3 generator was intermittent. A field technician was sent to the site to perform a non-routine calibration and repair as the corrective action. The unadjusted O_3 analyzer calibration indicated that the photometer measurements were accurate, and the O_3 generator was malfunctioning. The ozonator was repaired and adjusted.

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, III.A.1 (Appendix 1). The SOP includes instructions for documentation of the control charts maintained on-site and procedures 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 B.5.9). All data manually entered into the database are validated for accuracy through double entry.

Note: Sections B.5.2 through B.5.7 describe individual components chosen for meteorological monitoring. Climatronics system translators require zero and span checks; R.M. Young systems do not. The procedural

difference is noted, as appropriate, throughout the following sections. The ARS equipment and procedures (Appendix 3) are virtually identical to MACTEC's and are not discussed separately in the remainder of this section.

B.5.2 Meteorological – Wind

Climatronics F460 and R. M. Young AQ systems are used to collect meteorological data at CASTNet sites. These wind speed and wind direction systems were selected based on MACTEC's experience with these systems in a variety of field programs. General selection criteria included reliability, durability, and low maintenance requirements, as well as conformance with the accuracy and precision requirements of the program. Manufacturers' specifications for each type of sensor are shown in Table B.5.8.

B.5.2.1 Method Description

B.5.2.1.1 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 on the DAS. 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 potentiometer's wiper voltage is a measure of wind direction and is coupled with the wind direction translator. Circuits in the translator convert the 0° to 540° signal generated by the potentiometer into a 0 to 1 volt (V) signal for recording.

B.5.2.1.2 R.M. Young Monitor AQ

The propeller rotation on the R.M. Young wind monitor produces an alternating current (AC) sine wave signal with a frequency proportional to wind speed. The 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 conditioned by the translator to produce an analog output proportional to wind direction.

B.5.2.2 Equipment Calibration and Frequency

See Section B.5.1.2 for general information on calibrations. See Figure A.6.4 for calibration frequency.

B.5.2.2.1 Wind Speed

The wind speed sensor is calibrated by referencing the response when coupled to a NIST-traceable synchronous motor. A variable speed synchronous motor is used to produce five or more standard values [typically from < 1 to 40 meters per second (m/sec)], which permit the device response to be scaled appropriately to the corresponding wind speed. The wind speed sensor bearings are checked using an anemometer torque disc to determine that proper starting threshold criteria are met. The Wind System Data Form (see Figure B.5.10) is used to document wind speed calibration results.

B.5.2.2.2 Wind Direction

The wind direction device is calibrated to true north by referencing the alignment to the four cardinal directions and to a distant sighting object. The azimuth of the sighting object and the orientation of the sensor's alignment indicator are determined from compass readings, which are corrected for magnetic declination. The wind direction bearings are checked using a vane torque gauge to determine that proper starting threshold criteria are met (Figure B.5.10).

B.5.3 Meteorological – Temperature Sensors

B.5.3.1 Method Description

The Climatronics temperature sensors consist of an epoxy-coated thermistor composite housed in a stainless-steel probe casing. R.M. Young temperature sensors are platinum resistance-temperature devices (RTD). The sensors are housed in motor-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 is not required under normal use.

The translator supplies a regulated voltage to the sensor, which responds as a variable resistor with respect to temperature. The output voltage is a linear representation of temperature.

The temperature/delta temperature translator receives the signals from both sensors. Temperature is recorded at the 2 m and 9 m levels. The Climatronics temperature translator circuitry calculates delta temperature by subtracting the 9-m temperature (T1) from the 2-m temperature (T2) [T2 - T1]. The R.M. Young temperature translator calculates delta temperature by subtracting the 2-m temperature from the 9-m temperature [T1-T2].

B.5.3.2 Equipment Calibration and Frequency

See Section B.5.1.2 for general information. See Figure A.6.4 for calibration frequency. Temperature sensors are calibrated by using a NIST-traceable thermometer or RTD transfer standard as a reference device. A minimum of three temperatures, maintained by a stirred water bath, over a range of 0 to 50° C are compared to the standard. Temperature and delta temperature calibration results are documented on the Temperature/Relative Humidity Data Form (see Figure B.5.11).

B.5.3.3 Data Quality Indicators

Precision estimates are calculated quarterly and annually. Mean absolute difference (MAD) is calculated using collocated temperature and delta temperature measurements:

$$MAD = \frac{1}{k}\sum_{j=1}^{k}\left|S1 - S2\right|_j \qquad (2)$$

MAD is used instead of MARPD. Semiannual calibration results provide a measure of accuracy.

B.5.4 Meteorological – Relative Humidity

B.5.4.1 Method Description

Relative humidity is measured using the Climatronics Model 100098 relative humidity sensor or the Rotronics MP-100F humidity-temperature probe.

The Climatronics Model 100098 relative humidity sensor measures atmospheric moisture by the hygromechanical stress of small cellulose crystallite structures acting on a pair of thermally matched silicon strain gauges connected as a half Wheatstone bridge. The voltage supplied by the translator converts the strain into an electrical output signal. The Climatronics relative humidity sensor is mounted at 9 m above ground and is housed in a motor-aspirated shield to provide a protection from both short-wave and long-wave radiation.

The Rotronic MP-100F 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 Rotronics relative humidity sensor is mounted at 9 m above ground and is housed in a R.M. Young naturally-aspirated, gill, multi-plate radiation shield.

B.5.4.2 Equipment Calibration and Frequency

The Climatronics sensor is calibrated by the manufacturer and normally requires no adjustment. If the sensor is found to be out of calibration, the sensor is then recalibrated (if possible) or removed from the field. The sensor is returned to MACTEC to determine the cause for excessive drift. If necessary, the sensor is returned to the manufacturer for replacement or repair.

The Rotronic relative humidity sensor is calibrated by referencing the sensor output to that of a Rotronics transfer standard, model number A1H, or salt solutions.

Figure B.5.11 depicts an example of relative humidity calibration data entered on the Temperature/Relative Humidity Data Form.

B.5.5 Meteorological – Precipitation

B.5.5.1 Method Description

CASTNet sites are equipped with a Climatronics tipping bucket rain gauge, which has a heated collection basin to melt snow for a readable output. Additionally, some sites are equipped with a Belfort weighing rain gauge. Both precipitation collection devices are described in the following subsections.

B.5.5.1.1 Tipping Bucket Rain Gauge

The Climatronics tipping bucket rain gauge, Model 100508, consists of an 8-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 “buckets” balanced on the measuring apparatus. As one bucket fills, the weight of the liquid causes it to tip and bring the other bucket

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 DAS, 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 calibration.

B.5.5.1.2 Belfort Rain Gauge

The Belfort recording rain gauge is a device that converts the weight of precipitation (collected by an internal catch bucket) into an up-and-down motion of a recording pen on a paper chart. This instrument is widely used by national and state-level monitoring networks because of its ability to provide good resolution of precipitation timing and amount during a recording period and to provide hard copy of that data.

B.5.5.2 Equipment Calibration and Frequency

See Section B.5.1.2 for general information. See Figure A.6.4 for calibration frequency.

B.5.5.2.1 Tipping Bucket

The tipping bucket rain gauge is calibrated by adding a known volume of water (typically equivalent to 0.50 inch of rainfall) to the gauge and recording the number of tips produced.

B.5.5.2.2 The Belfort Rain Gauge

The Belfort rain gauge is calibrated by adding known weights to the bucket and checking deflection of the pen on the chart. The pen deflection should correspond to the added sum of the weights. Figure B.5.12 shows an example of Belfort rain gauge calibration data.

The Precipitation Data Form (Figure B.5.13) is used to document precipitation gauge calibration data from both the tipping bucket rain gauge and the Belfort weighing rain gauge.

B.5.6 Meteorological – Solar Radiation

B.5.6.1 Method Description

The LI-COR LI-200SB 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.

B.5.6.2 Equipment Calibration and Frequency

See Section B.5.1.2 for general information. See Figure A.6.4 for calibration frequency.

The solar radiation system is calibrated by referencing the output produced by a NIST-traceable standard. The solar radiation calibration results are recorded on the Solar Radiation Data Form (see Figure B.5.14). Both average values and peak values are compared. Ideally, a complete daily cycle of data is obtained, but this varies with weather conditions.

B.5.7 Meteorological – Surface Wetness Sensor

B.5.7.1 Method Description

The CASTNet sites are equipped with a R.M. 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.

B.5.7.2 Equipment Calibration and Frequency

See Section B.5.1.2 for general information. See Figure A.6.4 for calibration frequency.

The surface wetness sensor is calibrated by checking the signal output under dry conditions (nominally 0.00 V), and then misting the sensor and checking output under wet conditions (nominally 1.00 V). To ensure network uniformity, the wetness sensors are set to switch on at 235 kΩ and off at 245 kΩ. The set point is adjusted using a decade box as a reference.

B.5.8 Nephelometers

B.5.8.1 Method Description

The procedures listed below were followed by MACTEC until May 2001. Responsibility for the visibility network was transferred to IMPROVE at that time with the exception of the BVL130, IL site, which operated both CASTNet and IMPROVE sampling systems through 2001.

The Optec NGN-2 ambient nephelometer was used at the CASTNet visibility sites to measure the scattering component (b_{scat}) of total light extinction. The Optec NGN-2 was used to overcome to the sampling deficiencies of previous nephelometer designs by providing a method that continuously and accurately measured the scattering coefficient of ambient air. The NGN-2 features low-power operation, a rugged compact design, and digital electronics that ensure stable, linear performance over a wide range of environmental conditions. The optical chamber features a large door that opens a complete side of the chamber to unrestricted ambient airflow to minimize bias of the temperature, relative humidity, aerosols, and gases of the sample. The nephelometer monitoring systems included the following instrumentation:

- An Optec NGN-2 ambient nephelometer,

- A power supply,
- A serial data interface,
- A 3-m Rohn tower,
- A precipitation/solar radiation shield, and
- Power and signal cables.

The nephelometer specifications are shown in Table B.5.9.

B.5.8.2 Equipment Testing, Inspection and Maintenance

See Table B.5.10.

B.5.8.3 Equipment Calibration and Frequency

Nephelometer calibration required periodic recording of instrument zero (clean-air) and span (span gas of known scattering) and the integration of these measured values into the calculation of b_{scat} from instrument raw readings. Span gas calibrations were conducted biweekly with SUVA 134a, a refrigerant gas. Figure B.5.15 shows an example of nephelometer calibration documentation.

B.5.8.4 Data Quality Indicators

The relative error (uncertainty) in scattering due to drift of the slope of the calibration line was evaluated based on the instrument-specific manual zero and span checks that were performed. Nephelometer precision data were reported in quarterly and annual reports. The following analysis was applied to calculate uncertainty:

$V(t)$ = normalized nephelometer reading at time t,
$V_o(t)$ = normalized clean air reading at time t,
$V_s(t)$ = normalized SUVA 134a reading at time t,
$b_{scat,o}$ = b_{scat} scattering coefficient for clean air,
$b_{scat,s}$ = b_{scat} scattering coefficient for SUVA 134a,
V_o = average normalized clean air reading,
$b_{scat}(t)$ = scattering coefficient at time t, and
m = slope of the calibration line used to calculate the scattering coefficient $b_{scat}(t)$,
$m(t)$ = slope of the calibration line at time t.

$$m = \frac{\left(b_{scat,s} - b_{scat,o}\right)}{\left(V_s(t) - V_o\right)} \tag{3}$$

Given a normalized nephelometer reading $V(t)$, the theoretical b_{scat} at time t is:

$$b_{scat}(t) = b_{scat,o} + m(V(t) - V_o(t)) \tag{4}$$

assuming that $V_o(t)$ and $V(t)$ are known without error.

The slope of the calibration line is not constant as defined above, but changes (drifts) with time.

The actual slope of the calibration line at time t is:

$$m(t) = (b_{scat,s} - b_{scat,o}) / (V_s(t) - V_o(t)) \quad (5)$$

The actual b_{scat} (denoted b'_{scat}), given a nephelometer reading *V(t),* is:

$$b'_{scat}(t) = b_{scat,o} + m(t) \quad (V(t) - V_o(t)) \quad (6)$$

The relative error between the theoretical b_{scat} and actual b'_{scat}), is:

$$= ((m - m(t))(V(t) - V_o(t))) / (b_{scat,o} + m(V(t) - V_o(t))) \quad (7)$$

The magnitude of the relative error is:

$$= \left| (m - m(t)) / (b_{scat,o} / (V(t) - V_o(t)) + m \right| \quad (8)$$

The magnitude of the relative error is bounded by the slopes such that:

$$\left| \ relative\ e \ \right| \le \left| \ (m - m(t)) / m \ \right| \quad (9)$$

Assuming that the calculated slopes, *m(t)*, of the calibration lines are normally distributed about the average slope *m* with a standard deviation *s*, then for a probability (confidence level) of 95 percent:

$$\left| m - m(t) \right| \le 2s \quad (10)$$

so that:

$$\left| (b_{scat}(t) - b'_{scat}(t)) / b_{scat}(t) \right| \le \left| \ 2s / m \ \right| \quad (11)$$

Assuming that *s* is estimated by s_m with *k* degrees of freedom, based on *k*+1 sample values of *m(t)*, and using the two-tailed *t* distribution, the relative error at a 95 percent confidence level (which for a two-tailed *t* distribution is read from the 97.5 column of the *t* table) is:

$$\left| \ relative\ e \ \right| \le t_{k,0.025} * s_m / m \quad (12)$$

B.5.8.5 Record Keeping

Site operator activities were documented on the Nephelometer Operator Log Sheet (Figure B.5.15). The originals were sent to ARS and stored.

B.5.9 Dry Deposition Filter Pack and Flow

B.5.9.1 Method Description

Ambient measurements of SO_2, SO_4^{2-}, NO_3^-, HNO_3, NH_4^+, Cl^-, Na^+, K^+, Mg^{2+}, and Ca^{2+} required for dry deposition calculations, are performed at each CASTNet site. Atmospheric sampling for sulfur and nitrogen species is integrated over weekly collection periods using a three-stage filter pack (Figure B.3.1). See Section A.6.2.

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.

The only deviation from protocol involves the Egbert, Ontario site (EGB181, ON) in Canada. The Egbert site is the only CASTNet site that collects a composite sample (weekly filter pack), and day/night samples on a weekly schedule. The composite sample is the standard three-stage filter pack used at all the other CASTNet sites. The purpose of the day/night sampling is to facilitate comparison of data to CAPMoN. This site is not supplied with a quarterly field blank. The 12-hour day/night filter packs are prepared, shipped, received, and unpacked following the same procedures described previously. The sample labeling format (discussed in Section B.3.4.1) is:

CDCxx-y*1	Composite -weekly filter pack
CDDxx-y*1	Day sample filter pack
CDNxx-y*1	Night sample filter pack

where: xx = year (last two digits)
y = week number (1-52)

The composite sample analytical results are submitted to the DMC for calculation of atmospheric concentrations, as are the analytical results for the day and night filter packs. All analytical results (reported as total µg) are stored in the CLASS™ system. The data are archived in CLASS™ and at the DMC.

B.5.9.2 Equipment Calibration and Frequency

The filter pack flow controllers are calibrated by comparing the flow controller output with that of a NIST-traceable transfer standard. Five calibration points are used, ranging from approximately 1.0 to 3.0 Lpm for eastern sites and 2.0 to 4.0 Lpm for western sites.

B.5.9.3 Quality Control

The field operations staff reviews filter pack flow data from each site daily. The MFC is calibrated semiannually (Figure A.6.4) using a mass flow meter or dry piston meter (Table B.5.5). Because flow is so important in determining filter concentrations, the calibration acceptance criterion is two percent (Table B.5.5). In other words, the MFC is adjusted if the calibration results are outside the two percent tolerance. Figures B.5.16 and B.5.17 provide examples of completed Flow Pre-Calibration Data and Flow Calibration Data Forms. The latter is used only if the flow controller requires adjustment. The DQI for flow is five percent (Table A.7.2).

MACTEC scientists, as part of the Level II validation process (Section D), review the filter concentrations. In particular, the concentrations are reviewed for consistency among analytes from the three filters 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.

B.5.10 Visibility Aerosol Filter Pack and Flow

B.5.10.1 Method Description

The procedures listed below were followed by MACTEC until May 2001. Responsibility for the visibility network was transferred to IMPROVE at that time.

The CASTNet aerosol sampling system included three independent sample trains, each regulated by a MFC, at flow rates of 10.0, 16.7, and 10.0 Lpm. Samples were acquired from a weatherproof enclosure at 10 m above ground level. The sampler for aerosol SO_4^{2-} and NO_3^- included a 2.5 µm cyclone followed by a single base impregnated annular denuder tube, followed by a single-stage nylon filter pack. The trace/crustal elements and carbon samplers included a 2.5 µm cyclone followed by a single-stage filter pack. Trace/crustal element samples were collected on Teflo® filters, while carbon samples were collected on precombusted quartz fiber filters. Figure B.3.3 illustrates the aerosol sampling system. Advantages of this aerosol system included the following:

1. The 10-m sampling height provided some protection from surface activity and near-surface concentration gradients;
2. The MFC and logging of flows (as hourly averages) permitted accurate determination of sample volumes;
3. Independent flow systems protected each channel from problems associated with other channels; and
4. The overall system had the flexibility to meet a variety of monitoring requirements.

B.5.10.2 Equipment Calibration and Frequency

The visibility denuder/nylon and quartz MFC were calibrated using five calibration points, ranging from 9.0 to 11.0 Lpm. The Teflo® MFC was calibrated using five calibration points, ranging from 15.0 to 17.5 Lpm. Standard conditions for calibration of MFC were 760 mm Hg and 25°C.

B.5.11 Wet Deposition

B.5.11.1 Method Description

The procedures listed below were followed by MACTEC through 1998. NADP/NTN assumed responsibility for wet deposition measurements in 1999.

Wet deposition samples were collected in pre-cleaned polyethylene buckets. The site operator placed the bucket on the sampler on Tuesday and removed it, whether or not rainfall had occurred, the following Tuesday. Prior to 1996, the buckets were weighed in the field, sealed with a bucket lid, and then shipped to the CASTNet laboratory in Gainesville, FL where the buckets were reweighed prior to processing the samples. From 1996 until the transfer to NADP/NTN, after the samples were weighed, they were decanted into a 1-liter (L) bottle before shipment to the CASTNet laboratory. Wet deposition samples were collected using either an Aerochem Metrics or Andersen

wet/dry collection system. All wet/dry collectors were upgraded to the Aerochem Metrics system before transferring the collection responsibility to NADP/NTN.

Currently, the site operators at the CASTNet sites with wet deposition sample collection act under the direction and protocol of the NADP/NTN. In additional to collecting, weighing, and bottling wet deposition samples, site operators test each sample for pH and conductivity prior to sealing the bottles for shipment to the NADP/NTN laboratory. Precipitation amount (depth) is also monitored at wet deposition sites and recorded by the Belfort rain gauge. Samples from the CASTNet wet deposition sites are analyzed and reported by NADP/NTN.

B.5.11.2 Equipment Calibration and Frequency

The wet/dry collector is tested by checking the operation of both the event marker and the lid assembly when the precipitation sensor attached to the collector is wet. The lid liners on the wet and dry buckets are checked for their condition and a secure fit. The precipitation sensor heater is also checked.

B.5.12 Data Acquisition

B.5.12.1 Method Description

All of the continuous measurements described in the previous sections, with the exception of the Belfort rain gauge and wet deposition samples, are recorded by the ESC 8816 or Odessa DSM-3260, the primary DAS, and also by a DSM-3260L, the backup DAS. 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 12-bit analog to digital converter, with a resolution of 0.00024 V over an input range of 0 to 1 V.

Table B.5.11 describes the Odessa 3260 DAS resolution by channel based on the instrument range over the 0 to 1 V range.

Each instrument's analog voltage output is stored as an hourly average in the on-site DAS random access memory (RAM). ENVICOM, the Odessa data management software, is used to retrieve the analog voltages stored in RAM, convert the analog voltages into engineering units, and store the engineering units in binary monthly data files. Each hourly data point is accompanied by a data status flag. These flags are stored in binary status files. Each CASTNet site is polled daily between 0200 and 0500 hours local standard time to retrieve hourly averages and status files for up to the previous seven days. O_3, meteorological, and flow data are reviewed daily by field operations personnel as part of the data validation process (Section D).

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.5.12.2 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 B.5.18 is an example of a completed DAS Calibration Form.

B.5.12.3 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.

B.5.13 Equipment Calibration and Certification Laboratory

MACTEC maintains an equipment 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.

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 MACTEC 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 equipment laboratory. Table B.5.12 summarizes the procedures and frequency of the primary standard certifications.

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B.6 Laboratory Analytical Methods

The proprietary SOP in the CASTNet Laboratory SOP (Appendix 4) and Sunset Laboratory and Chester LabNet SOP (Appendix 5 of the CASTNet QAPP, Revision 1.0, January 2003) describe the analytical procedures used for CASTNet. Table B.6.1 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 factory-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. The manufacturer service contracts or agreements cover the major instrumentation in the laboratory.

Prior to the transfers of wet deposition monitoring to NADP/NTN in 1999 and the visibility network to IMPROVE in 2001, the laboratory operations for CASTNet included 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^+, K^+, and pH;
   - Nylon filter extracts and QC samples for SO_4^{2-} and NO_3^-;
   - Whatman filter extracts and QC samples for SO_4^{2-} and NO_3^-;
   - Wet deposition samples and QC samples for SO_4^{2-}, NO_3^-, NO_2^-, Cl^-, NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, K^+, pH, conductivity, and acidity;
   - Quartz filter punches and QC samples for elemental, organic, and total carbon; and
   - Teflo® filter samples and QC samples for trace elements and gravimetry.
6. Data validation and storage; and
7. Reports for project management and EPA.

These tasks are summarized in Figure B.6.1 for filter packs. Prior to the transfer of the visibility network to IMPROVE in May 2001 and of the wet deposition sampling and analysis to NADP/NTN in 1999, the CASTNet laboratory completed the tasks summarized in Figures B.6.2 and B.6.3.

B.6.1 Method – IC

B.6.1.1 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 eluant 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 or peak height.

The inorganic anions that may be analyzed by this method and their reporting limits are as follows:

Anion	Reporting Limit
Chloride (Cl^-)	0.020 mg/L
Sulfate (SO_4^{2-})	0.040 mg/L
Nitrite (NO_2^-)	0.010 mg-N/L
Nitrate (NO_3^-)	0.008 mg-N/L

B.6.1.2 Method Performance

Method performance data, such as precision and accuracy statistics, are documented in the quarterly and annual reports provided to EPA. The assessment of instrument precision and accuracy is summarized in Section B.6.1.6.

B.6.1.3 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 at all times to ensure continuous operation.

B.6.1.4 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 A.7.3.

B.6.1.5 Analytical QC

The following laboratory method subsections summarize the routine QC procedures that are implemented in order to meet the DQI of the CASTNet program. Laboratory precision is estimated via analysis of replicate samples. Analytical accuracy is determined by the analysis of reference and CVS that are traceable to NIST.

B.6.1.6 QC Checks

1. 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 ≥ 0.995, and the Y-intercept 95 percent confidence limit must be less than the limit of quantitation.
2. One method blank extraction solution is used for filters. Prior to the transfer of wet deposition sampling and analysis to the NADP/NTN, DI water was used for wet deposition samples.

3. One mid-level CVS (independent stock) is analyzed every 10 environmental samples. The response must be within 5 percent of the certified target value.
4. A reference standard that is NIST-traceable is analyzed at the beginning and end of a run to assess accuracy.
5. Approximately 5 percent of filter pack and wet deposition samples from each batch are analyzed in duplicate to monitor within-run precision. Samples are selected at random.
6. An internal standard (rubidium bromide) is used in IC analyses to assess shifts in retention time and sample injection volume.
7. All sample responses are within the standard calibration range. Samples with responses above the calibration curve high standard are diluted and reanalyzed.

Tables B.6.2 and B.5.4 summarize the QC procedures and associated corrective actions.

Laboratory precision is estimated through the analysis of the replicate samples. About 5 percent of the IC samples from each batch are reanalyzed. Differences between the original and replicate concentrations are calculated. MARPD statistics (Equation 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 A.7.3. These goals apply to both the replicate analysis and the analysis of the collocated concentrations.

Laboratory accuracy (Table A.7.3) is determined by the analysis of reference samples and CVS. An independent reference standard that is NIST-traceable is analyzed at the beginning and end of an analytical run. One midlevel CVS, which is also produced by an independent laboratory and is NIST-traceable, is analyzed every ten IC samples. The responses relative to the CVS 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 (Harding ESE, 2001).

B.6.1.7 Record Keeping

All records for analytical analysis are stored in a batch folder. This discussion applies to all of the following analytical methods performed in the CASTNet laboratory. The folder contains documentation that verifies the analytical activities and is stored on-site in the laboratory. The documentation consists of copies of analytical laboratory notebook pages pertaining to the analysis, standards documentation, extraction records, instrument printouts, and the finalized data batch entered into CLASS™. Electronic files of the IC chromatograms are stored in CLASS™ as additional backup.

B.6.2 Method – TRAACS®

B.6.2.1 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 ethylenediamine-tetraacetic 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.

B.6.2.2 Method Performance

Method performance data, such as precision and accuracy statistics, are documented in the quarterly and annual reports provided to EPA. The discussion of instrument precision and accuracy, which is summarized in Section B.6.1.6 for IC, applies also to the TRAACS® and the other methods that are discussed in subsequent sections.

B.6.2.3 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.

B.6.2.4 Instrument Calibration

The TRAACS® Autoanalyzer™ for NH_4^+ 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_4^+ is presented in Table A.7.3.

B.6.2.5 QC Checks

1. 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 ≥ 0.995, and the Y-intercept 95 percent confidence limit must be less than the limit of quantitation.
2. One method blank extraction solution is used for filters. Prior to the transfer of wet deposition sampling and analysis to the NADP/NTN, DI water is used for wet deposition samples.
3. One mid-level CVS (independent stock) is analyzed every 10 environmental samples. The response must be within 10 percent of certified target value.
4. A reference standard that is NIST-traceable is analyzed at the beginning and end of a run to assess accuracy.
5. Approximately 5 percent of samples from each batch are analyzed in duplicate to monitor within-run precision. Samples are selected at random.

6. All sample responses must be within the standard calibration range. Samples with responses above the calibration curve high standard are diluted and reanalyzed.

Tables B.5.4 and B.6.2 summarize QC procedures and associated corrective actions.

B.6.3 Method – pH in Water

This procedure was followed until January 1999 when all wet deposition monitoring activities, including sample analysis, were transferred to NADP/NTN.

B.6.3.1 Method Description

This method was used to determine the pH of wet deposition samples through electrometric measurement with a combination pH electrode. To help speed electrode response, all samples are agitated slightly and then allowed to rest before taking a pH reading.

B.6.3.2 Instrument Testing, Inspection, and Maintenance

Preventive maintenance for the pH meter and electrode primarily involved the proper care of the electrode. Electrodes were stored in a 1:1 solution of pH 7 buffer and DI water. The access hole for addition of internal filling solution was plugged when the electrode was not in use to prevent solution evaporation. If the internal filling solution had dried out, the chamber was rinsed with DI water before replacement of the solution. This step prevented clogging of the probe and poor (< 100 %) slope adjustments when calibrating the electrode. Whenever slope readings exceeded the range of 95 percent to 102 percent, or a low ionic strength sample gave erroneous readings, the electrode was treated with l normal potassium hydroxide (KOH) and one normal hydrochloric acid (HCl) according to the manufacturer's procedures. If this failed to bring the slope within range, the electrode was replaced.

B.6.3.3 Instrument Calibration

The primary instruments used by MACTEC for determination of pH of wet deposition samples with electrometric measurement were the pH meter and the autotitrator for acidity. Calibration of these instruments is described in the following subsections.

B.6.3.3.1 pH Meter

The pH meter was calibrated by electronically adjusting the meter response to correspond to the values of two NIST-traceable buffer solutions (nominal pH values 4.0 and 7.0). The calibration was verified by analysis of a reference sample (traceable to NIST). Because temperature is an important variable to consider in pH measurement, samples and solutions were equilibrated to room temperature, and temperature compensation (to 25°) was applied. Calibration data were recorded in the pH laboratory notebook.

B.6.3.3.2 Autotitrator

The pH electrode used in conjunction with an autotitrator was calibrated by electronically adjusting the instrument response to two NIST-traceable buffer solutions of pH 7.0 and 10.0. The calibration was verified by analysis of known concentrations of low ionic strength solution. All standards and samples were equilibrated to room temperature.

B.6.3.4 QC Checks

During the entire measurement process, care was taken to prevent any sample contamination. The electrode was dedicated for use with wet deposition samples only. QC checks were conducted for both pH and acidity measurements and are described in the following subsections.

B.6.3.4.1 pH

1. Two standards (commercially available, color-coded, NIST-traceable buffer solutions) were used that bracketed the sample range;
2. A reference standard that was NIST-traceable was analyzed at the beginning and end of a run to assess accuracy;
3. One NIST-traceable low ionic strength reference was analyzed every 10 samples; and
4. Within-run replicates were analyzed when sample volume dictated.

B.6.3.4.2 Acidity

1. Titrant was standardized;
2. pH meter was calibrated with pH 7.0 and 10.0 standards (commercially available, color-coded, NIST-traceable buffer solutions);
3. One method blank was analyzed;
4. One CVS was analyzed before and after every 10 samples and at the end of a run; and
5. Within-run replicates were analyzed when sample volume dictated.

See Tables B.5.4 and B.6.2 for QC procedures and associated corrective actions.

B.6.4 Method – Conductance

This procedure was followed until January 1999 when all wet deposition monitoring activities, including sample analysis, were transferred to NADP/NTN.

B.6.4.1 Method Description

This method was used to measure specific conductivity in wet deposition samples. Conductivity is a function of the activity (concentration) of ions in solution and the temperature of the solution. This method was an electrometric measurement that was corrected for temperature and the conductivity cell constant in a single step. Specific conductivity serves as an indicator of the ionic strength of the sample.

B.6.4.2 Instrument Testing, Inspection, and Maintenance

Preventive maintenance for the conductivity bridge required keeping the rechargeable battery fully charged. Care for the conductivity cell involved storing it in DI water. Replatinization of the conductivity cell was performed [according to the publication Standard Methods for the Examination of Water and Wastewater (Greenberg *et al*., 1992)] only when the cell response became erratic, a sharp endpoint could not be obtained, or inspection showed that any of the platinum black had flaked off.

B.6.4.3 Instrument Calibration

The conductivity meter was calibrated by determination of an appropriate correction factor for the conductivity cell using two conductivity standards (nominally 30 and 75 µmho/cm). Because temperature is an important variable in this measurement, standard solutions and samples were equilibrated to room temperature prior to calibration and measurement. The meter correction factor was then applied to the meter response for each sample. The calibration information was recorded in the conductivity laboratory notebook.

B.6.4.4 QC Checks

1. A NIST-traceable reference standard was analyzed at the beginning and end of a run to assess accuracy;
2. One CVS was analyzed before and after every 10 samples and at the end of a run;
3. One method blank was analyzed; and
4. Within-run replicates were analyzed when sample volume dictated.

See Tables B.5.4 and B.6.2 for QC procedures and associated corrective actions.

B.6.5 Method – ICP-AES

B.6.5.1 Method Description

This method measures element-emitted light by optical spectrometry. Samples are nebulized 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 may be analyzed by this method and their reporting limits are as follows:

Cation	Reporting Limit
Calcium (Ca^{2+})	0.003 mg/L
Magnesium (Mg^{2+})	0.003 mg/L
Potassium (K^{+})	0.005 mg/L
Sodium (Na^{+})	0.005 mg/L

B.6.5.2 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.

B.6.5.3 Instrument Calibration

The procedure for ICP-AES 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.

B.6.5.4 QC Checks

1. A 4-point calibration curve is generated;
2. The first standard is 2 to 3 times the reporting limit depending on analyte (10 ppb);
3. A NIST-traceable reference standard is analyzed at the beginning and end of a run to assess accuracy;
4. A CVS is analyzed after every 10 environmental samples and at the end of the run to track instrument drift; and
5. Replicates of environmental samples are analyzed to assess within-run precision using a relative standard deviation (RSD) criterion.

See Tables B.6.2 and B.5.4 for a listing of QC procedures and associated corrective actions.

B.6.6 Method – XRF

This procedure was followed by Chester for analysis of the Teflo® filters until May 2001 when all visibility monitoring activities, including analysis, were transferred to IMPROVE.

XRF is a nondestructive method for the elemental analysis of solids and liquids.

B.6.6.1 Method Description

The sample was irradiated by an intense x-ray beam, which caused the emission of fluorescent x-rays. The emitted x-rays were detected using an energy dispersive detector. The energies of the emitted x-rays were used to identify the elements present in the sample, while the concentrations of the elements were determined by the intensity of the x-rays through a direct comparison with standards. The elements commonly detected ranges from sodium to uranium.

B.6.6.2 Instrument Testing, Inspection, and Maintenance

Preventive maintenance for the XRF was performed under warranty by the manufacturer on an as-needed basis.

B.6.6.3 Instrument Calibration

The Chester XRF instruments were initially calibrated with commercial, single-element, thin-film, vapor-deposited standards (from MicroMatter, Inc.) and with multi-element, solution-deposited standards (from Columbia Scientific Industries). Weekly calibration verification was accomplished through the analysis of NIST thin-film standards SRM 1832 and SRM 1833 for eleven representative elements. The instrument was recalibrated if accuracy criteria were not met. In addition, ongoing calibration was checked every 1 in 10 samples by the analysis of six elements on a QC standard filter. If accuracy criteria for ongoing calibration were not met, the batch of samples was reanalyzed.

B.6.6.4 QC Checks

1. Initial system calibration with a complete set of elemental standards obtained from commercial sources;
2. Weekly calibration verification by analysis of NIST thin-film standards for eleven representative elements. Calibration results were required to be within NIST-specified, element-dependent accuracy criteria;
3. Ongoing calibration checks performed for 1 in every 10 samples. Calibration range was required to be within 95 percent to 105 percent recovery of the target value;
4. Sample duplicate analysis performed for 1 in every 10 samples. Results were required to be within a RPD of 5 percent;
5. Excitation condition check performed every sample for several elements. Results were required to be within analysis uncertainty or sample was reanalyzed; and
6. Blank analysis performed at a rate of one per batch. Sample results were blank corrected.

B.6.6.5 Record Keeping

Analytical records and documentation are maintained by Chester. MACTEC received an electronic dBASE® file of the data in addition to a hard copy report. The dBASE® file was downloaded into CLASS™.

B.6.7 Method – Gravimetric

This procedure was followed by Chester for analysis of the Teflo® filters until May 2001 when all visibility monitoring activities, including analysis, were transferred to IMPROVE.

B.6.7.1 Method Description

Filters were tare weighted using a calibrated balance and ASTM standard weights

B.6.7.2 Instrument Testing, Inspection, and Maintenance

The microbalance was cleaned on a daily basis. Annual calibrations were performed by an independent, certified calibration and maintenance service.

B.6.7.3 Instrument Calibration

At the start of each analytical session, the microbalance was zeroed and then calibrated using a 200-milligram (mg) Class S NIST-traceable calibration weight. If the difference between the observed and expected weight exceeded 0.003 mg, the balance was recalibrated. The calibration was verified by weighing a 100.0 mg weight immediately after the calibration weight. The NIST-traceable weight was weighed after every 10 samples and at the end of the session. If the 0.003 mg criterion was exceeded, the microbalance was recalibrated and the previous 10 samples reweighed.

B.6.7.4 QC Checks

1. Calibration of the balance with Class S standard (200.0 mg) at the start of analysis and after every 10 samples;
2. Calibration verification immediately after initial calibration with 100.0 mg weight;
3. Daily reweighing of a laboratory blank filter for a temperature and humidity check;
4. Zero check after every 10 samples. Value was required to be within 0.003 mg, or balance was recalibrated;

5. Reweigh of 10 percent of all tare and gross-weighed filters after equilibration for an additional 24 hours; and
6. Comparison of normal calibration standards with a second set of reference standard masses at least semiannually.

B.6.7.5 Record Keeping

Analytical records and documentation are maintained by Chester. MACTEC received an electronic dBASE® file of the data in addition to a hard copy report. The dBASE® file was downloaded into CLASS™.

B.6.8 Method – TOA

This procedure was followed by Sunset for the analysis of the quartz filters until May 2001 when all visibility monitoring activities, including analysis, were transferred to IMPROVE.

In the TOA of carbonaceous aerosols, speciation of OC and EC was accomplished through temperature and atmosphere control, and by continuous monitoring of filter transmittance.

B.6.8.1 Method Description

A precision tool was used to punch out a section from the filter sample. The section (punch) was then placed in a quartz oven and the OC and EC components of the particles were measured by a TOA technique. TOA proceeds essentially in two stages. In the first, organic and carbonate (if present) carbon are evolved in a helium atmosphere as the oven temperature is raised. The evolved carbon is catalytically oxidized to carbon dioxide (CO_2), and then reduced to methane (CH_4). A flame ionization detector (FID) quantifies the CH_4. In the second stage, the sample oven temperature is reduced, an oxygen-helium mix is introduced, and the temperature is raised. As oxygen enters the oven, pyrolytically-generated carbon is oxidized and a concurrent increase in filter transmittance occurs. The point at which the filter transmittance reaches its initial value is defined as the "split" between OC and EC. Carbon evolved prior to the split is considered OC (including carbonate), and carbon volatilized after the split is considered EC.

B.6.8.2 Instrument Testing, Inspection, and Maintenance

Procedures included daily cleaning of all surfaces, cleaning of punching tools and forceps between each sample, daily check of compressed gas supplies, and daily backup of data files.

B.6.8.3 Instrument Calibration

The TOA system was calibrated biweekly by analyzing known amounts of external standards and instrument blanks. The range typically covered was 10 to 150 µg of carbon, which covered the range of most environmental samples. Responses were required to be with 5 percent of expected (in-house) criteria. Each sample also incorporated an internal quantitating standard of a known amount of CH_4 in a fixed calibration loop. This provided a means for calculating the amount of each carbon species and served as a good indicator of instrument operation for QC purposes. Instrument blanks were analyzed daily to ensure cleanliness, freedom of bias, and proper operation. Replicates were analyzed for approximately 5 percent of all samples. Nationally accepted primary standards for EC and/or OC were not available.

B.6.8.4 QC Checks

1. Biweekly instrument calibration curve and linearity checks were performed by analysis of sucrose-spiked external standards;
2. Injections of known amounts of CH_4 in a fixed calibration loop for each sample aided in determination of system leaks, flame-out, flow problems, and methanator-catalyst deterioration;
3. Analysis of continuous run of several samples on intervals of 3 to 4 was performed weekly to provide a continuous record of instrument response to TC and the OC/EC split. Responses were required to be 10 percent for either species;
4. Daily instrument blanks were analyzed (concentration was required to be below 0.2 µg carbon); and
5. Replicate analyses of approximately 5 percent of all samples were performed in-house (precision was required to be 5 percent).

B.6.8.5 Record Keeping

Analytical records and documentation are maintained by Sunset Laboratory. MACTEC received an electronic file of the data in addition to a hard copy QC report. The electronic data file was printed and entered into CLASS™. A batch folder contains the original data and the print out of the finalized CLASS™ data batch. The batch folder is stored on-site in the laboratory.

B.7 Data Operations

This section summarizes the overall system used for data management on this project. The MACTEC DMC is the repository for CASTNet data, including raw data that have been collected but not validated, and data that have been validated using various validation schemes (e.g., Level I and Level II). The MACTEC DMC also provides the hardware, CASTNet Data Management System software, data security, and the computer programming necessary to manage, maintain, and deliver the CASTNet data. The CASTNet DMC uses a client-server, SQL database management system for maintaining the CASTNet data. This system provides a robust environment for handling the data and an option for future expansion. The following subsections detail the database management system used for CASTNet; 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 D.

The flows of data for the dry and wet deposition and visibility sites are shown in Figures B.7.1 and B.7.2, respectively. MACTEC performs the following data management tasks for MACTEC operated CASTNet sites:

1. Organizes and controls data flow from field sites and the respective analytical laboratories to the DMC;
2. Inputs and validates data;
3. Manages and archives the CASTNet database;
4. Analyzes, evaluates, and models the CASTNet data; and
5. Regularly submits data to EPA.

B.7.1 Field Data Management

Field data, or continuous data, are handled by the DMC. The data acquisition process stresses multiple levels of redundancy to minimize data loss. The primary mode of data acquisition from the field is via telephone modem.

The sites are automatically polled daily using an IBM-compatible personal computer (PC) 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. The polling software enables recovery of hourly data and status files, power failure logs, and automated calibration results from the previous seven days. The program also maintains synchronization of the network by checking the clock within each DAS and correcting the time if it deviates from expectation by more than three minutes. If daily polling results in incomplete data capture from any site, then diskettes of data from the primary and backup DAS are read into the database management system. If data are still incomplete, the missing data are entered manually either from SPO or recovered from data cartridges. The source of each datum is documented. Data that are manually entered into the system are validated for accuracy through double entry.

B.7.1.1 Data Acquisition and Storage

The flow of field data for MACTEC operated CASTNet sites from acquisition to delivery is outlined in this section. The sequence of data management events is as follows:

1. Data acquisition and recording on-site:
   - Field measurements from each instrument are electronically recorded by the DAS and stored on the electronically-erasable, programmable, read-only memory (EEPROM) cartridge of the DAS at each site.
   - Data status, consisting of a status code for each datum produced, is generated and recorded by the DAS.
   - The DAS produces a daily hard copy listing of hourly data, along with status flags indicating data validity, using a dedicated printer located on-site.
   - 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. Transmission of data to DMC – three methods of data transfer are used:
   - Data and data status codes/flags from the DAS are transmitted via modem over commercial telephone lines to the polling computer. These files are then migrated to a network server in the MACTEC Gainesville, FL office where they are stored as raw data files.
   - Monthly, the site operator downloads the data and status flags from the primary DAS EEPROM cartridge to a diskette. Once on diskette, the file containing the data and the data flags are copied to a second diskette, which is retained on-site. The same steps are repeated for the backup DAS. The original diskettes for the primary and backup DAS are mailed to the DMC.
   - Hard copy SPO, SSRF, and Site Narrative Log Sheets are mailed to the DMC weekly.
3. Raw data, collected as a result of Steps 1 and 2 above, are processed through Level I and II validation and maintained in the CASTNet database.
4. Final data are delivered to the EPA Project Officer as described in Table A.6.4.

Figure B.7.3 depicts the data traceability of a datum for a continuously recorded parameter. It also shows the locations and project personnel involved.

B.7.1.2 Field Data Processing Equipment

Each MACTEC operated CASTNet site has an Odessa DSM-3260 or ESC 8816 primary DAS and an Odessa DSM-3260L backup DAS. Every site transmits data to the DMC via modem over commercial telephone lines.

These data are retrieved and processed using a custom version of Odessa's Environmental Aide software or ESC's custom communications and data transmittal software, E-DAS Ambient ATX, for those sites using ESC data loggers. The Environmental Aide system consists of two programs, ENVICOM and ENVAID, which reside on a LAN in the DMC. ENVICOM is a communications and data transmittal package that polls each site daily and incorporates the previous day's hourly averages into the raw database. Data retrieved through ENVICOM are entered directly into the raw database and stored in binary data and status files. The binary data are imported into MS SQL Server™ using custom software written in MS Visual Basic™ Version 6. The ENVAID software is no longer used.

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.7.1.3 Preventative Maintenance Procedures

Each site operator verifies the operation of the DAS during the weekly site visit. The CASTNet FOM or field coordinator monitors 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.

B.7.2 Laboratory Data Management

All data for the CASTNet Gainesville, FL analytical laboratories are managed by the CLASS™ System. CLASS™ is an automated, interactive PC-based Laboratory Information Management System, designed and developed by MACTEC's Laboratory Information Specialist (LIS) staff. CLASS™, which integrates information from sample collection and laboratory analyses, tracks, calculates, checks, stores, and reports data in a variety of formats. QC requirements specific for each type of EPA, or other analytical method, are built into the system and are automatically checked with every analytical data batch. Incorporated into the system is the ability to combine field data; analytical results from all laboratory analyses, and QC data to produce project specific reports, statistical analyses, plots, and electronic export files. The CLASS™ program is illustrated in Figure B.7.4. CLASS™ resides on a Microsoft® network that is connected to more than 20 computers throughout the laboratories and offices.

B.7.2.1 Data Acquisition and Storage

The CLASS™ database is stored, managed, and retrieved using a database manager, Advanced Revelation© from COSMOS, Inc. The file structure and indexing allow easy storage, retrieval, grouping, and formatting of data. MACTEC has written software to interface its laboratory instruments (e.g., ICP-AES and IC) with CLASS™, so data generated by these instruments are automatically merged into the database.

CLASS™ efficiently manages the flow of samples and data through the laboratory. A barcode system is used to aid in the tracking of samples through sample receipt, sample storage, and laboratory analysis. Sample labels include a barcode for the laboratory sample number, so the location of a sample can be monitored at each step of processing.

CLASS™ uses a combination of EPA storage and retrieval (STORET) numbers and instrument method codes to designate parameters required for analysis. Each STORET method combination has its own laboratory QC requirements, specific to that analytical method, programmed into the computer. These requirements include both extraction and analytical holding times, types of QC required, percent recovery limits for spikes, and appropriate significant figures and decimal places. Daily reports show the samples available for every analysis, along with the remaining days the sample can be held prior to analysis. On the report, the samples are sorted so that the ones with the shortest holding time left are at the top of the list.

The processing of each laboratory batch includes several steps. The instrument calibration curve data are tested to determine if they are within the acceptable range specific to the analysis. Information for all required QC samples for that method such as method blanks, control spikes, and replicates are entered, and results are calculated and compared to control limits for that method and analyte. Sample responses are entered into the batch, and final concentrations are calculated for each sample. Responses are checked to ensure that they are bracketed by the standard curve. The final batch report includes a QC checklist showing the QC checks performed by the system and any discrepancies that were flagged for the analyst by the computer. CLASS™ provides both computer and hard copy documentation for analyses to ensure consistently high data quality.

Analysts use CLASS™ to reserve samples for analysis, calculate final concentrations, and interactively check calibration curves and QC results. By allowing the analyst to enter data directly and check QC and sample results, the analyst is notified immediately of QC problems. When the analyst enters the QC and sample data, the batch printouts, including checklists, worksheets, and any other pertinent documentation (such as chromatograms) are placed in a file folder and submitted to the laboratory data assistant.

LIS personnel process the batch to verify QC compliance and to update the sample record and final calculated concentrations. Once a batch has been finalized by the laboratory data assistant, the batch is locked, and data cannot be changed.

If during data review and validation, a change to a finalized (locked) batch is identified as necessary, a Batch Update Form (see Figure B.7.5) must be initiated. The form requires the following documentation:

- Batch number,
- Analysis type,
- Person requesting the change,
- Why a change is necessary, and
- Signature of the analytical group leader or LOM.

The laboratory data assistant “definalizes” the batch and documents the action, change, and reason electronically in the “notes” section of the batch. After the analyst makes the changes, the new batch printout along with the completed update form is turned into the laboratory data assistant for finalizing. 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. The CLASS™ barcode system is used to track the location of every batch folder whether it is checked out by an individual, in a file cabinet, or boxed for storage. A history of batch locations is available for every batch on the CLASS™ tracking menu. Laboratory sample concentration data are then submitted to the DMC for conversion to atmospheric concentrations, data storage, analysis, and reporting to EPA.

B.7.2.2 Laboratory Data Processing Equipment

MACTEC currently uses three commercial data acquisition/reduction programs. All IC operate under PEAKNet® 5.1 licensed from Dionex Corporation. PEAKNet® controls the IC operation, acquires data, and generates a formatted ASCII report for upload into CLASS™. PEAKNet® is also capable of storing analytical curves and generating final results. MACTEC does all IC data reduction in the CLASS™ database. MACTEC uses Automated Analyzer Control and Evaluation (AACE™) software for much the same purposes with TRAACS® 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 CLASS™. Finally, the Perkin-Elmer ICP-AES uses the Perkin-Elmer WINLAB™ software for instrument operation, data acquisition, data reporting, and other ancillary functions. Again, a formatted ASCII file is created for upload into CLASS™.

B.7.2.3 Preventative Maintenance and Backup Procedures

Potential data losses are controlled by a system backup protocol. The CLASS™ data management system is backed up weekly on two CDs. These CDs are placed in locked storage in an Underwriter's Laboratories (UL) listed fire safe on-site at MACTEC. The data are stored in a permanent archive at the end of every month.

B.7.3 CASTNet Data Management Center

B.7.3.1 Database Management System

The CASTNet DMC uses a client-server, SQL database management system for maintaining the CASTNet data. This system provides a robust environment for ensuring data quality, offering controlled user access, and capabilities for future expansion.

B.7.3.1.1 Database Elements

The CASTNet database consists of both hardware and software components. The following items are the major elements that comprise the database management system:

1. Database management software and associated data tables,
2. Client-access software,
3. Modeling software (not strictly an element of the database management system),
4. Server, and
5. Client machines.

B.7.3.1.2 Software Requirements

The software currently used to manage the CASTNet data is MS SQL Server™ Version 7.0. The software was upgraded in the first quarter of 2001 from MS SQL Server™ Version 6.5 to improve performance and to add

additional capabilities to the system. A discussion of the approach used to perform software upgrades is located in Section B.7.3.1.3.

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

1. **Database management software**

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

   - ***castnet*** - The *castnet* database contains all of the primary CASTNet data. This includes site information, data definitions, dry chemistry data, meteorology data, data codes, and O_3 information.
   - ***castnet _application*** - The *castnet _application* database includes tables specifically required for the CDMSA. It includes tables to 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 II validation. The database also includes the equipment inventory table and tables associated with the Field Operations Problem Report.
   - ***castnet _model*** - The *castnet _model* database contains tables that hold hourly, weekly, quarterly, and annual estimates of concentrations, V_d, and fluxes.
   - ***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.
   - ***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.
   - ***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.

Each of these databases contains a number of data tables. The tables associated with each database are listed in Table B.7.1.

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 various data tables stored in the database management software. The software provides mechanisms for validating laboratory and meteorology data, reporting and logging problems reported by field operations personnel, and maintaining and tracking equipment inventories.

   The ability to report and log field problems was added to the CDMSA during the first quarter of 2001. This capability was added to the CDMSA to more effectively tie the field operations to the data validation operations within the CASTNet DMC. Problems noted in the field were being tracked using a stand-alone FoxPro® based system. Since the FoxPro® system was stand-alone, it did not provide a mechanism for the data validators to directly view the problem reports and use that information to

assist them in validating data. With the addition of the Field Problem Report to the CDMSA, the field operations staff can document field problems, recommend whether or not the data should be flagged, and track problems for prompt resolution. When field operations personnel make recommendations on the validity status of the data, these data are then flagged for review by the data validation team. Then, data validation personnel can use the exact data entered in the Field Problem Report and the recommendations from field operations personnel to determine if the data are valid. The new capabilities provide a more robust, traceable, and integrated system for coordinating field operations with the data validation process.

3. **Modeling software (not strictly an element of the database management system)**
   The third software component is the MLM. The MLM calculates V_d and pollutant fluxes using algorithms developed by Meyers *et al*. (1998), coupled with chemistry, meteorology, and site parameter data housed in the CASTNet database. The MLM is written in FORTRAN. MACTEC 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.

B.7.3.1.3 Performing Software Upgrades

Software upgrades are put into place to either:

1. Improve performance,
2. Increase capabilities,
3. Correct bugs found in earlier versions, or
4. For any combination of the above.

Software upgrades generally affect any one of four components:

1. The operating system,
2. The database management system software,
3. The CDMSA, or
4. 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, MACTEC's information technology (IT) staff perform 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 database management system 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:

1. 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 II validation, parallel systems were run. For a period of two months, MACTEC used test tables that mimicked the CASTNet working tables. The data entered using the old MS Access™ based system were compared to the same data entered using the new system. Had differences occurred (there were none), the systems would be reviewed to ascertain what was causing the variability, and the CDMSA would be corrected and modified. Additional testing would be performed before allowing the upgraded CDMSA to be used for CASTNet data.
2. 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 are instituted when the MLM is updated and improved. At that time, model runs are made using both the old and new versions to ascertain where differences occur and whether the differences are the expected results from the model's revision. If the results are unexpected, MACTEC determines the cause of the discrepancy, makes suggestions for improvement, and does not implement the newer version until the discrepancies are fully understood and clarified or fixed. Once the newer version is in place, the data produced from model runs using the older version are archived to CD, with the exception of the values used for the annual report, which are maintained in the *castnet_model_arch* database.

B.7.3.2 Data Processing Equipment

Since the database management system is a client-server system, the main data processing components are the server and the client-access machines. The server holds the data and the database management software. The current server (which is dedicated to the CASTNet Data Management System) has dual 733 megaHertz (MHz) Pentium® III processors, 1 gigabyte (GB) of system memory, and three hard drives totaling 72 GB of data storage. In addition, the new server has a Redundant Array of Independent Disks (RAID) level 5 disk subsystem.

All client-access machines are Pentium® class machines with a minimum of 64 megabytes (MB) of memory and a 4 GB hard drive.

B.7.3.3 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.

B.7.4 Non-Direct Measurements

Site operators record surface conditions (e.g., dew, frost, and snow) and vegetation status weekly to support model calculations of dry deposition. Vegetation status and land-use information are used to define the distribution and condition of plant species around each site that could influence deposition rates for gases and particles. Vegetation data track evolution of the dominant plant canopy, from leaf emergence (or germination) to senescence (or harvesting).

B.7.5 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.

B.7.5.1 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 B.7.3.1.3. 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 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 B.7.3.1.3.

Program code changes to the MLM are validated using test data subsets. Typically, at least one year of data is utilized in testing program code in the MLM. The program code is 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 are anomalous, MACTEC determines what has caused the discrepancy, modifies the code and then re-runs the test data set to determine if the fix has corrected the problem. This iterative approach is used until MACTEC is sure that the model program code is 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.

B.7.5.2 Documentation

Computer program code documentation is an important part of producing a high quality, replicable product. As a consequence, MACTEC 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. Table B.7.1 was prepared by using that table.

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

B.7.5.3 Version Control

MACTEC'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 3.00 to 3.01) or at the hundreds decimal place (e.g., version 2.30 to version 2.31).

B.7.6 Data Security

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

B.7.6.1 Access Control

Access control to the CASTNet database is implemented in two ways. First, general access control is established across MACTEC's network by the MACTEC IT staff. All MACTEC staff must perform a password-protected log on to obtain access to MACTEC's network resources. Additionally, the CASTNet database server is located on a separate sub-network of the main MACTEC network. This means that the CASTNet database server cannot be accessed without first obtaining access to the MACTEC main network and then obtaining rights to access that sub-network.

The second access control is established via the database management system. All users of the CDMSA must have an 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 is limited to only the few people who must be able to modify tables and fields.

B.7.7 Data Backup

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.

Although not strictly a data backup system, a RAID disk subsystem is included in the CASTNet server at MACTEC. A RAID disk subsystem increases performance and/or provides fault tolerance. There are ten levels of RAID (RAID 1 through RAID 10). RAID is a set of two or more hard disks and a specialized disk controller that contains the RAID functionality. RAID improves performance by disk striping, which interleaves bytes or groups of bytes across multiple drives, so more than one disk is reading and writing simultaneously. Fault tolerance is achieved by mirroring or parity. Mirroring is 100 percent duplication of the data on two drives (RAID 1), and parity (RAID 3 and 5) calculates the data in two drives and stores the result on a third drive: a bit from drive 1 is compared with a bit from drive 2, and the result bit is stored on drive 3. If a drive fails, for example drive 1, the result bit on the third drive is no longer correct. A failed drive can be hot swapped with a new one, and the RAID controller automatically rebuilds the lost data based on the data on the remaining drive (drive 2 in this example) and the summed data on the third drive. Thus, implementation of a RAID subsystem improves data security and recoverability. The DMC server utilizes a RAID 5 subsystem, which is the most widely used. In a RAID level 5 system, data are striped across three or more drives for performance, and parity bits are used for fault tolerance. The parity bits from two drives are stored on a third drive.

B.7.8 ARS Data Management Center

The ARS Information Management Center (IMC) manages the continuous data collection activities for all NPS sites in CASTNet. The DAS at each site collects and temporarily stores data from on-site instruments. IMC programs retrieve the data via telephone modem each day and create ASCII files on the IMC network file server. The data are then loaded into an Oracle® database. Data from all sites are transmitted to the MACTEC DMC on a monthly basis.

B.7.8.1 Database Management System

Oracle® is a comprehensive RDBMS operating on a database server that connects to multiple client workstations. The Oracle® database and Oracle® networking programs reside on the database server. Network drivers installed on client workstations access the database. The system also includes database administration utilities.

B.7.8.2 Data Processing Equipment

Each site uses ESC Model 8816 Data Loggers. The ESC Model 8816 is a microprocessor-based DAS designed to acquire, process, store, report, and telemeter data. Every NPS site transmits data to the IMC via modem over commercial telephone lines. The data are stored in an Oracle® database, which resides on two Compaq Prolient® servers that have a total storage capacity of 30 GB.

B.7.8.3 Preventative Maintenance and Backup Procedures

ARS Air Quality Database Management System (AQDBMS) Database Administrator and Programmers' Reference instructs database administrators to backup the system files on a regular basis. Whenever the backup procedure is performed, the database must first be shut down as described in the AQDBMS Reference. The administrator is responsible for ensuring that all database files are included in the list of files to be backed up during the procedure.

Table B.2.1 Site-Specific Siting Criteria for 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	500 m
Secondary road, lightly traveled	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

Table B.2.2 Additional Siting Criteria for Visibility Monitoring

Attribute	Criterion
View	Horizon visibility targets in one or more directions
Target Size	≥ 0.1° of solid angle
Target Conditions	Coniferous forest or uniformly dark background
Target Distance	10 - 25% of standard visual range (25% ideal)
Elevation Angle	≤ 1°
Sight Path	Should not be affected by local pollution sources.

Table B.2.3 Summary of Site Installation and Initiation Activities

Task	Activities
Preinstallation	• Finalize land leases, permits, contracts • Establish electricity/telephone 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 telephone 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 B.3.1 Teflon®, Nylon, and Whatman 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	< 0.08	< 0.13	< 0.13
Nylon	< 1.00	< 0.200	N/A	N/A	N/A	N/A	N/A	N/A
Impregnated Whatman	< 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 B.5.1 Measurement/Methods Matrix (Page 1 of 3)

Measurement	EPA	NPS
Ozone-Analyzer*	• Continuous measurements yielding hourly averages using UV absorbance method, Thermo Environmental 49-103 analyzer on 0-500 ppb range • Sample inlet at 10 m through 5 micron filter at tower inlet and analyzer sample port • Sample tubing 3/8-inch, analyzer pump used for entire sample draw	• Continuous measurements yielding hourly averages using UV absorbance and chemluminescence method. Analyzers include: API 400 Dasibi 1003-AH, -RS or -PC Forney Corporation (CSI) OA325 Monitor Labs 8810 Thermo Environmental 49-103 Thermo Environmental 49C • Forced aspirated manifold system used with 7-10 Lpm flow rate • 20 micron filter at 10-m inlet with 3/8-inch tubing into shelter • 5 micron filter at analyzer inlet
Ozone-Calibrator**	• Zero air supply and ozone generator set for weekly zero, span, and precision level checks	• Zero air supply and ozone generator set for daily zero and span checks and daily or weekly precision level checks • Independent verification of test atmosphere with second in-station photometer
Wind Speed 10 m	• Climatronics anemometer chopper wheel/LED proportional to wind speed • R.M. Young Wind Monitor-AQ magnetic/sine wave frequency proportional to wind speed	• Climatronics anemometer chopper wheel/LED proportional to wind speed • R.M. Young Wind Monitor-AQ magnetic/sine wave frequency proportional to wind speed
Wind Direction 10 m	• Climatronics F460 vane and translator • R.M. Young Wind Monitor-AQ vane and translator	• Climatronics F460 vane and translator • R.M. Young Wind Monitor-AQ vane and translator

Table B.5.1 Measurement/Methods Matrix (Page 2 of 3)

Measurement	EPA	NPS
Temperature/Delta Temperature	• Climatronics thermistor in forced-aspirated housing • R.M. Young RTD in forced-aspirated housing • R.M. Young RTD in naturally-aspirated shields • Temperature measurement at 9 m, delta temperature at 9 and 2 m	• Climatronics thermistor in forced-aspirated housing • R.M. Young RTD in forced-aspirated housing • Temperature measurement at 9 m, delta temperature at 9 and 2 m
Relative Humidity 9 m	• Climatronics 100098: • Atmospheric moisture measured by hygromechanical stress of an organic seed in motor-aspirated shield • Rotronics: MP-100F • Capacitor sensor in naturally-aspirated shield	• Climatronics: (No longer used) • Atmospheric moisture measured by hygromechanical stress of an organic seed in motor-aspirated shield • Rotronics: MP-601 or MP-101 • Capacitor sensor in motor-aspirated shield
Precipitation 1 - 2 m	• Climatronics 8-inch, heated, tipping bucket rain gauge • Belfort universal recording rain gauge	• Heated, tipping bucket rain gauge • Belfort universal recording rain gauge
Solar Radiation 1 - 4 m	• Li-Cor pyranometer, silicon photovoltaic sensor with R.M. Young or Climatronics translator	• Li-Cor pyranometer, silicon photovoltaic sensor
Surface Wetness	• R.M. Young wetness sensor mounted near the height of ground level vegetation	• R.M. Young wetness sensor mounted near the height of ground level vegetation
Station Temperature	• Max/min thermometer which can be reset to record extremes of station temperature. Reset weekly	• Continuous measurement using thermistor mounted near or on instrument rack. Hourly averages of station temperature logged onto data logger

Table B.5.1 Measurement/Methods Matrix (Page 3 of 3)

Measurement	EPA	NPS
Filter Pack Flow Measurement	• Mass flow-rate controlled system to maintain a predetermined flow rate through a laboratory prepared filter pack	• Mass flow-rate controlled system to maintain a predetermined flow rate through a laboratory prepared filter pack
Data Recording Backup	• Digital data logger using an Odessa DSM-3260 data logger • Digital data logger using an ESC 8816 data logger • Odessa DSM-3260L data logger for selected parameters	• Digital data logger using an ESC 8816 data logger • Strip chart recorder on ozone measurement only
Data Collection Performance Goals***	• 90% by parameter per quarter • < 75% is an invalid sampling quarter	<u>Quarterly Criteria:</u> • 100% of sites ≥ 85% valid data capture • 90% of sites ≥ 90% valid data capture • 80% of sites ≥ 95% valid data capture <u>Monthly Criteria:</u> • 100% of sites ≥ 60% valid data capture • 90% of sites ≥ 75% valid data capture • 80% of sites ≥ 85% valid data capture
Precision	• Calculated difference between collocated sites, all parameters	• Calculated between ozone analyzer and on-site calibrator on quarterly basis

Note:
* Monitor Labs 9810 analyzer is used at CHE185, OK.
** A second in-station photometer is utilized at CHE185, OK for bi-weekly verification of test atmosphere.
*** Calculated by percent of valid data points relative to total possible data points.

Table B.5.2 Summary of Site Operator Responsibilities (Page 1 of 2)

Operation	Frequency	Reference
Site Inspections/Station Integrity	Every Tuesday	SOP/SSRF
Dry Deposition Sample System • Filter pack changed/shipped • Sample mast inspection • Flow system leak checked	Every Tuesday	SOP/SSRF
Aerosol Sample System • Filter pack changed • Teflo®/quartz refrigerated • Flow system leak check • After May 2001, IMPROVE procedures	 Every 6 days After every sample change Every 6 days Every 3 days	SOP/VSRF
Wet Deposition Sample System • Wet bucket changed • Dry bucket changed • Wet sample shipped • Collector operation/lid secured • After January 1999, NADP/NTN procedures	 Every Tuesday Every other month, first Tuesday Weekly Every Tuesday Every Tuesday	SOP/PSRF
O_3 Analyzer • Automated z/s/p checks at 0, 400, 90 ppb • Plot automated z/s/p results • Perform manual z/s/p checks • Check internal diagnostics • Sample tubing integrity • Check 5 micron Teflon® filters, replace if needed	 Every Sunday Every Tuesday As requested by FOM or field coordinator Every Tuesday Every Tuesday Every Tuesday	 SOP/Control Chart SOP/Site Log/Control Chart SOP/Site Log/Control Chart SOP/SSRF SOP/SSRF SOP/SSRF
Wind Speed/Wind Direction • Check reasonableness of data • Check integrity of cups/vane/prop • Perform electronic z/s, if applicable	Every Tuesday	SOP/SSRF
Ambient/Delta Temperature • Check reasonableness of data • Perform electronic z/s, if applicable • Check aspirated shield motor operation	Every Tuesday	SOP/SSRF
Relative Humidity • Check reasonableness of data • Perform electronic z/s, if applicable	Every Tuesday	SOP/SSRF
Tipping Bucket Rain Gauge • Check reasonableness of data • Verify operation-manual tips • Level gauge • Clean debris from collection basin	Every Tuesday	SOP/SSRF

Table B.5.2 Summary of Site Operator Responsibilities (Page 2 of 2)

Operation	Frequency	Reference
Weighing Rain Gauge • Replace and interpret chart • Check with standard weight • Check event marker • Check wind chart drive mechanism • Winterize/de-winterize • Check pen operation	 Every Tuesday Every Tuesday Every Tuesday Every Tuesday Seasonally Every Tuesday	 SOP/PSRF SOP/PSRF SOP SOP SOP SOP
Solar Radiation • Check for sensor obstructions • Clean sensor • Check reasonableness of data • Perform electronic z/s, if applicable	Every Tuesday	SOP/SSRF
Surface Wetness • Check instrument response • Clean sensor • Check sensor height is 6" to 12" above natural vegetation	 Every Tuesday Monthly Monthly	SOP/SSRF
Nephelometer • Check system integrity • Perform manual z/s calibration	 Every Tuesday Every 2 weeks	 SOP/Site Logbook SOP/Logsheet
Data Acquisition System • Verify data/instrument readings • Verify internal clock • Verify communications	Every Tuesday	SOP/SSRF
Communication • Call-in to FOM	Every Tuesday	SOP
Data Transfer • Floppy disks • Site logs, data printouts, SSRF, and PSRF • VSRF	 Monthly, first Tuesday Every Tuesday After every 3 samples	SOP
Sample Shipment • Dry and wet deposition • Aerosol (refrigerated)	 Weekly After every 3 samples	SOP

Table B.5.3 CASTNet Field Maintenance Schedule

Parameter	Year 1 Site Visit		Year 2 Site Visit		Year 3 Site Visit	
	1	**2**	**1**	**2**	**1**	**2**
O_3 Analyzer						
Sample Pump		3		3		3
Sample Cells	2	2	2	2	2	2
Scrubber				3		
Source Lamp					1	
Ozonator Lamp					1	
Zero Air Pump	1		1		1	
Charcoal	1		1		1	
Flow System						
Pump	1		1		1	
Balston Filter	1	1	1	1	1	1
Quick Connect		2		2		2
Climatronics						
WSP Cups		3		3		3
WSP Bearings	1	1	1	1	1	1
WDR Sensor	1		1		1	
WDR Vane	3		3		3	
Heater Assembly			1			
Rel. Hum. Filters	1	2	1	2	1	2
Temp Shield	2	2	2	2	2	2
R.M. Young						
WSP Prop		3		3		3
WSP Bearings	1	1	1	1	1	1
WDR Sensor		1		1		1
WDR Vane		3		3		3
Blowers	2	2	2	2	2	2
Rel. Hum. Filter	1	2	1	2	1	2
Temp Shield	2	2	2	2	2	2
Wet/Dry Collector						
Lid Liner	3	3	3	3	3	3
Miscellaneous						
Contact Set	3	3	3	3	3	3
Belfort Clock	3	3	3	3	3	3
Hardware	3	3	3	3	3	3

Note:

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

WDR = wind direction.
WSP = wind speed.
Rel. Hum. = relative humidity.
Temp = temperature.

Table B.5.4 Summary of Possible QC Failures (Page 1 of 3)

Instrument	QC Failure	Corrective Action
Field Instrumentation		
Ozone Analyzer	Automated zero, span, and precision > ±10 percent of target value	Site operator notifies FOM or field coordinator for instructions to perform manual check. If problem persists, instrument response is corrected by field technician during semiannual calibration.
Filter Pack Sampling System	Flow rate > ± 2 percent of target value, 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.
Meteorological Sensors	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.
Field Documentation		
Site Printouts, Diskettes	Documentation missing or incomplete	List of missing documentation is generated from files maintained at DMC and submitted to FOM or field coordinator for verification with site operators during Tuesday call-in.
SSRF, VSRF, PSRF	Documentation missing	List of missing 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-in.
	Documentation information incomplete or incorrect	List of documentation insufficiencies is compiled during internal quarterly audits and submitted to FOM or field coordinator for site operator notification.
Laboratory Instrumentation		
IC and TRAACS®	1. Not all samples documented in the batch 2. Analysis holding time not within criteria 3. Calibration curve correlation coefficient < 0.995 4. Calibration curve y-intercept > curve detection limit 5. Sample responses greater than highest standard response 6. Method blank not present 7. Method blank not within acceptance criteria 8. Reference standard solution not present. 9. Reference standard solution not within acceptance criteria. 10. Sample replicate not present 11. Sample replicate not within acceptance criteria Standard matrix spike solution (CVS) not present	Failure of any item requires laboratory analyst to provide written explanation included in the batch narrative. The batch narrative is also stored in CLASS™ database. LOM will review all documentation and accept or reject the data. If data rejected, samples are reanalyzed.

Table B.5.4 Summary of Possible QC Failures (Page 2 of 3)

Instrument	QC Failure	Corrective Action
Laboratory Instrumentation		
IC and TRAACS® (continued)	13. Standard matrix spike solution response not within acceptance criteria 14. Insufficient number of CVS present 15. Insufficient number of replicates present	
ICP-AES	1. Not all samples documented in the batch 2. Analysis holding time not within criteria 3. Method blank not present 4. Method blank not within acceptance criteria 5. Reference standard solution not present 6. Reference standard solution not within acceptance criteria 7. Sample replicate not present 8. Sample replicate not within acceptance criteria 9. Standard matrix spike solution not present 10. Standard matrix spike solution response not within acceptance criteria 11. Insufficient number of CVS present 12. Insufficient number of replicates present	Failure of any item requires laboratory analyst to provide written explanation included in the batch narrative. The batch narrative is also stored in CLASS™ database. LOM will review all documentation and accept or reject the data. If data rejected, samples are reanalyzed.
Specific Conductance, pH, Acidity	1. Not all samples documented in the batch 2. Analysis holding time not within criteria 3. Reference standard solution not present 4. Reference standard solution not within acceptance criteria 5. Sample replicate not present 6. Sample replicate not within acceptance criteria 7. Standard matrix spike solution not present 8. Standard matrix spike solution response not within acceptance criteria 9. Insufficient number of CVS present	Failure of any item requires laboratory analyst to provide written explanation included in the batch narrative. The batch narrative is also stored in CLASS™ database. LOM will review all documentation and accept or reject the data. If data rejected, samples are reanalyzed.

Table B.5.4 Summary of Possible QC Failures (Page 3 of 3)

Instrument	QC Failure	Corrective Action
Laboratory Instrumentation		
Specific Conductance, pH, Acidity (continued)	10. Insufficient number of replicates present	
Laboratory Documentation		
IC/TRAACS®	Analytical documentation missing or incomplete	If missing information is electronic, print out again. If missing information is only in hardcopy, then recopy.
	Analytical documentation is incorrect	If information is in electronic format, complete a batch update correction form. 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-AES	Analytical documentation missing or incomplete	If missing information is electronic, print out again. If missing information is only in hardcopy, then recopy.
	Analytical documentation is incorrect	If information is in electronic format, complete a batch update correction form. 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.
Specific Conductance, pH, Acidity	Analytical documentation missing or incomplete	If missing information is electronic, print out again. If missing information is only in hardcopy, then recopy.
	Analytical documentation is incorrect	If information is in electronic format, complete a batch update correction form. Provide explanation and back up signatures. If information is not in electronic format (laboratory notebooks, extraction logs), cross out error with single line, write correction, initial, and date.

Table B.5.5 Acceptance Criteria for CASTNet Field Calibrations

Measurement Parameter	Measurement Method	Calibration Method	Acceptance Criteria
Wind Speed	Anemometer	Adjustable synchronous motor	± 0.2 m/sec < 5 m/sec ± 5% ≥ 5 m/sec
Wind Direction	Wind vane	Vane aligned with compass sighted target	± 3°each point
Relative Humidity	Thin film capacitor	Transfer sensor or standard salts	± 20% rel. hum. < 85% ± 5% rel. hum. ≥ 85%
Solar Radiation	Pyranometer	Transfer sensor	± 5% of average
Precipitation	Tipping bucket rain gauge	Known volume addition	± 0.02 inches at 0.50 inches
Temperature	Platinum RTD	Certified platinum RTD in isothermal bath	± 0.30°C
Delta Temperature	Platinum RTD	Certified platinum RTD in isothermal bath	± 0.25°C
O_3	UV absorbance (photometric analyzer)	Certified transfer photometer	± 5% of actual for any value 0.9500 < slope < 1.050 –3.0 ppb < Int. < 3.0 ppb $r^2 > 0.995$
Surface Wetness	Conductivity bridge	Test with 230-240 kΩ resistance	Full-scale response to test resistance
Filter Pack Flow	Mass flow controller	Mass flow meter or dry piston meter	± 2% of actual flow rate

Note:

Int. = Intercept
r^2 = correlation coefficient
rel. hum = relative humidity

Table B.5.6 Accuracy Results for Field Measurements (1990-2000)

Parameter	Percent Within Criterion	Parameter	Percent Within Criterion
Temperature (0°C)	98%	Wind Direction South	96%
Temperature (ambient)	98%	Wind Speed < 5 m/s	96%
Delta Temperature (0°C)	99%	Wind Speed > 5 m/s	97%
Delta Temperature (ambient)	98%	Precipitation	95%
Relative Humidity > 85%	98%	Wetness (w/in 0.5 volts)	98%
Relative Humidity < 50%	96%	Ozone Slope	98%
Solar Radiation	92%	Ozone Intercept	99%
Wind Direction North	95%	Flow Rate	97%

Note:

°C = degrees Celsius
m/s = meters per second

Table B.5.7 O_3 Analyzer 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 Environmental Instruments, Inc.

Table B.5.8 Meteorological Instrument Specifications

Parameter	Manufacturer's Specifications
Wind Speed	
Climatronics	
Accuracy	± 0.07 m/sec < 5 m/sec; ± 1% otherwise
Threshold	0.22 m/sec
R.M. 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
R.M. Young	
Accuracy	± 5 degrees
Threshold	0.5 m/sec up to 11 g/cm torque
Temperature	
Climatronics	
Accuracy	± 0.3°C
Range	-30 to 50°C
R.M. Young	
Accuracy	± 0.3°C
Range	-50 to 50°C
Temperature Difference	
Climatronics	
Accuracy	± 0.10°C
R.M. Young	
Accuracy	± 0.10°C
Precipitation	
Tipping Bucket Rain Gauge	
Climatronics	
Accuracy	± 4.0% up to 76 mm/hr
Weighing Rain Gauge	
Belfort	
Accuracy	± 0.02 inches
Solar Radiation	
Climatronics (Li-Cor)	
Accuracy	± 5.0%
Linearity	± 5.0%
R.M. Young (Li-Cor)	
Accuracy	± 5.0%
Linearity	± 2.0%
Relative Humidity	
Climatronics	
Accuracy	± 5.0%
R.M. Young (Rotronic)	
Accuracy	± 3.0%
Surface Wetness	
R.M. Young	
Accuracy	Undefined

Table B.5.9 Nephelometer Specifications

Parameter	Specification
Extinction Range	0 to 32,768 count (serial output) (typically equal to 0.01 to 24.00 per km after post processing) 0 to 10.00 V (analog channel 1 or 2) (typically equal to 0.01 to 7.00 per km after post processing)
Resolution	± 1 count, (serial output) (one Rayleigh is ≅ 12 counts) ± 2.44 mV (analog channel 1 or 2) (one Rayleigh is ≅ 12.0 mV with multiplier = 1)
Accuracy	± 10% of true value for air near Rayleigh and using 2 minutes of integration
Measured Wavelength	550 nm center wavelength, 100 nm bandwidth photopic response
Operating Temperature	-20° to 45°C

Source: ARS

Table B.5.10 Nephelometer Maintenance Schedule

Interval	Tasks
Weekly Interval	• Check integrity of the tower and mounting hardware. • Check integrity and operation of the support system. • Check operation and calibration of the ambient nephelometer. • Check status of fan and clean air pump • Check operation of the ΔT/RH sensor. • Complete log sheet.
2 Week Interval	• Precision checks using SUVA 134a gas. • Exchange storage module at sites where telephone modem data collection is not possible. • Inspect clean air filter assembly and replace clean air filter cartridge. • Inspect light trap.
Annual Interval	• Field technicians make visits once a year to exchange the existing nephelometer for a newly serviced instrument. • Training of site operators in the servicing and maintenance of the monitoring system components takes place during annual visits.

Source: ARS

Table B.5.11 DAS Accuracy and Resolution

A/D Bits			± Resolution	Less Over-range
12 - 1 = 11 (1 bit reserved for ± sign)			2048	2000
Parameter	**Units**	**Full Scale**	**Zero Offset**	**DAS A/D Accuracy**
Tipping Bucket Rain Gauge	inches	10.00	0.00	0.0050
Wind Direction (RMY)	degrees	360	0	0.1800
Wind Direction (Climatronics)	degrees	540	0	0.2700
Wind Speed	m/sec	50.0	0.0	0.0250
Temperature (RMY)	°C	50.0	-50.0	0.0500
Delta Temperature (RMY)	°C	7.00	-3.00	0.0050
Temperature (Climatronics)	°C	50.0	-30.0	0.0400
Delta Temperature (Climatronics)	°C	5.00	-5.00	0.0050
Relative Humidity	%	100.0	0.0	0.0500
O_3	ppb	500	0	0.2500
Solar Radiation	W/m^2	1396	0	0.6980
Flow (ex. 1)	Lpm	4.78	-0.04	0.0024
Flow (ex. 2)	Lpm	5.41	0	0.0027
Scalar Wind Speed	m/sec	50.0	0.0	0.0250
Wetness	on/off	1.00	0.00	0.0005
Standard Deviation of Wind Direction	degrees	99.99	0	0.0500

Note: RMY = R.M. Young

Table B.5.12 Calibration Standards, Certification Procedures, and Frequency

Measurement Device	Calibration Procedure	Calibration Frequency
Ozone Analyzer: Thermo Environmental Model 49C	Multi-point comparison to the NIST reference photometer maintained by NERL.	Primary standard is certified annually against the NIST reference at NERL.
Wind Speed Sensor: R.M.Young Model 18801 Synchronous motor	Multi-point comparison to a NIST traceable frequency meter.	The NIST traceable synchronous motor is calibrated annually by the vendor.
Wind Direction Sensor: R.M. Young Model 18212 Test fixture	This is a 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	This is a fixed test fixture, no calibration needed.	This is a fixed test fixture; if the validity is in question, it is replaced.
Wind Direction Torque: R.M. Young Model 18331 Torque Gauge	This is a fixed test gauge, no calibration needed.	This is a fixed test fixture; if the validity is in question, it is replaced.
Wind Speed Torque: R.M.Young Model 18310 Torque Disc	This is a fixed test disc, no calibration needed.	This is a fixed test fixture; if the validity is in question, it is replaced.
Mass Flow Controller: Bios Model DC-1 Mass Flow Controller: Gillian Model 5100	Certified using NIST traceable Phillips Universal Counter/ Timer and a Mitutoyo Master Gauge Block.	The NIST traceable mass flow standards are calibrated annually by the vendor.
Relative Humidity Sensors: Aqueous Salts	Aqueous saturated salts are made using laboratory grade reagents and DI water following ASTM Standards E 104-85.	Salts are checked semiannually using a NIST-traceable Rotronics GTL hygrometer.
Relative Humidity Sensor: Rotronic Model GTL100 GTL Hygrometer	Calibrated using a NIST-traceable chilled mirror instrument and saturated salt solutions.	The NIST traceable GTL hygrometer is calibrated annually by the vendor.
Solar Radiation Sensor: Eppley Model PSP100	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.
Precipitation: Water measurement using a laboratory grade graduated cylinder	This is a fixed test cylinder, no calibration is needed.	This is a fixed test cylinder; if the validity is in question, it is replaced.
Multimeter: Fluke Model 8060A	Tested under varying conditions using measurement standards that are NIST traceable.	The NIST traceable multimeter is calibrated annually by the vendor.
Thermometers: Brooklyn Model 41MM	A two-point comparison to NIST standards.	The NIST traceable thermometer are calibrated annually by the vendor.

Table B.6.1 Summary of Analytical Methods by Sample Type for the CASTNet Base Program

Operation	Sampling Media	Analytes	Instrumentation	Reference Method
Dry Deposition				
Filter Pack System	Teflon® Filter	NO_3^-, SO_4^{2-}, Cl^-	IC Dionex DX500/300	EPA Method 300.0*
	Teflon® Filter	NH_4^+	TRAACS® 800 AutoAnalyzer™	EPA Method 350.1
	Teflon® Filter	Ca^{2+}, Mg^{2+}, Na^+, K^+	ICP-AES PE 3000 DV	EPA Method 6010
	Nylon Filter	NO_3^-, SO_4^{2-}	IC Dionex DX500/300	EPA Method 300.0
	Whatman Filter	NO_3^-, SO_4^{2-}	IC Dionex DX500/300	EPA Method 300.0
Visibility				
Filter Pack	Nylon Filter	NO_3^-, SO_4^{2-}	IC Dionex 4000	EPA Method 300.0
Filter Pack	Teflo® Filter	Fine Particle Mass	Electrobalance	EPA Method 40 CFR 50
	Teflo® Filter	Trace/Crustal Elements	XRF	NIOSH Method 5040
Filter Pack	Quartz Filter	Total Carbon	Calculation	Calculation
	Quartz Filter	Elemental Carbon	Thermal-Optical CA/FID	Birch & Cary, 1996
	Quartz Filter	Organic Carbon	Thermal-Optical CA/FID	Birch & Cary, 1996
Wet Deposition				
Wet/Dry Collector	Rain Bucket	pH	pH Meter	EPA Method 150.1
	Rain Bucket	Conductivity	Conductivity Meter	EPA Method 120.1
	Rain Bucket	Acidity	Auto Titrator	EPA Method 305.2
	Rain Bucket	Cl^-, NO_3^-, SO_4^{2-}, NO_2^-	ICX Dionex DX500/300	EPA Method 300.0
	Rain Bucket	Ca^{2+}, Mg^{2+}, Na^+, K^+	ICP-AES PE 3000 DV	EPA Method 6010

* Further information on reference methods is provided in Section E – References.

NIOSH = National Institute for Occupational Safety and Health
CA/FID = Carbon Flame Ionization Detector

Table B.6.2 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.
CVS	± 5% of true value for IC and ICP-AES 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	± 5% 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.
Reference sample	± 5% of true value for IC analyses ± 10% of true value for AC (NH_4^+) and ICP-AES 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 B.7.1 Data Tables that Constitute the CASTNet Database (Page 1 of 4)

Database	Table Name	Description
castnet		
	calibration_summary	Summary of calibration results from the semiannual calibrations of EPA sites conducted by field operations personnel.
	codes	Lists all QA codes, qualifiers, and status flags for each table in the database.
	drychem	Ambient concentrations of gases and particles as measured by filter packs.
	drychem_daynight	Day/night ambient concentrations of gases and particles as measured by filter packs at sites where two filter packs are collected, one representing daytime conditions and one representing nighttime conditions.
	drychem_summary	Summary of minimum, mean, standard deviation, and maximum atmospheric concentration values for each analyte and site-month or site-quarter.
	filter_pack	Dry chemistry filter pack data. Data input from SSRF.
	formats	Data definitions for tables in the CASTNet data repository.
	lab_chem_historical	Historical total microgram filter pack results from the laboratory in a cross-tabbed format. Includes data from 1/1/87 to 6/30/98.
	lab_comments_historical	Laboratory comment codes associated with filter packs run prior to 1/1/99.
	labdata_historical	Laboratory analytical and QC data in total micrograms for samples run prior to 1/1/99.
	leaf_angle	Leaf angle data used as input to create the lang.sph file. Used by MLM model.
	leaf_status	Leaf status of site location as documented by the site operator during weekly site visit. Data input from SSRF.
	metdata	Level II validated continuous meteorological data.
	metdata_level1	Continuous meteorological data record prior to validation.
	metdata_level1x	Level 1x validated continuous meteorological data.
	metdata_summary	Summary of minimum, mean, standard deviation, and maximum values for each parameter and site-month or site-quarter.
	ozone	Level II validated continuous ozone data with rolling eight-hour ozone eight hour averages and rankings by site-year. This table is updated annually after all ozone measurements for the year have been validated.
	ozone_qc	Ozone autocalibration data.
	ozone_SUM06	Ozone SUM06 values for three-month periods during the ozone season for a specific site.
	plant	Plant types and coefficients. Used by MLM model.
	plant_profile	Canopy data used as input to create the padprof1.20, padprof2.20, and padprof3.20 files. Used by MLM model.
	report_group	Identifies quarter and year assigned to a laboratory sample as designated by the sample week number. Used by CDMSA
	site_operators	Documentation of primary contact, site operator, emergency, utility, and telephone information for each site.
	site_ops	Operational information for each site.
	site_plant_detail	Plant leaf out periods for each site. Used by MLM model.
	site_plant_summary	Plant coverage for each site. Used by MLM model.
	site_status	Status of network components present at each specific site.
	sites	Information concerning location, elevation, and other details of a specific site.

Table B.7.1 Data Tables that Constitute the CASTNet Database (Page 2 of 4)

Database	Table Name	Description
castnet		
	sites_renamed	Documentation of sites that have been renamed during the history of the network but have remained at the same location.
	sites_schedule	History and schedule of data submittals.
	table_descriptions	Description of tables in the CASTNet data repository.
	vischem	Chemical speciation data from aerosol filter packs at local conditions.
	vischem_stp	Chemical speciation data from aerosol filter packs at standard temperature and pressure conditions
	visflow	Hourly flow data for aerosol filter packs.
	visneph	Nephelometer data (conforms to IMPROVE network standards).
	wetchem	Weekly wet deposition concentrations and sampling information from January 1989 – February 1999
castnet_application		
	assumed_flow	Assumed hourly flow rates for each site. Used by CDMSA.
	calibration_criteria	Calibration and validation criteria for continuous data. Used by CDMSA.
	cdrf_template	Template for the CDRF report in the CDMSA.
	climatronics_sites	CASTNet sites using Climatronics meteorological equipment. Used by CMDSA.
	color_codes	Color-codes for metdata editor grid cells. Used by CDMSA.
	equipment_inventory	Inventory of all CASTNet equipment that is purchased, maintained, and utilized by the MACTEC for EPA.
	ese_inventory	Inventory of all MACTEC equipment used in CASTNet activities.
	field_actions	Actions taken on an operational problem at a site as documented in the Field Problem Report.
	field_alt_descr	Alternative reviews of an operational problem at a site as documented in the Field Problem Report.
	field_calibration_matrix	Matrix of calibration group designations and associated calibration months.
	field_problems	Operational problems at sites as documented in the Field Problem Report.
	field_review_hist	Number of problems at a site on a specific day.
	field_sites	Site information specific to Field Operations.
	field_validation	Validation recommendations based on daily review process.
	met_setup	Grid specifications for metdata editor. Used by CDMSA.
	missing_codes	List of common reasons associated with the occurrence of missing data. Used by CDMSA
	reason_codes	List of common reasons associated with changes made to continuous data during Level II validation. Used by CDMSA.
	site_setup	Documentation of equipment required for the initial setup of a CASTNet site.
	temp2_sites	CASTNet sites operated using solar power. Used by CDMSA.
castnet_model		
	velan	Annual estimates of concentrations, deposition velocities, and fluxes; aggregated from quarterly estimates in the VELQR table.
	velhr	MLM output providing hourly estimates for concentration, deposition velocity, and flux.

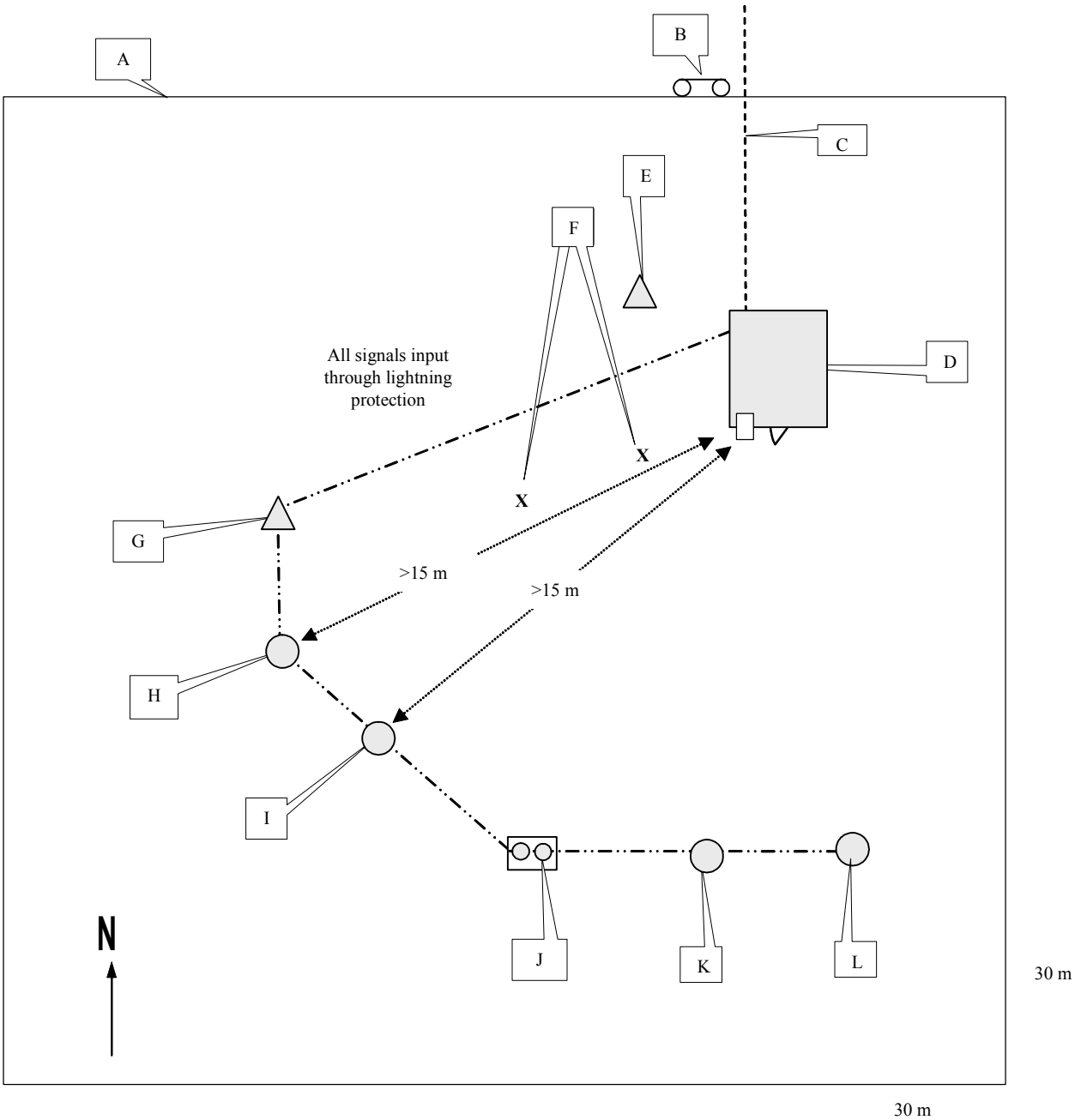
Table B.7.1 Data Tables that Constitute the CASTNet Database (Page 3 of 4)

Database	Table Name	Description
castnet_model		
	velqr	Quarterly estimates of concentrations, deposition velocities, and fluxes; aggregated from weekly estimates in the VELWK table.
	velsn	Seasonal estimates of concentration, deposition velocities and fluxes; aggregated from weekly estimates in the VELWK table.
	velwk	Weekly estimates of concentrations, deposition velocities, and fluxes; aggregated from hourly estimates in the VELHR table for sequential Tuesday-to-Tuesday weeks.
castnet_model_arch		
	mlm_versions	Descriptions of changes made to the MLM that resulted in a change of the version number
	velan	Archived annual estimates of concentrations, deposition velocities, and fluxes; aggregated from quarterly estimates in the VELQR table.
	velhr	Archived MLM output providing hourly estimates for concentration, deposition velocity, and flux.
	velqr	Archived quarterly estimates of concentrations, deposition velocities, and fluxes; aggregated from weekly estimates in the VELWK table.
	velsn	Archived seasonal estimates of concentration, deposition velocities and fluxes; aggregated from weekly estimates in the VELWK table.
	velwk	Archived weekly estimates of concentrations, deposition velocities and fluxes; aggregated from hourly estimates in the VELHR table for sequential Tuesday-to-Tuesday weeks.
castnet_temp		
	calibration_l0	Staging table for input of ozone autocalibration data from binary files.
	daynight_flow_l0	Staging table for input of EGB181, ON day/night filter pack flow data from binary files.
	lab_comments_temp	Staging table for input of laboratory comments.
	labdata_temp	Staging table for input of total microgram laboratory data.
	labdata_transfer	Staging table for input of total microgram laboratory data.
	metdata_l0	Staging table for input of continuous meteorological data from binary files.
	visflow_l0	Staging table for input of aerosol filter pack flow data from binary files.
castnet_working		
	daynight_flow	Day and night hourly flow data associated with day/night filter pack measurements.
	daynight_flow_level1	Day and night hourly Level I flow data associated with day/night filter pack measurements
	daynight_flow_summary	Temporary table of the most recently calculated flow volumes (in cubic m) used to calculate day/night dry chemistry ambient concentrations.
	drychem_daynight_temp	Temporary table of the most recently calculated day/night ambient concentrations of gases and particles as measured by filter packs.
	drychem_temp	Temporary table of the most recently calculated ambient concentrations of gases and particles as measured by filter packs.

Table B.7.1 Data Tables that Constitute the CASTNet Database (Page 4 of 4)

Database	Table Name	Description
castnet_working		
	flow_summary	Temporary table of the most recently calculated flow volumes (in cubic m) used to calculate dry chemistry ambient concentrations.
	lab_comments	Laboratory comment codes associated with filter pack samples.
	lab_temp_crosstab	Temporary table of the most recently cross-tabbed total microgram laboratory data used to calculate dry chemistry ambient concentrations.
	labdata	Laboratory analytical and QC data in total micrograms.
	metdata_l1	Level I continuous meteorological data currently in the validation process.
	metdata_l2	Level II continuous meteorological data currently in the validation process.
	ozone_calibration	Ozone calibration data as polled from sites.
	transaction_log	Record of changes made to continuous meteorological data or flags during the validation process.

Figure B.2.1 Typical EPA Sponsored CASTNet III Site Configuration



Typical EPA Sponsored CASTNet III Site Configuration

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 (>15m from shelter)
J - Wet/Dry Collection (optional)
K - Belfort Weighing Rain Gauge (optional)
L - Wetness Sensor

Figure B.2.2 Sample Site Inventory Form

CLEAN AIR STATUS AND TRENDS NETWORK SITE INVENTORY LIST

November 18, 1998

Sorted By EPA Bar Code Within Site

EPA Bar Code	Castnet #	Equipment Name	Serial Number	Site Number
808741		A-ANALYZER, OZONE	49-20458-190	138
	02750	A-PUMP, VACUUM	001955	138
810905X	01255	D-CARTRIDGE, 128K-R	871	138
492124X	00244	D-CARTRIDGE, 64K-RA	N/A	138
810654X	02129	D-COMPUTER, 20 MEG	506242	138
810704		D-DATA LOGGER	102315	138
810904X	01941	D-DATA LOGGER, BACK	102360	138
664704X	00989	D-MODEM, EXTERNAL	1057278	138
	03377	D-MONITOR, MONOCHRM	3230004294	138
	04056	D-PRINTER, DOT MATR	7AECEB20775	138
	03484	F-POWERSUPPLY/READO	FP9404007	138
	02909	F-PUMP, VACUUM	001861	138
492222X	03554	F-TOWER, FOLDING	N/A	138
492297X	02347	M-INTERFACE, SENSOR	N/A	138
880688X	00944	M-MONITOR-AQ, WIND	3828	138
809173X	02704	M-RAIN GAUGE, TIPPI	667	138
492120X	02596	M-SENSOR, RELATIVE	1054	138
	02726	M-SENSOR, SOLAR RAD	PY17023	138
	02677	M-SENSOR, TEMPERATU	N/A	138
	03288	M-SENSOR, TEMPERATU	0431	138
	03052	M-SENSOR, WETNESS	N/A	138
880516X	01189	M-SHIELD, RELATIVE	N/A	138
	02536	M-SHIELD, TEMPERATU	N/A	138
492068X	03553	M-TOWER, 10 METER	N/A	138
	03216	M-TRANSLATOR, SOLAR	N/A	138
	03871	M-TRANSLATOR, TEMPE	191143	138
811697		S-SHELTER, 8'X8'X10	2149-21	138

Figure B.2.3 Sample CASTNet Site Contact List

CASTNet SITE CONTACT LIST

Updated: *08-Dec-98*

Site Number: 120 (VPI120) **Site Name:** Horton Station, VA

Shelter Telephone: (540) 626-7003

Latitude:	37.330	**Longitude:**	80.557
Magnetic Declination:	-6D 16.4M (-7.7 AROC)	**Elevation:**	920 meters
USGS quadrangle:	Eggleston, VA	**Site deactivated:**	N/A
Site installed:	06/22/87	**Envicom Number:**	20
Calibration Group:	A	**Site Type:**	Base, A & B
Equipment Type:	CLI		

Contacts/Operators

Primary Contact: Dr. Boris Chevone
Department of Plant Pathology
Virginia Polytechnic Institute
Blacksburg, VA 24061
(540) 951-7633 (540) 231-6530

Site Operator: Dr. Boris Chevone
Department of Plant Pathology
Virginia Polytechnic Institute

Blacksburg, VA 24061
Home: (540) 951-7633 *Other:*
Work: (540) 231-6530

Backup Site Operator: Stanley Long

540-382-9254

Shipping Information

Federal Express: Dept of Plant Path., Air Poll. Ctr.
Glad Rd. Research Ctr. VPISU
Blacksburg, VA 24061-0330

Figure B.3.1 Diagram of the Filter Pack Assembly

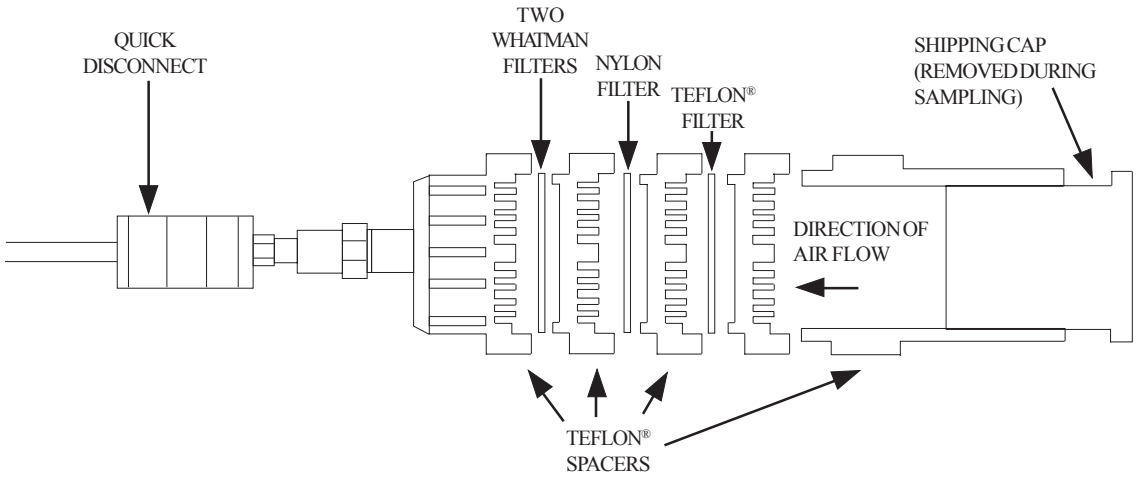


Figure B.3.2 Sample Site Status Report Form

CASTNET

SITE STATUS REPORT FORM (SSRF)

DAS AND OZONE

SITE NAME / NO. MKG 113

VISIT DATE / DAY 08-15-00, Tues

CALLED ESE CONTACT Eric / Voice Mail

DAS	PRIMARY	BACKUP
JULIAN DATE	229	229
TIME (2400 hr)	0533	0531
DATA DOWNLOADED (YES / NO)	✓	✓
FILES BACKED UP (YES / NO)	✓	✓

FILE NAMES

OZONE CHECKS (for "Filter On" Date)	A	B
SAMPLE FREQUENCY (Hz x 1000)	97	97
NOISE	1.0	0.7
CELL PRESSURE (mm)	731	732
CELL TEMPERATURE (°C)	35.5	35.5
SAMPLE FLOW (LPM)	1.1	1.1

	YES	NO
OUTSIDE FILTER CHANGED	✓	
INSIDE FILTER CHANGED		✓
WATER IN LINE/TRAP		✓
REMOTE MODE ON	✓	
P/T CORRECTION ON	✓	

OFFSET OR BACKGROUND 57

SPAN OR COEFFICIENT 504

AUTO CAL	ZERO ppb	400 ppb	90 ppb
DATE 08-13	-07	411	11
DATE 08-20	-01	389	85

DMC USE ONLY REVIEWED BY / ON

FILTER PACK INFO

ACTUAL SAMPLE RUN

FILTER PACK ID # DD0034

	FILTER ON	FILTER OFF
DATE	08/15/00	08/22/00
TIME	0547	0627
MFC (PUMP OFF)	-0.03	-0.05
MFC LEAK CHECK	0.03	0.02
DAS FLOW (LPM)	1.50	1.50
ROTAMETER (LPM)	1.6	1.6
ELAPSED TIME (HRS)		165.5

M Schroth 08-22-00

RETURN SHIPMENT PREPARED BY DATE

EXPECTED SHIPMENT DATE 8-22-00

LAB USE ONLY

ESE SAMPLE NO. DD00-34 x 2.2

LAB TECH RECEIPT A Reed DATE 8-25-00

COMMENTS:

CHAIN-OF CUSTODY LABEL

Filter Pack ID # **DD0034** **Site:** *MKG113*

Scheduled On Date: 08/15/00 *22

SHIPMENT OPENED BY: M Schroth DATE: 08-05-00

PACKED BY: 3578

D-253

SITE OBSERVATIONS DURING FILTER INSTALLATION

CIRCLE IF PRESENT: DEW FROST SNOW FOG

WHAT % OF LEAVES:	0%	<25%	25-50%	50-75%	>75%
HAVE DROPPED					
HAVE FALL COLOR					
ARE GREEN					✓

	CURRENT 5-MINUTE AVERAGES	REASONABLE YES	REASONABLE NO	EQUIPMENT	ZERO	SPAN
RAINFALL (inches)	0.00	✓		☑ RM YOUNG		
CLEAN & LEVEL		✓		☑ CLIMATRONICS		
10-TIP CHECK	.00					
WIND DIRECTION (DEGREES)	02	✓			0.001 540	0.669 0.665
WIND SPEED (m/s)	0.5	✓			0.009	0.501
TEMPERATURE (°C)	13.4	✓			0.004	1.002
BLOWER WORKING		✓				
DELTA TEMPERATURE (°C)	1.15	✓			0.004	1.000
BLOWER WORKING		✓				
RELATIVE HUMIDITY (%)	93.8	✓			0.002	1.002
SOLAR RADIATION (W/M²)	21	✓			0.001	1.001
CLEAN & LEVEL		✓				
WETNESS SENSOR	1.01	✓		SHELTER TEMPERATURE (°F) 66	MAX 78	
CLEAN		✓			MIN 65	
TEST RESPONSE	-.00			THERMOMETER RESET	YES ✓	NO

NOTES:
weather: cool, relcalm, clear
partly foggy, dew

MFC 1.31
Roto 1.6

WHITE COPY: ESE (in tube with filter) YELLOW COPY: ESE (in envelope) PINK COPY: SITE OPERATOR'S NOTEBOOK

Figure B.3.3 Visibility Network Aerosol Sampling System

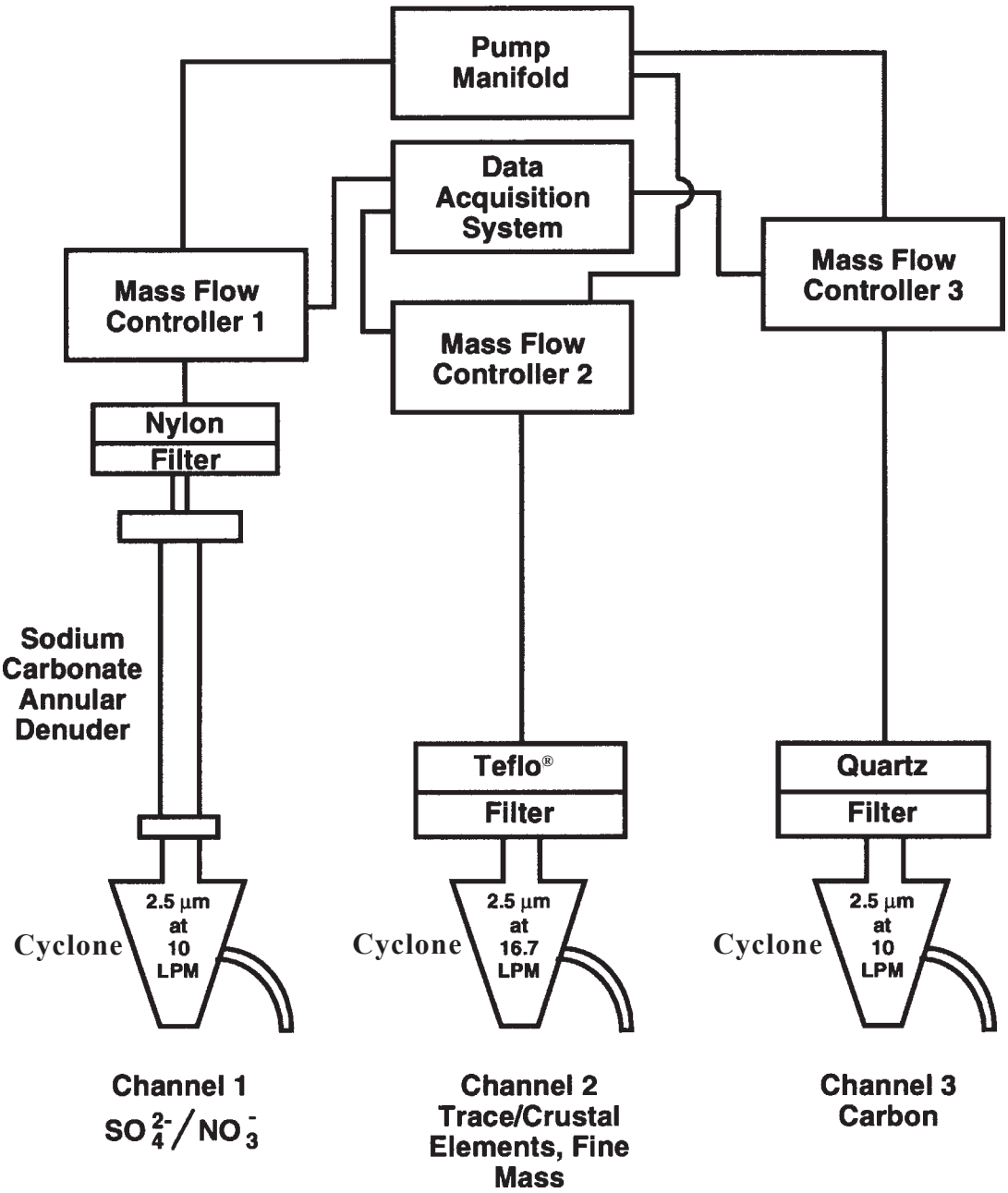


Figure B.3.4 Sample Visibility Status Report Form

CASTNET	VISIBILITY SAMPLE REPORT FORM		
CHAIN-OF-CUSTODY	SITE NO. 570	SITE OPERATOR [signature]	ACTUAL RUN DATE 1 5 98

SCHEDULED ON DATE 01/05/98 SITE SIK570

SAMPLE # V98-1*500-S

PACKED BY
DEC 16 1997
1842

Shipment Opened by: [signature]
DATE: 1-4-98
Flt/Ondr ✓
Teflo Flt ✓
Qrtz Flt ✓

SAMPLE NUMBER: V98-1-500-S

	DENUDER	TEFLON (ID NO. 31)	QUARTZ (ID NO. 1)
ON DATE:	1 4 98	1 4 98	1 4 98
TIME INSTALLED (24 HOUR)	10:00	10:00	10:00
PUMP OFF (LPM)	0.68	-0.40	0.01
LEAK CHECK (LPM)	0.70	-0.38	0.02
INITIAL FLOW (LPM)	10.00	16.66	9.93
FINAL FLOW (LPM)	10.01	16.66	9.93
CYCLONES REPLACED? YES ___ NO ✓ DATE ___		YES ___ NO ✓ DATE ___	YES ___ NO ✓ DATE ___
	DENUDER	TEFLON	QUARTZ
OFF DATE:	1 6 98	1 6 98	1 6 98
TIME REMOVED (24 HOUR)	09:00	09:00	09:00

ELAPSED TIME (HRS): END 24.00; START 00.00; FINAL 24.00

02/03/98

RETURN SHIPMENT
PACKED BY [signature]
DATE 1-6-98

LAB USE ONLY:
LAB TECH RECEIPT M. White
DATE 1-20-98

COMMENTS

	YES	NO
1. CHAIN OF CUSTODY COMPLETE	✓	
2. ON / OFF DATES COMPLETED	✓	
3. ON / OFF TIMES COMPLETED	✓	
4. ELAPSED TIME REASONABLE	✓	
5. RUN DATE CORRECT	✓	
6. ADDITIONAL COMMENTS:		

FIELD COMMENTS:

SUPPLIES NEEDED – CIRCLE:
GLOVES LARGE MEDIUM
MERCHANDISE RETURN LABEL
KIMWIPES
DI WATER
OTHER – EXPLAIN

WHITE COPY: ESE YELLOW COPY: ESE PINK COPY: SITE OPERATORS NOTEBOOK

C1 / VISIBILITY SAMPLE REPORT 9/98 MH

Figure B.3.5 Sample Precipitation Sample Report Form

CASTNET | **PRECIPITATION SAMPLE REPORT FORM**

1 STATION SITE ID NO: 134
NAME: PRK

2 OPERATOR INITIALS: FGE
SIGNATURE: Fred G. Ernstrom

3 BUCKET TYPE ☐ DRY-SIDE ☒ WET-SIDE

For lab use only.
LAB SAMPLE # W98-28 #10

LAB REMARKS:

4

	DATE MO	DAY	YR	TIME (FROM DAS) 0000-2400
BUCKET ON	07	07	98	06/3
BUCKET OFF	07	14	98	05/9

5 SITE OPERATIONS *Check YES or NO for each item for all buckets. If NO, explain in Data Block 10.*

	YES	NO
1. IS WET/DRY OK?	✓	
2. IS RAIN GAUGE OK?	✓	
3. IS SENSOR HEATING PROPERLY?	✓	
4. WHAT IS BATTERY VOLTAGE?	13.9	

6a ELAPSED TIME (HOURS)
ON 0032.9
– OFF 0033.8
0000.9

6b LID OPENINGS
NUMBER (EXCLUSIVE OF TESTS) 0002
IS COUNTER RESET? YES ✓ NO

7 BUCKET AND LID WEIGHTS *(From labels on each.)*

ID NO.	WEIGHT (GRAMS)
B 0524	647 BUCKET WEIGHT
L 0553	+ 138 LID WEIGHT
	0785 TOTAL WEIGHT

BALANCE ZERO CHECK: YES ✓ NO

8 SAMPLE WEIGHT
0155 STANDARD WEIGHT
0148 BUCKET + LID + SAMPLE
– 0785 TOTAL WEIGHT (FROM 7)
0363 SAMPLE WEIGHT (GRAMS)
x 0.00058
00.20 SAMPLE AMOUNT IN INCHES

9 SAMPLE CONDITION *Check YES or NO for all buckets.*

	YES	NO
1. BIRD DROPPINGS?		✓
2. CLOUDY OR DISCOLORED?		✓
3. INSECTS, SOOT, OR DIRT?	✓	

(1 tiny insect)

Describe all YES responses and any other conditions in Data Block 10.

10 FIELD REMARKS (MANDATORY)
NOTE ANY EQUIPMENT MALFUNCTION, INSECTS, BIRD CONTAMINATION, HAZE, FIRES, AGRICULTURAL OR CONSTRUCTION ACTIVITIES, TYPE OF WEATHER DURING WEEK, ETC.

Sun. Cldy. + rain showers
Wed. fog, Cldy, & Clear
Thurs. fog, Clear.
Fri. Clear.
Low 55°F. Thurs. High 87°F. Thurs.
Sat. Clear
Sun. ~~Cldy. &~~ Clear
Mon. Cldy. & Clear
Tues Cldy.
Low 60°F. Sat. High 89°F. Mon.
New Balance - 0 Cabl. Wt: 2000

11 PRECIPITATION AMOUNT

COLLECTOR EFFICIENCY
SAMPLE WEIGHT (INCHES) / TOTAL RAIN FOR WEEK (INCHES) X 100 = 0.87 *

BUCKET ON TO BUCKET OFF

0.23	TUES 7
–	WED 8
–	THUR 9
–	FRI 10
–	SAT 11
–	SUN 12
–	MON 13
–	TUES 14
+	
TOTAL RAIN FOR WEEK 00.23	INCHES
STANDARD WEIGHT 01.35	INCHES

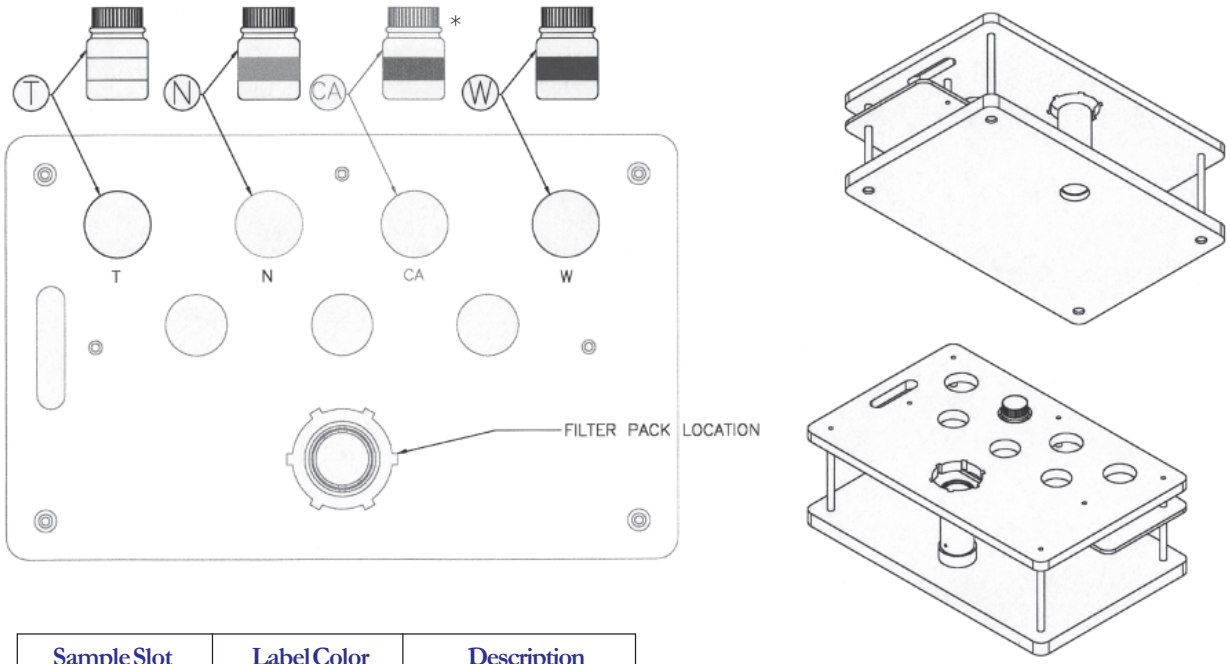
SUPPLIES *Circle if needed. Request at least 2 weeks prior to running out.*
GLOVES
FIELD FORMS
RAIN GAUGE CHARTS
RETURN SHIPPING LABELS
OTHER
MAINTENANCE LIDS
D.I. WATER
KIMWIPES
NUMBER OF CLEAN REPLACEMENT BUCKETS ON HAND: 03 *

★ DATA TO BE PHONED TO FIELD COORDINATOR ON TUESDAY.

C4 / 92303 8/94SS

WHITE COPY: ESE YELLOW COPY: ESE PINK COPY: FIELD NOTEBOOK

Figure B.3.6 Filter Pack Assembly/Disassembly Apparatus



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

Note = * Not used on CASTNet Project.

Figure B.3.7 Sample Acceptance Test Results for Teflon® Filters

Acceptance Test Results, Teflon Filters--Second Quarter 1996

				Teflon			
Fld Grp	Seq	Lot No.	Filter On Date	ug SO4 97277*IC	ug NO3-N 97280*IC	ug NH4-N 97550*DD	STATUS
TAT96	21	477708	05/14/96	<1.000	0.310	<0.500	FAIL
TAT96	22	477708	05/14/96	<1.000	<0.200	<0.500	PASS
TAT96	23	477708	05/14/96	<1.000	<0.200	<0.500	PASS
TAT96	24	477708	05/14/96	<1.000	<0.200	<0.500	PASS
TAT96	25	477708	05/14/96	<1.000	<0.200	<0.500	PASS
TAT96	26	477708	05/14/96	<1.000	<0.200	<0.500	PASS
TAT96	27	477708	05/14/96	<1.000	<0.200	<0.500	PASS
TAT96	28	477708	05/14/96	<1.000	0.445	<0.500	FAIL
TAT96	29	477710	05/14/96	<1.000	<0.200	<0.500	PASS
TAT96	30	414010	05/14/96	<1.000	<0.200	<0.500	PASS
TAT96	31	1007	06/12/96	<1.000	0.656	<0.500	FAIL
TAT96	32	1007	06/12/96	<1.000	<0.200	<0.500	PASS
TAT96	33	1007	06/12/96	<1.000	<0.200	<0.500	PASS
TAT96	34	1007	06/12/96	<1.000	0.374	<0.500	FAIL
TAT96	35	1007	06/12/96	<1.000	<0.200	<0.500	PASS
TAT96	36	1007	06/12/96	<1.000	<0.200	<0.500	PASS
TAT96	37	1007	06/12/96	<1.000	0.217	<0.500	FAIL
TAT96	38	1007	06/12/96	<1.000	<0.200	<0.500	PASS
TAT96	39	1007	06/12/96	<1.000	<0.200	<0.500	PASS
TAT96	40	1007	06/12/96	<1.000	<0.200	<0.500	PASS

Figure B.3.8 Sample Acceptance Test Results for Nylon Filters

Acceptance Test Results, Nylon Filters--Second Quarter 1996

				Nylon		
Fld Grp	Seq	Lot No.	Analysis Date	ug SO4 97278*IC	ug NO3-N 97281*IC	STATUS
NAT96	11	2112210	05/10/96	<1.000	<0.200	PASS
NAT96	12	2112210	05/10/96	<1.000	<0.200	
NAT96	13	2112210	05/10/96	<1.000	<0.200	PASS
NAT96	14	2112210	05/10/96	<1.000	<0.200	
NAT96	15	2121806	05/10/96	<1.000	<0.200	PASS
NAT96	16	2121806	05/10/96	<1.000	<0.200	
NAT96	17	2121806	05/10/96	<1.000	<0.200	PASS
NAT96	18	2121806	05/10/96	<1.000	<0.200	
NAT96	19	2121806	05/10/96	<1.000	<0.200	PASS
NAT96	20	2121806	05/10/96	<1.000	<0.200	
NAT96	21	2121806	06/11/96	<1.000	<0.200	PASS
NAT96	22	2121806	06/11/96	<1.000	<0.200	
NAT96	23	2121806	06/11/96	<1.000	<0.200	PASS
NAT96	24	2121806	06/11/96	<1.000	<0.200	
NAT96	25	2121806	06/11/96	<1.000	<0.200	PASS
NAT96	26	2121806	06/11/96	<1.000	<0.200	
NAT96	27	2121806	06/11/96	<1.000	<0.200	PASS
NAT96	28	2121806	06/11/96	<1.000	<0.200	
NAT96	29	2121806	06/11/96	<1.000	<0.200	PASS
NAT96	30	2121806	06/11/96	<1.000	<0.200	
NAT96	31	2121806	06/11/96	<1.000	<0.200	PASS
NAT96	32	2121806	06/11/96	<1.000	<0.200	

Figure B.3.9 Sample Acceptance Test Results for Whatman Filters

Acceptance Test Results, Whatman Filters--Second Quarter 1996

Fld Grp	Seq	Impregnation Date	Analysis Date	Whatman ug SO4 97279*IC	Whatman ug NO3-N 97282*IC	STATUS
WAT96	19	04/03/96	04/04/96	<2.000	<0.400	
WAT96	20	04/03/96	04/04/96	<2.000	<0.400	
WAT96	21	04/03/96	04/04/96	<2.000	<0.400	
WAT96	22	04/03/96	04/04/96	<2.000	<0.400	PASS
WAT96	23	04/03/96	04/04/96	<2.000	<0.400	
WAT96	24	04/03/96	04/04/96	<2.000	<0.400	
WAT96	25	04/24/96	04/26/96	<2.000	<0.400	
WAT96	26	04/24/96	04/26/96	<2.000	<0.400	
WAT96	27	04/24/96	04/26/96	<2.000	<0.400	PASS
WAT96	28	04/24/96	04/26/96	<2.000	<0.400	
WAT96	29	04/24/96	04/26/96	<2.000	<0.400	
WAT96	30	04/24/96	04/26/96	<2.000	<0.400	
WAT96	31	05/13/96	05/21/96	<2.000	<0.400	
WAT96	32	05/13/96	05/21/96	<2.000	<0.400	
WAT96	33	05/13/96	05/21/96	<2.000	<0.400	PASS
WAT96	34	05/13/96	05/21/96	<2.000	<0.400	
WAT96	35	05/13/96	05/21/96	<2.000	<0.400	
WAT96	36	05/13/96	05/21/96	<2.000	<0.400	
WAT96	37	05/14/96	05/21/96	<2.000	<0.400	
WAT96	38	05/14/96	05/21/96	<2.000	<0.400	
WAT96	39	05/14/96	05/21/96	<2.000	<0.400	PASS
WAT96	40	05/14/96	05/21/96	<2.000	<0.400	
WAT96	41	05/14/96	05/21/96	<2.000	<0.400	
WAT96	42	05/14/96	05/21/96	<2.000	<0.400	
WAT96	43	05/17/96	05/21/96	<2.000	<0.400	
WAT96	44	05/17/96	05/21/96	<2.000	<0.400	
WAT96	45	05/17/96	05/21/96	<2.000	<0.400	PASS
WAT96	46	05/17/96	05/21/96	<2.000	<0.400	
WAT96	47	05/17/96	05/21/96	<2.000	<0.400	
WAT96	48	05/17/96	05/21/96	<2.000	<0.400	
WAT96	49	06/03/96	06/13/96	<2.000	0.559	
WAT96	50	06/03/96	06/13/96	<2.000	0.643	
WAT96	51	06/03/96	06/13/96	<2.000	<0.400	
WAT96	52	06/03/96	06/13/96	<2.000	0.524	
WAT96	53	06/03/96	06/13/96	<2.000	0.497	
WAT96	54	06/03/96	06/13/96	<2.000	0.590	
WAT96	55	06/03/96	06/13/96	<2.000	<0.400	PASS
WAT96	56	06/03/96	06/13/96	<2.000	0.838	
WAT96	57	06/03/96	06/13/96	<2.000	1.109	
WAT96	58	06/03/96	06/13/96	<2.000	0.720	
WAT96	59	06/03/96	06/13/96	<2.000	<0.400	
WAT96	60	06/03/96	06/13/96	<2.000	<0.400	
WAT96	61	06/03/96	06/13/96	<2.000	0.874	
WAT96	62	06/03/96	06/13/96	<2.000	0.486	
WAT96	63	06/10/96	06/13/96	<2.000	1.234	
WAT96	64	06/10/96	06/13/96	<2.000	<0.400	
WAT96	65	06/10/96	06/13/96	<2.000	1.090	PASS
WAT96	66	06/10/96	06/13/96	<2.000	1.380	
WAT96	67	06/10/96	06/13/96	<2.000	0.751	
WAT96	68	06/10/96	06/13/96	<2.000	<0.400	
WAT96	69	06/17/96	06/21/96	<2.000	0.601	
WAT96	70	06/17/96	06/21/96	<2.000	0.566	
WAT96	71	06/17/96	06/21/96	<2.000	0.637	PASS
WAT96	72	06/17/96	06/21/96	<2.000	<0.400	
WAT96	73	06/17/96	06/21/96	<2.000	<0.400	
WAT96	74	06/17/96	06/21/96	<2.000	<0.400	

Figure B.5.1 Schematic of an EPA Sponsored CASTNet Site (page 1 of 8)

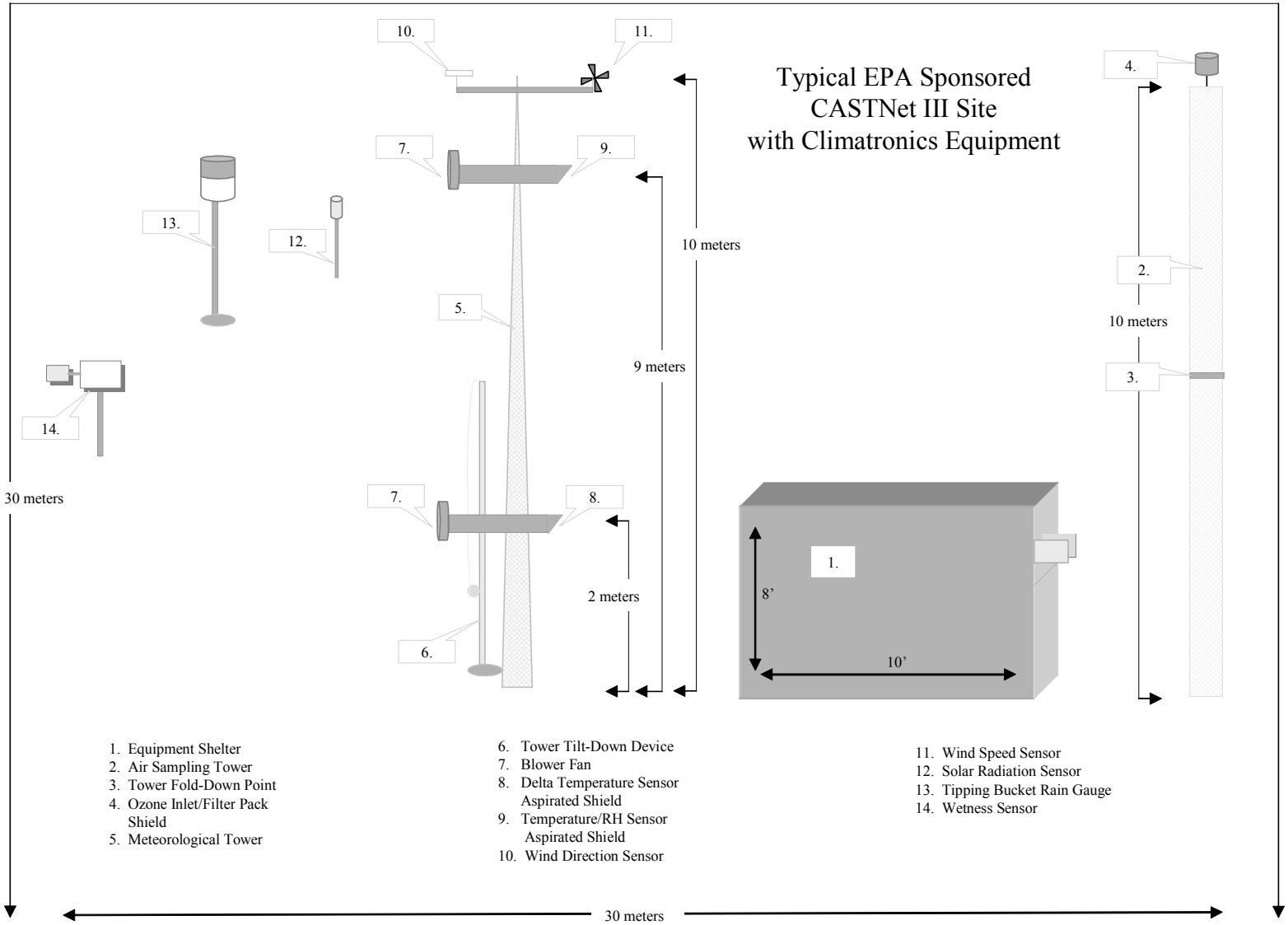


Figure B.5.1 Schematic of an EPA Sponsored CASTNet Site (page 2 of 8)

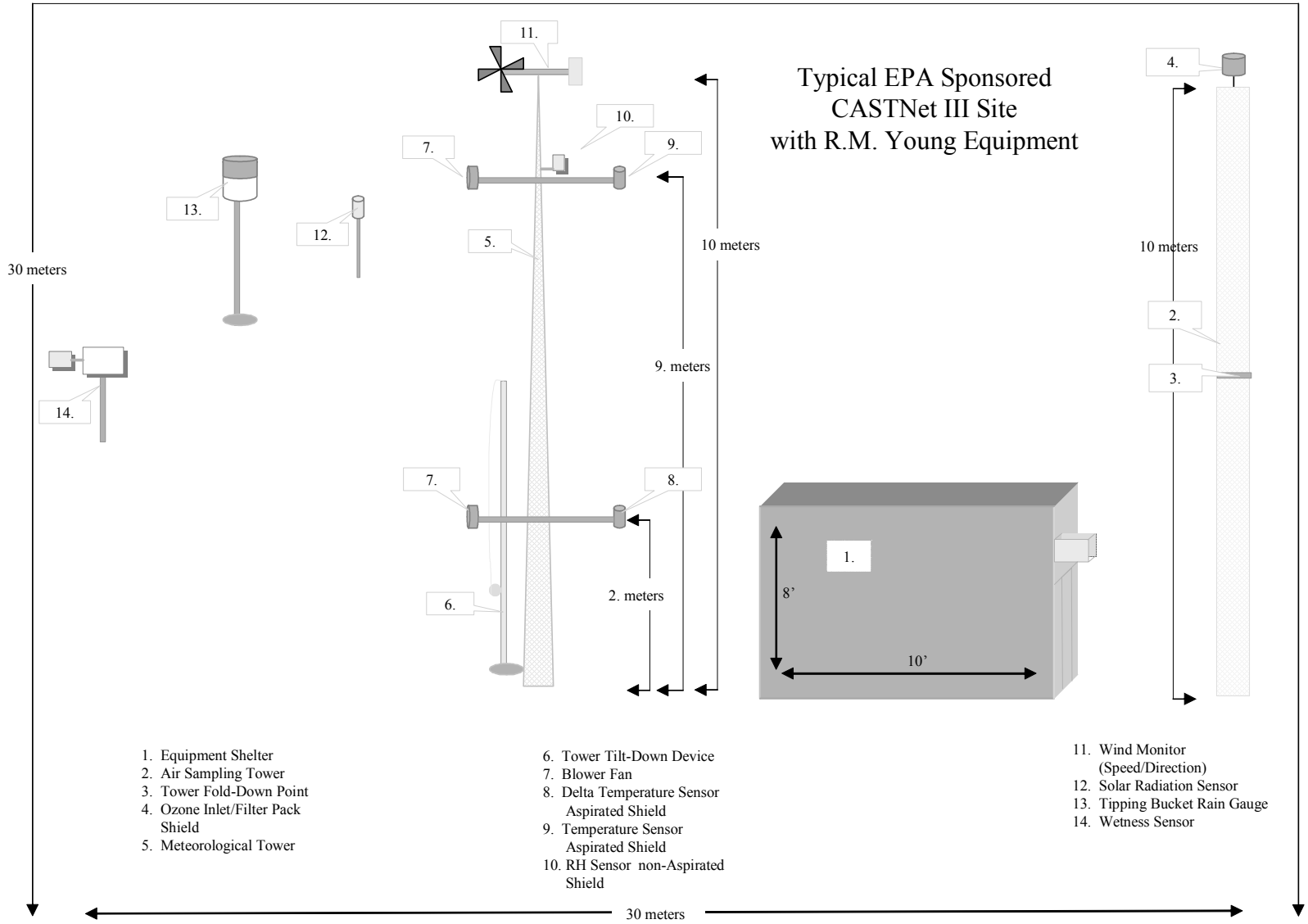


Figure B.5.1 Schematic of an EPA Sponsored CASTNet Site (page 3 of 8)

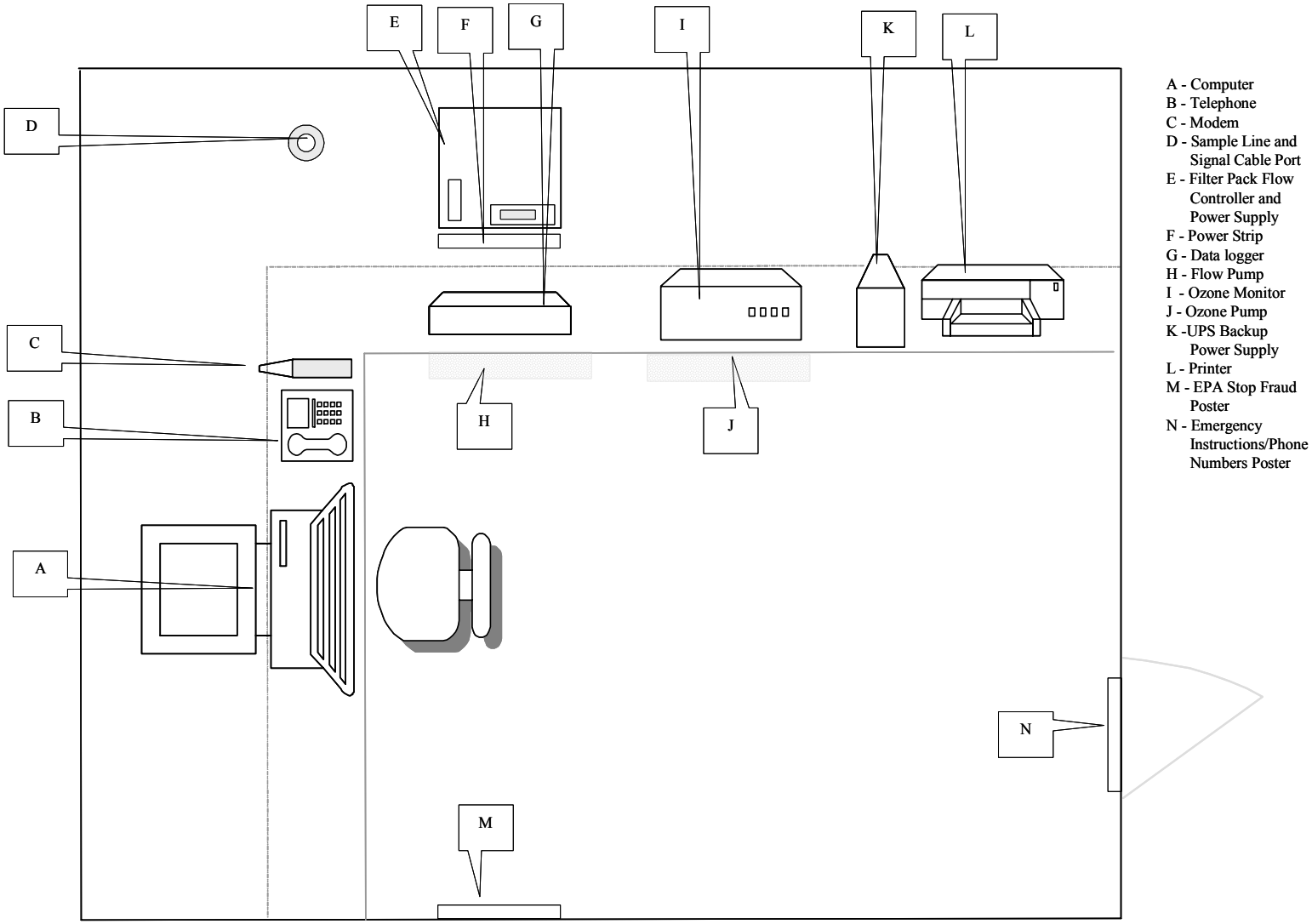
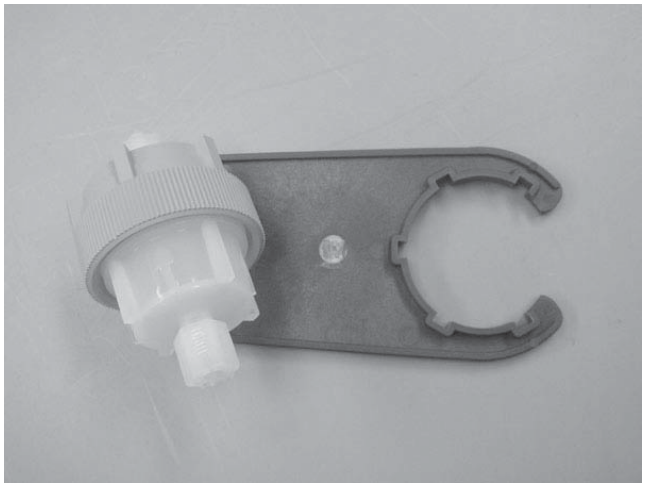


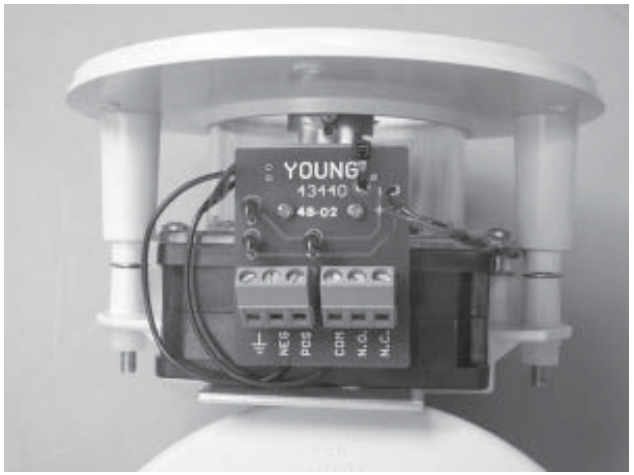
Figure B.5.1 Schematic of an EPA Sponsored CASTNet Site (page 4 of 8)

Ozone Inlet/Filter Pack Shield
See Sections B.5.1.1 and B.5.9.1



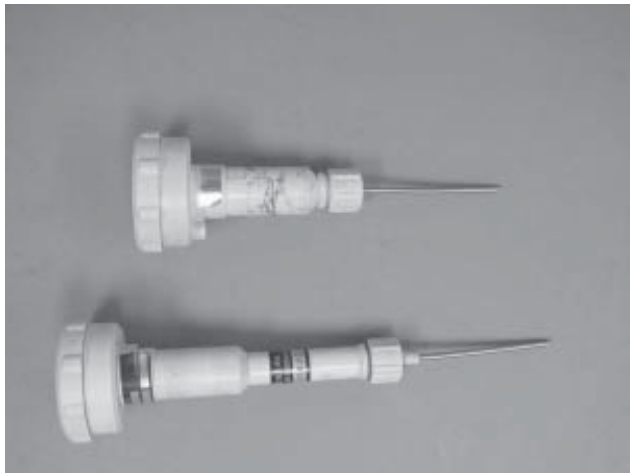
Ozone Filter Cartridge
See Section B.5.1.1

Three-Stage Filter Pack
See Section B.5.9.1

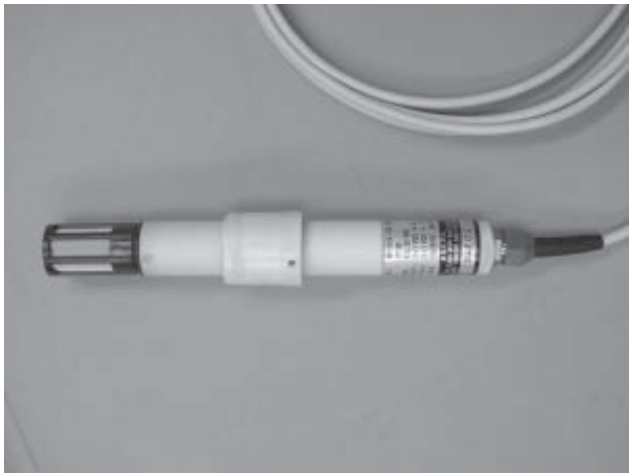


Blower Fan for Aspirated Temperature and RH Sensor
See Section B.5.3.1

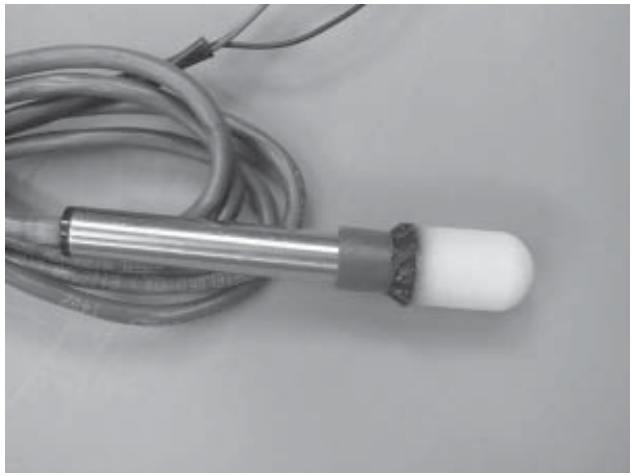
Figure B.5.1 Schematic of an EPA Sponsored CASTNet Site (page 5 of 8)



Temperature (longer) / Delta Temperature Sensors
See Section B.5.3.1



Non-Aspirated RH Sensor (Rotronic)
See Section B.5.4.1



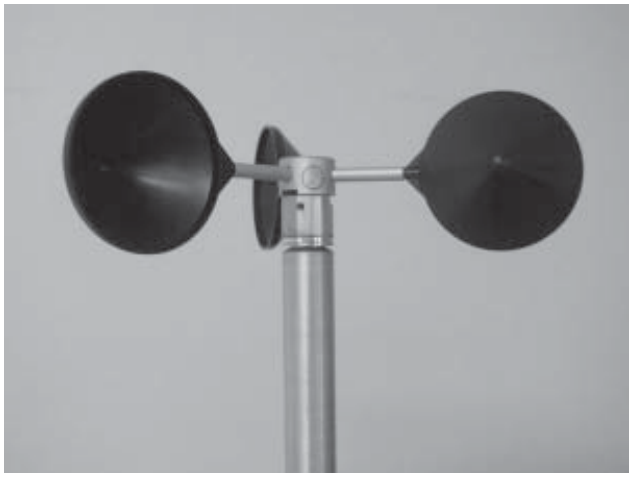
Aspirated RH Sensor (Climatronics)
See Section B.5.4.1

Non-Aspirated RH Sensor Shield
See Section B.5.4.1

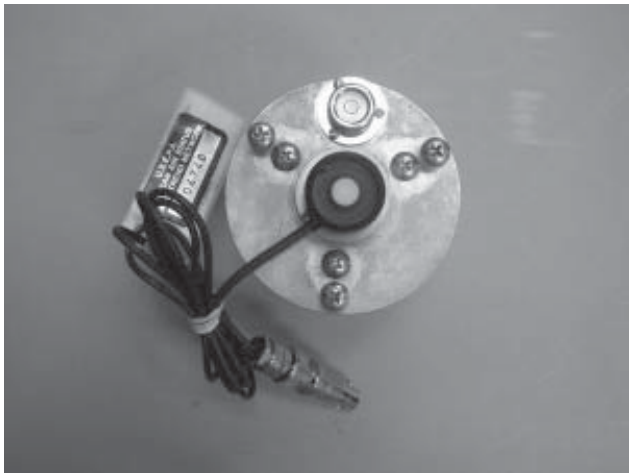
Figure B.5.1 Schematic of an EPA Sponsored CASTNet Site (page 6 of 8)

Wind Sensor (Speed/Direction) - RM Young
See Section B.5.2

Wind Direction Sensor - Climatronics
See Section B.5.2



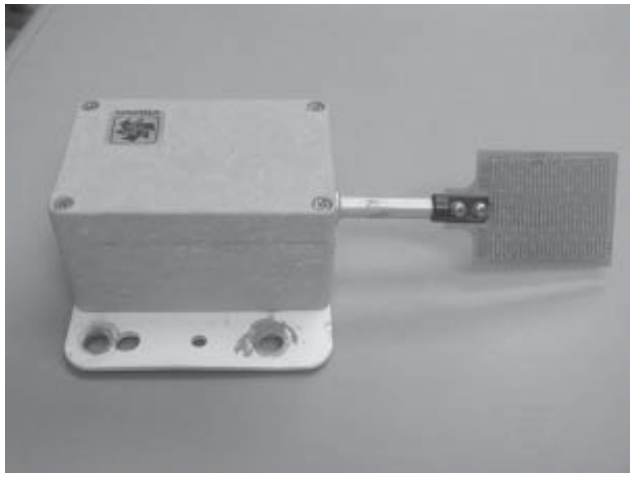
Wind Speed Sensor - Climatronics
See Section B.52



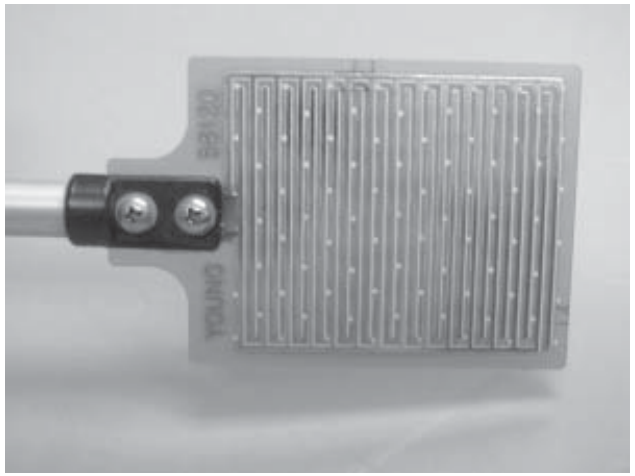
Solar Radiation Sensor
See Section B.5.6

Figure B.5.1 Schematic of an EPA Sponsored CASTNet Site (page 7 of 8)

Tipping Bucket Rain Gauge
See Section B.5.5.1.1



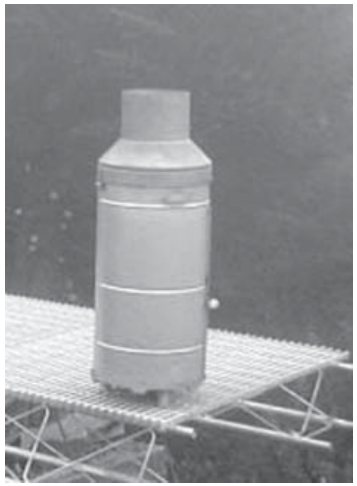
Wetness Sensor
See Section B.5.7.1



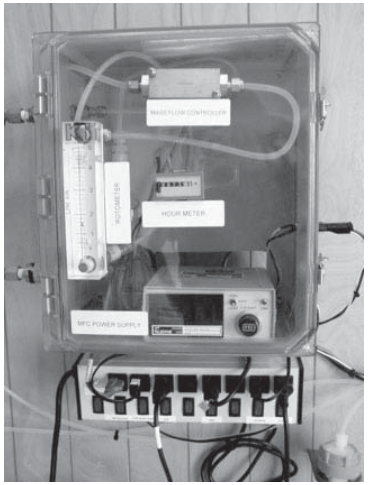
Wetness Sensor Grid
See Section B.5.7.1

Wet/Dry Bucket Collector
See Section B.5.11.1

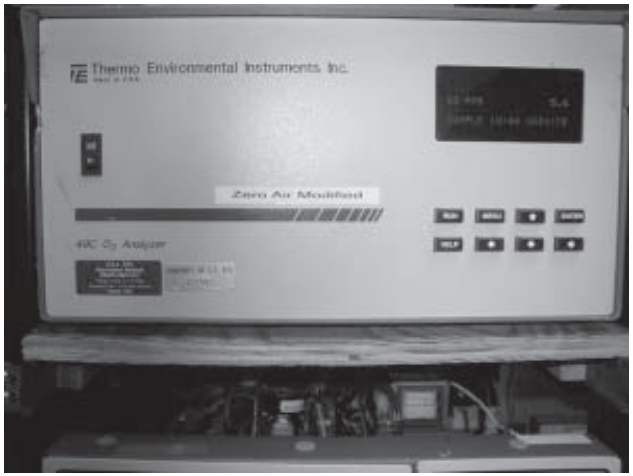
Figure B.5.1 Schematic of an EPA Sponsored CASTNet Site (page 8 of 8)



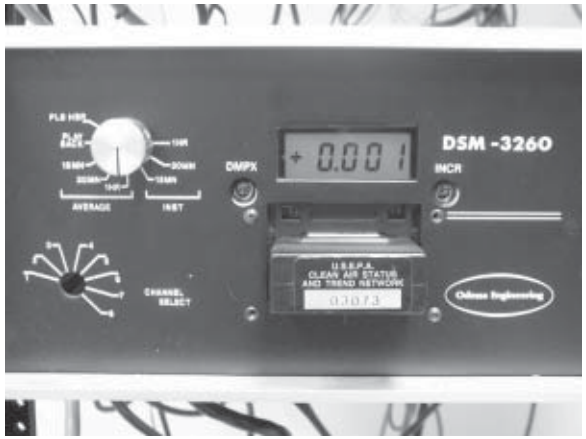
Belfort Weighing Rain Gauge
See Section B.5.5.1.2



Mass Flow Controller
See Section B.59



Ozone Analyzer
See Section B.5.1.1



Data Logger
See Section B.5.12.1

Figure B.5.2 Sample Calibration Result Summaries Form

QST ENVIRONMENTAL

CALIBRATION RESULT SUMMARIES

SITE NAME/NUMBER: PED 108

CALIBRATION DATE: 10/14/98

PARAMETER	UNADJUSTED	ADJUSTED
TEMPERATURE (°C)		
TRANSFER STD	0.46 / 19.88	0.31 / 19.12
SITE SENSOR	0.40 / 19.60	0.24 / 19.04
DELTA TEMPERATURE		
SITE SENSOR	-0.13 / -0.08	-0.08/-0.06
RELATIVE HUMIDITY		
TRANSFER STD	82.0	
SITE SENSOR	85.1	
SOLAR RADIATION (W/M2)		
TRANSFER STD AVG.	670	714
SITE SENSOR AVG.	604	717
WIND SPEED (M/S)		
TRANSFER STD	4.96 / 14.29	4.97 / 9.61
SITE SENSOR	4.85 / 14.25	4.90 / 9.60
WIND DIRECTION 360 / 180	-1 / 0	
PRECIPITATION TIPS / VOLUME	231.5 / 0.49	
WETNESS CHECK	1.02	1.00

FLOW

DAS FULL SCALE:	4.58	PRECAL MFC SETTING:	1.53
DAS ZERO :	0.09	PRECAL FLOW (SLPM):	1.48
MFC SETTING FOR 1.50 OR 3.00 LPM:	1.57	POSTCAL POT SETTING:	N/A
		POSTCAL FLOW (SLPM):	1.51

OZONE

UNADJUSTED		ADJUSTED	
	RE-KEYED		0.9881 RE-KEYED
SLOPE:	~~1.00861~~ 1.0086	SLOPE:	~~0.98805~~
INTERCEPT:	~~-0.53241~~ -0.5325	INTERCEPT:	~~0.86472~~ 0.8647
R2:	~~0.99999~~ 1.0000	R2:	~~0.99999~~ 1.0000
SPAN SETTING:	550	SPAN SETTING:	511
OFFSET SETTING:	51	OFFSET SETTING:	52

COMMENTS: REPLACED O_3 ANALYZER W/ ONE THAT HAS ZAIR KIT BUT THE RELAY BOX STILL NEEDS TO BE REMOVED

CALIBRATED BY: [signature] DATE: 10/15/98

VERIFIED BY: [signature] DATE: 10-25-98

Figure B.5.3 Sample Test Equipment Calibration and Maintenance Record

TEST EQUIPMENT CALIBRATION AND MAINTENANCE RECORD

INSTRUMENT _____

MODEL NUMBER _____

SERIAL NUMBER _____

PURCHASE DATE _____

INSTALLATION DATE _____

PROJECT NAME CAST NET II

PROJECT NUMBER 319850OGB

STATION NAME PRINCE EDWARD, VA

STATION NUMBER PED 108

DATE	CALIBRATION/MAINTENANCE PERFORMED
10/14/98	(1) ADJUSTED PRIMARY DAS
	(2) ADJUSTED SR
	(3) ADJUSTED FLOW
	(4) REPLACED TECO 49-103 O_3 ANALYZER
	WITH ONE HAVING Z-AIR MODIFICATION.
	(5) ADJUSTED BELFORT ZERO
10/15/98	(6) REPLACED WSP SENSOR
	(7) REPLACED FLOW PUMP DIAPHRAM & BALSTON FILTER
	(8) REPLACED Z AIR PUMP DIAPHRAM, CHARC. & DESICCANT
	(9) ERRADICATED WASPS AT POTHEAD
	(10) REMOVED WASP NESTS FROM BOTH BLOWERHOUSINGS

WHITE: Station Log YELLOW: QST PINK: Client File (Optional)

Figure B.5.4 Sample Ozone Data Form

QST ENVIRONMENTAL 1-00861

OZONE DATA FORM

Site Name: PRINCE EDWARD, VA
Site Number: PED 108

Slope: ~~[illegible]~~ Intercept: -0.53246
Correlation Coefficient: 0.99999

Level A Potentiometer Setting: 092
Zero Air Pressure Reading: 15 psi

LEVEL B 117

		1 Ozone Setting: 0		2 Ozone Setting: 400		3 Ozone Setting: 300		4 Ozone Setting: 200		5 Ozone Setting: 100		6 Ozone Setting: 60	
		Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:
Values based on display	1	1 2	1 2	414 416	400 401	305 305	296 296	204 204	196 196	118 118	112 112	59 58	60 60
	2	2 1	3 3	415 415	401 401	305 303	294 295	204 204	198 197	117 117	113 112	58 59	57 59
	3	1 2	2 1	414 416	401 403	306 305	295 296	204 205	197 198	116 116	113 114	58 58	58 56
LEAK CHECK OK	4	2 2	0 2	414 415	401 401	304 306	296 296	205 204	198 198	117 117	114 114	58 58	57 58
	5	2 2	3 2	413 414	401 402	304 305	295 295	203 204	197 198	116 118	113 113	58 57	57 57
	Total												289 290
	Average	2	2	415	401	305	295	204	197	117	113	58	58
	*Actual		2		401		295		197		113		58
	Percent Difference		—	3.5		3.4		3.6		3.5		Ø	
Values based on 5 minute DAS averages	Average	2	2	405	402	298	296	198	197	114	113	57	58
	*Actual		2		402		296		197		113		58
	Percent Difference		—	0.7		0.7		0.5		0.9		-1.7	
				094		084		074		062		054	

Voltage Output: (Unadjusted) Site Analyzer Zero: -0.000 Full Scale: 0.974
Transfer Analyzer Zero: 0.000 Full Scale: 1.000
Voltage Output: (Adjusted) Site Analyzer Zero: ____ Full Scale: ____

(A) Analyzer Mfg.: TECO Model: 49-103 Serial Number: 810809 Sample (A) Frequency: 88k Previous Calibration: 4/28/98
Offset: 51 Sample Flow (A/B): 1.0/1.0 Ozone Flow/Pressure: 15 psi Control (B) Frequency: 90k
Span: 550 Barometric Pressure: 767/768 Cell Temperature (A/B): 35.4/35.4 Noise (A/B): 0.5/0.7
DAS Mfg.: ODESSA Model: 3260 Serial Number 810176
(B) Transfer Mfg.: TECO Model: 49-103 Serial Number: 665603 Sample (A) Frequency: 104k Control (B) Frequency: 98k
Offset: 51 Sample Flow (A/B): 1.0/1.0 Ozone Flow/Pressure: N/A Noise (A/B): 0.7/0.6 Slope: 0.9994
Span: 506 Barometric Pressure: 729/730 Cell Temperature (A/B): 33.3/33.3 Certification Date: 6/1/98 Intercept: 0.2285
DAS Mfg.: ODESSA Model: 3260 Serial Number: ~~810~~ 810176 Coefficient: 1.0000

Comments: REGRESSION BASED ON DISPLAY = CC/0.99999 SLOPE/1.03684 INT/-0.71155

Performed By: [signature] Date: 10/14/98 Reviewed By: [signature] Date: 10-25-98

* Actual for transfer is corrected to EPA SRP by: Actual = Average - Intercept / Slope

** Slope, intercept, and correlation coefficient based on DAS averages

WHITE: Site File YELLOW: QST PINK: EPA

Figure B.5.5 Sample Ozone Precision Control Chart

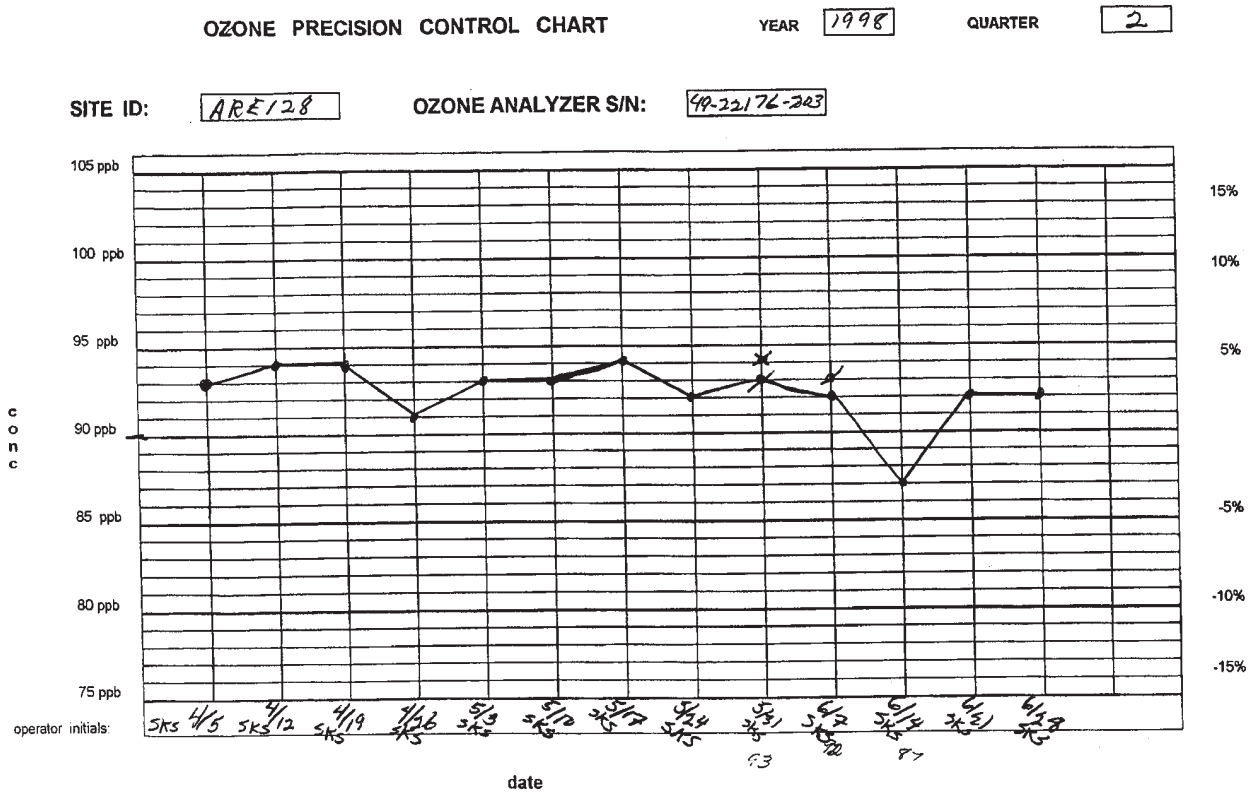


Figure B.5.6 Sample Control Chart Produced from Polled Data

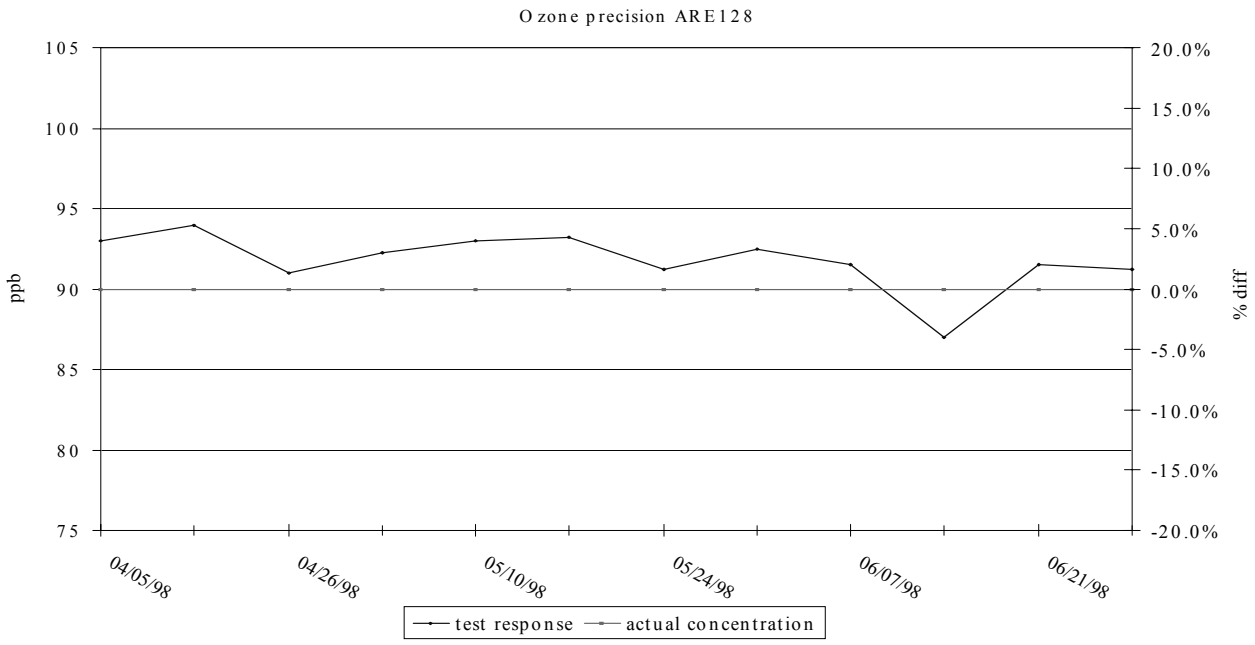


Figure B.5.7 Sample Control Chart Produced from Polled Data

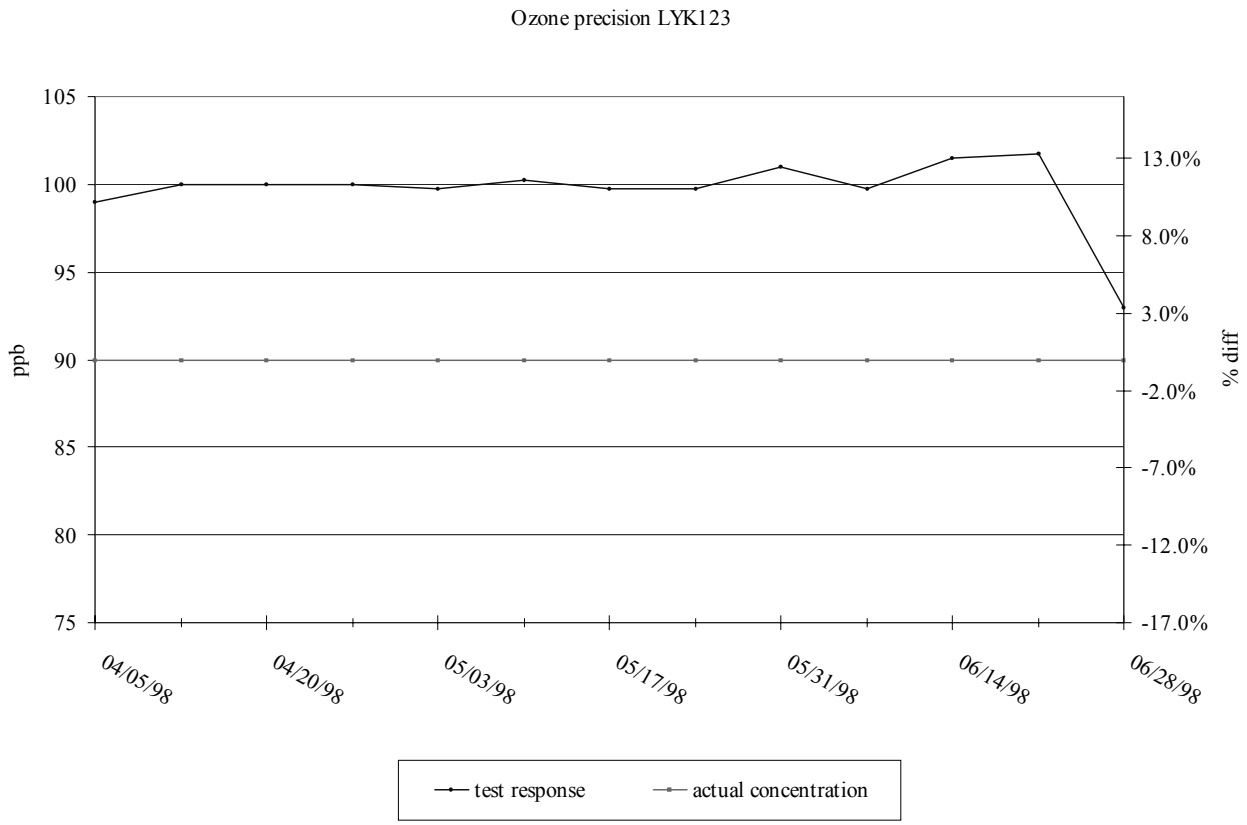


Figure B.5.8 Sample Control Chart Produced from Polled Data

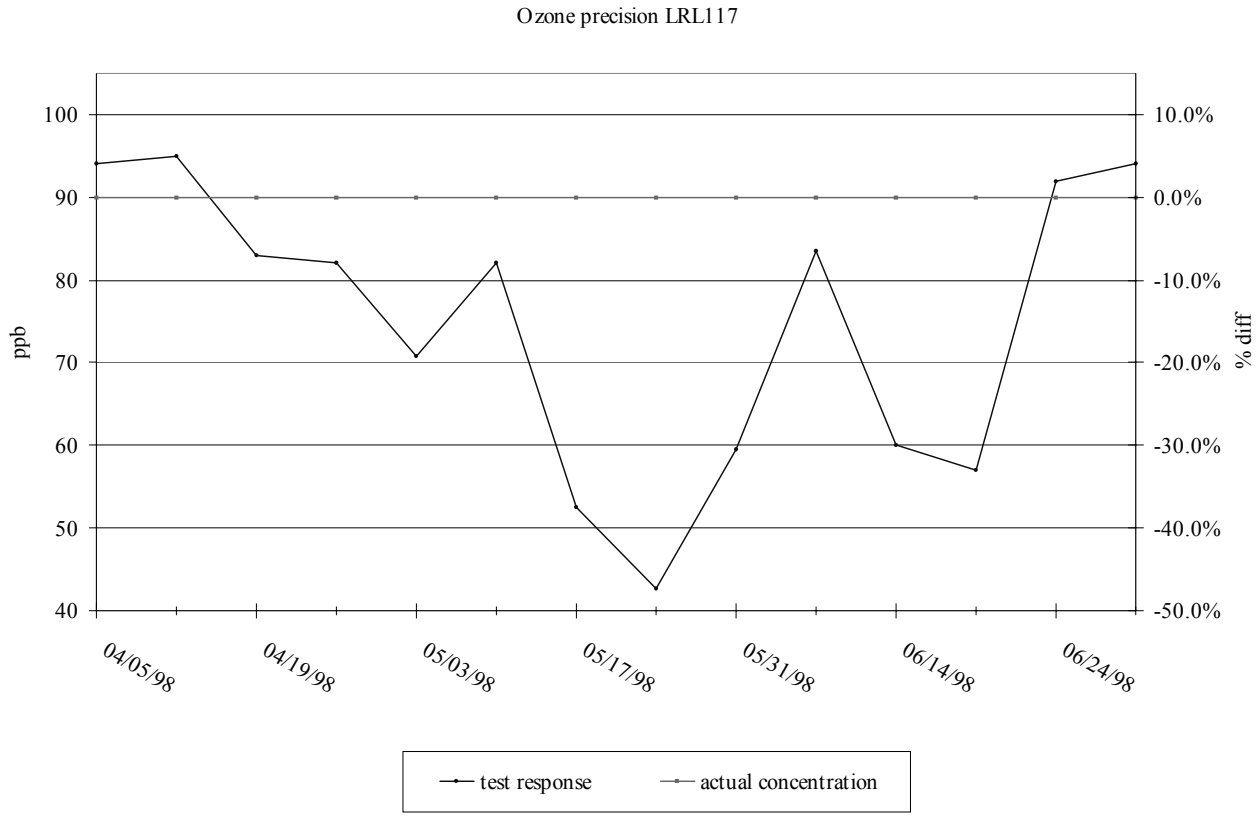


Figure B.5.9 Sample Site Narrative Log

ESE Environmental Science & Engineering, Inc.

№ 0058

PROJECT NUMBER _____ PARAMETER _____

PROJECT NAME _____ PROJECT LOCATION PED 108

NARRATIVE LOG

DATE	COMMENTS
10/15/98 (288)	RKB ONSITE TO FINISH CALS AND MAINT. FLOW PUMP OFF AT 0830 FOR WASP REMOVAL. HM/50.41. NOTE – THIS TIME OF YEAR SR IS IN SHADOWS FROM SIGNATURE _____
	TREELINE TO EAST UNTIL ABOUT 0930. FILTER BACK ON, TOWERUP, PUMP ON AT 0958/51.00 hm HOURMETER RAN FOR 0.59 HOURS DURING CALIBRATION CAL RESULTS SIGNATURE _____
	FOUND #1 VOLTAGE 3 mv low AT 0.9–1.0 VDC, 2mv low FROM 0.5–0.8 VDC AND within 1mv BELOW THAT. (#2 WAS Accurate) PERFORMED UNADJUSTED T/ΔT CHECK, THEN ADJUSTED #1. SIGNATURE RKB

WHITE COPY: ESE YELLOW COPY: ESE PINK COPY: STATION LOG FORMS 4/87094

Figure B.5.10 Sample Wind System Data Form

— UNADJUSTED — (see adjusted) WSP

Forms 7 92113

QST	WIND SYSTEM DATA FORM

Site Name/Number: PED 108 Site Location: PRINCE EDWARD, VA

Magnetic Declination: −8° 4.3′ DSM 3260 S/N: 810176

Crossarm Alignment: TRUE N/S DSM 3260L S/N: 01130

WIND DIRECTION		
Sensor Mfg.: ELIMATRONICS	Translator S/N: 00751	
Sensor S/N: 00760	Translator Zero: −0.004 / 0.000	
Vane S/N: 238	Translator Span: 0.664 / 0.666	
	Translator 540: 0.664 / 0.666	

UNADJUSTED

NONE MADE

DDR SENSOR & F460 CARD REPLACED BY OP on 7/28/98

VANE DIRECTION	DAS OUTPUT 3260 Voltage	3260L Voltage	Degrees	REMARKS (condition of tower, vane, cups, etc.):
S. / TAIL - KARN	0.334		180°	
N. / NOSE - KARN	0.665		359°	WDR BEARINGS = 7-9 gm/cm
E1 ✓	0.831		89°	
W	0.501		270°	
E2	0.165		89°	
<RE-CHECKED AFTER ADJUSTING Z/S - O.K.>				
— see calibration on printout for results —				

WINDSPEED		
Sensor Mfg.: ELIMATRONICS	Translator S/N: 00751	
Sensor S/N: 00610	Cups S/N: 111	
Synchronous Motor Mfg.: RMY	Translator Zero: 0.004	
Synchronous Motor S/N(s): 02911	Translator Span: 0.4967	

UNADJUSTED

SYNCHRONOUS MOTOR RPM	FREQUENCY	EQUIVALENT WINDSPEED* (M/S)	DAS OUTPUT 3260 Voltage	3260L Voltage	M/S
cups off	0.00	0.2	0.004		0.2
100	54.64	2.79	0.055		2.75
200	100.70	4.96	0.097		4.85
400	210.90	10.14	0.202		10.10
600	299.30	14.29	0.285		14.25
1600	799.10	37.78	0.754		37.70
WSP	BEARINGS =	0.2 gm/cm			

* [(Frequency / 9.511) + 0.5] / 2.237 = Windspeed in M/S.

Remarks: cups & vane OK
TOWER OK

Performed by: [signature] Date: 10/14/98 Calibrated: ☑

Reviewed by: [signature] Date: 10/25/98 Audited: ☑

WHITE: Site File YELLOW: ESE PINK: EPA

Figure B.5.11 Sample Temperature/Relative Humidity Data Form

QST ENVIRONMENTAL

TEMPERATURE/RELATIVE HUMIDITY DATA FORM

Site Name/Number: PED 108 **Site Location:** PRINCE EDWARD, VA

DSM 3260 S/N: 810176 **DSM 3260L S/N:** 01130

TEMPERATURE

10-m Sensor S/N: 04172 Translator S/N: 01582

2-m Sensor S/N: 02652

RTD S/N: 04101

	UNADJ #1	UNADJ #2	ADJ #1		UNADJ #1	UNADJ #2	ADJ #1
Temp. Zero	~~0.003~~	~~-0.000~~	-0.004	ΔTemp. Zero:	-0.001	0.001	-0.001
Temp. Span	0.995	0.999	0.997	ΔTemp. Span:	0.996	0.999	0.998

UNADJUSTED PRIOR TO ADJ. OF #1 DAS V+

THERMOMETER READING (°C) Uncorrected	Corrected	DAS TEMPERATURE OUTPUT 3260 Voltage	3260L Voltage	Temp. (°C)	DAS ΔTEMPERATURE OUTPUT 3260 Voltage	3260L Voltage	Temp. (°C)
0.47	0.46	0.380	0.382	0.40	0.487	0.491	-0.13
22.44	22.42	0.651	0.654	22.08	0.492	0.495	-0.08
44.20	44.18	0.925	0.929	44.00	0.497	0.499	-0.03
32.64	32.64	0.781	0.784	32.48	0.494	0.496	-0.06
19.90	19.88	0.620	0.622	19.60	0.492	0.494	-0.08
19.14	19.12	0.613	0.613	19.04	0.494	0.494	-0.06
0.32	0.31	0.378	0.379	0.24	0.492	0.493	-0.08
45.08	45.06	0.938	0.939	45.04	0.494	0.495	-0.06
32.87	32.87	0.785	0.786	32.80	0.494	0.495	-0.06

ADJUSTED PRIMARY DAS V+ -ONLY-

RELATIVE HUMIDITY

Sensor S/N: 03670 Translator S/N: 03701

Transfer S/N: 00106 Translator Zero/Span: 0.004 / 1.002 UNADJ; ~~0.000 / 1.000~~ ADJ

GTL 80.0	SALT	82.0 EQUIVALENT RELATIVE HUMIDITY	0.851 DAS OUTPUT 3260 Voltage	3260L Voltage	85.1 % Rel. Hum.
	KNO3	93.6	0.791		79.1
	NACL	75.3	0.773		77.3
	MGCL2	32.8	0.484		48.4
	~~REQUESTED FRESH SALTS~~				
32.8		33.8	0.395		39.5

QUESTIONABLE SALTS

UNADJ

CHECKED W/GTL 10/15/98

Remarks: USE GTL RESULTS FOR RH VALIDATION

Performed by: [signature] Date: 10/15/98 Calibrated: ☑

Reviewed by: [signature] Date: 10-25-98 Audited: ☑

WHITE: Site File YELLOW: QST PINK: EPA C1/93012 12/93ss

Figure B.5.12 Sample Belfort Rain Gauge Calibration Chart

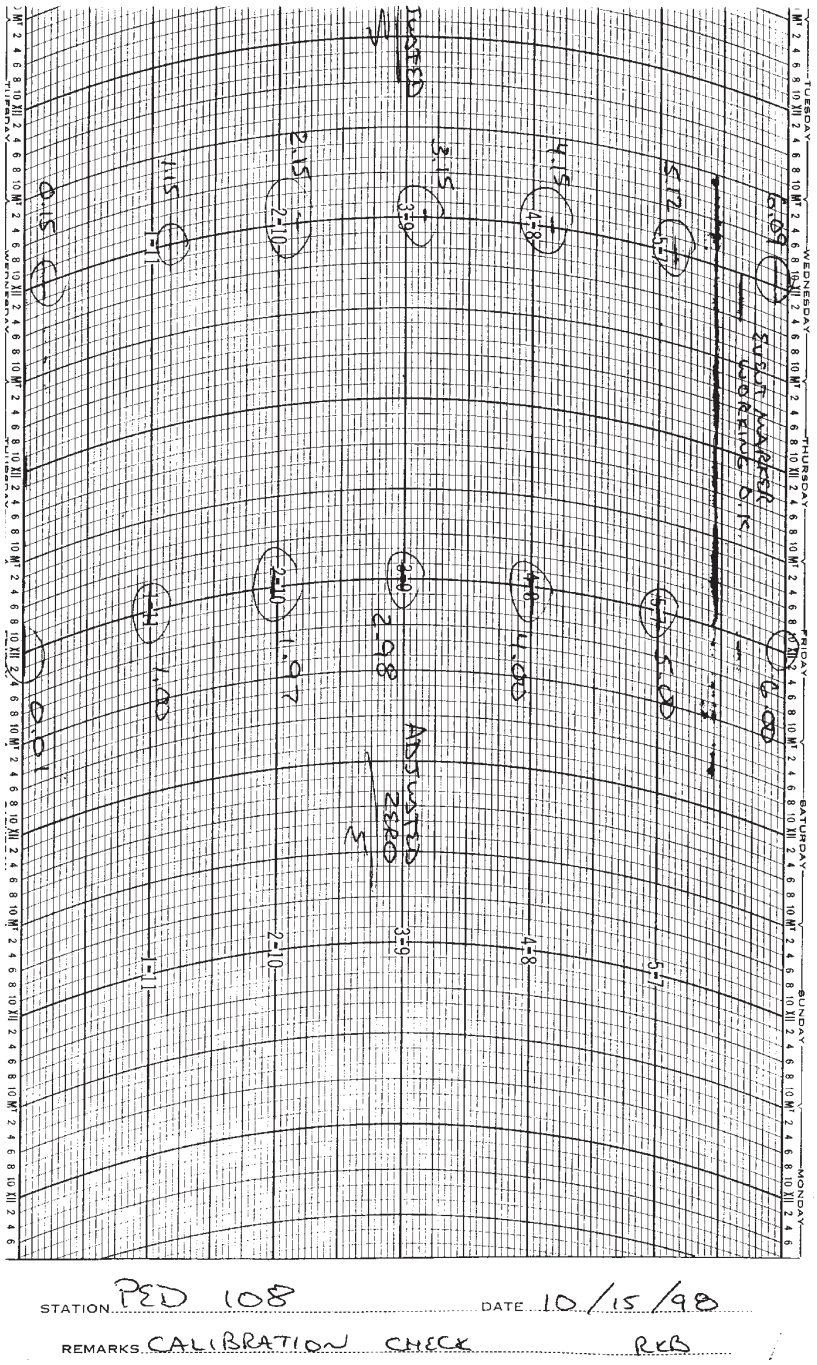


Figure B.5.13 Sample Precipitation Data Form

Forms 7 92112

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.	PRECIPITATION DATA FORM

Site Name/Number: PED 108 **Site Location:** PRINCE EDWARD, VA

Gauge Mfg.: CLIMATRONICS DSM 3260 S/N: 810176

Gauge S/N: 01613

UNADJ T.B. is clean and level

TIPPING-BUCKET RAIN GAUGE

Volume H_2O	Equivalent Inches of Rain	Approximate Time Per Tip	3260 DAS Output
ten tip	0.10	12 sec	0.10
231.5 ml	0.50	12-15 sec	0.49 / 0.50
	NO ADJUSTMENT REQUIRED		
Wetness S/N: 036658	Wetness Test:	Wet UNADJ / ADJ	Dry UNADJ / ADJ
	Output Volts	1.013 / 1.001	0.007 / 0.007
	Output Units	1.02 / 1.00	0.01 / 0.01

810709 WEIGHING-TYPE RAIN GAUGE

Weights Added FACTORY STANDARD WTS.	Equivalent Inches of Rain	Recorder Response UNADJ.	Recorder Response ADJ. ZERO	WEIGH
0	0	0.15	6.00	6
1	1	1.15	5.00	5
2	2	2.15	4.00	4
3	3	3.15	2.98	3
4	4	4.15	1.97	2
5	5	5.12	1.00	1
6	6	6.09	0.01	0

Remarks: Aerochem # 809092 EVENT MARKER WORKING FINE.

Performed by: [signature] Date: 10/15/98 Calibrated: ✓

Reviewed by: [signature] Date: 10/25/98 Audited: ✓

WHITE: Site File YELLOW: ESE PINK: EPA

Figure B.5.14 Sample Solar Radiation Data Form

Environmental Science & Engineering, Inc.	SOLAR RADIATION DATA FORM

Site Name/Number: PED 108 Site Location: PRINCE EDWARD, VA

Sensor Mfg.: LICOR
Sensor S/N: 02694
Translator Mfg.: CLIMATRONICS
Translator S/N: 04075
Translator Zero: -0.000 Span: 0.998
ADJ- 0.000 1.000

Transfer Standard Mfg.: LICOR / RMY
Transfer Standard Sensor S/N.: 02736
Transfer Standard Translator S/N: 01830
DSM 3260 S/N: 810176
DSM 3260L S/N: 01130
Transfer Translator ~~Zero~~ INT 17.74137 ~~Span~~ SLOPE 0.97786

Hour	X Transfer Standard Response (from DAS)	Y Sensor Response (from DAS)	Remarks
1305	708 (706)	638	
10	702	632	
15	695	625	$\bar{X}$ = 673.18182
20	691	621	corr = 670.28045
25	686	616	
30	678	608	$\bar{Y}$ = 604.27273
40	668	599	
45	656	587	
50	649	582	-9.8 Δ% AVG
55	641	574	
1400	631	565	(-9.6 Δ% HIGHEST VALUE)
[redacted]	ADJUSTED AT	1450 10/14/98	TWEAKED AT 1159 10/15/98
1205	712	711	
10	719	720	$\bar{X}$ = 716.25000
15	723	722	corr = 714.32375
20	738	(735) 736	
25	708	707	$\bar{Y}$ = 716.66667
30	727	728	
35	707	709	0.3 Δ% AVG
40	727	725	
45	709	709	
50	713	712	(0.4 Δ% HIGHEST VALUE)
55	710	711	
1300	707	705	

SENSOR Y TRANSFER X

Performed by: [signature] Date: 10/15/98 Calibrated: ☑
Reviewed by: [signature] Date: 10/25/98 Audited: ☐

White Copy: Site File Yellow Copy: ESE Pink Copy : USEPA NDDN2/FORMS/RAD.1-P

Figure B.5.15 Sample Nephelometer Operator Log Sheet

OCT.14.1998 9:06AM AIR RESOURCE SPECIAL NO.089 P.1/1

Air Resource Specialists, Inc.

Location CDZ571

CASTNET NGN-2 NEPHELOMETER OPERATOR LOG SHEET

Date 7-26-98 Local Time 12 : 35 ( ) Operator(s) D. Chesnut

Weather Conditions Cloudy, Warm, + wind, Distant HAZE

Visibility Conditions 6 Miles

Support Tower, Guy Wires and/or Other Structural Components

1. Describe general physical condition: Good

Nephelometer

1. Nephelometer serial number: NGN-2-34
2. Describe general physical condition of the nephelometer: Changed out analog + serial chips
3. Is the nephelometer door open? (YES) NO
4. If the door is open, is the lamp cycling at the 2 minute ON, 3 minute OFF schedule? (YES) NO
   Did you change the lamp? YES (NO) If YES, note time nephelometer was reset (HH:MM): 13:58
5. What is the condition of the nephelometer screen? Good (If the screen is very dirty, call ARS for Instructions)
6. Is the nephelometer sample fan on? (YES) NO Condition of the fan and fan guard? OK
7. Listen to the nephelometer. Is the clean air pump on? YES (NO)
8. For nephelometers equipped with desiccant clean air drying option: N/A
   What color is the desiccant? BLUE BLUE/PINK PINK Did you change the desiccant canister? YES NO

Operator Initiated Zero and Span Check - Every Other Week

1. If you are scheduled to perform a zero and span check, carry out the following procedures:
   a. Attach span gas calibration system to the nephelometer span gas hose.
   b. Turn on the span gas tank valve 1/2 turn.
   c. Press and hold the power reset button on the nephelometer power supply for 5 seconds.
      Record the date and time the button was pressed (MM-DD-YY HH:MM:SS): 07-26-98 13:58:
   d. The nephelometer will initiate its Power-On Self Test (POST). Document that the POST functions operate correctly:
      - Door open and close? (YES) NO
      - Lamp on and off? (YES) NO
      - Solenoid on and off? (YES) NO
      - Clean air pump on and off? (YES) NO
      - Fan on and off? (YES) NO
   e. Following the POST, the system will begin the 20 minute span calibration:
      Adjust the regulator control valve to 8 PSI. Record the outlet pressure: 8 PSI
      7.0 volts DC will appear on the nephelometer status line (Datalogger channel NPHSTA).
      Nephelometer will perform the 20 minute span calibration.
      The span calibration result will appear on the nephelometer data line (Datalogger channel NPHNRM).
      3.0 volts DC will appear on the nephelometer status line (Datalogger channel NPHSTA).
   f. Record the span calibration result from Datalogger channel NPHNRM: 0.135 (VOLT/2)
   g. Following the span calibration, the nephelometer will open for 1 minute to exhaust the span gas.
   h. The nephelometer will begin the 15 minute zero calibration :
      7.0 volts DC will appear on the nephelometer status line (Datalogger channel NPHSTA).
      The nephelometer will perform the 15 minute zero calibration.
      The zero calibration result will appear on the nephelometer data line (Datalogger channel NPHNRM).
      2.0 volts DC will appear on the nephelometer status line (Datalogger channel NPHSTA).
   i. Record the zero calibration result from Datalogger channel NPHNRM: 0.055 (VOLT/2)
   j. When the nephelometer opens the door after 35 minutes the zero and span sequence is complete.
   k. TURN THE SPAN GAS TANK VALVE TO THE FULL OFF POSITION
      DISCONNECT AND STORE THE SPAN GAS CALIBRATION SYSTEM
      Note the time the span gas was turned off (HH:MM:SS): 14:39:

Changed filter + Memory Module

2. Call ARS immediately if you have any problems or questions.

Send the original white copy of this form to:

Data Coordinator
Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, CO 80525

Phone: 970-484-7941
Fax: 970-484-3423

Unit Seems OK

(3/98)

OCT 14 '98 11:15 PAGE.01

Figure B.5.16 Sample Flow Pre-Calibration Data Form

QST ENVIRONMENTAL

FLOW PRE-CALIBRATION DATA FORM

Site Name/Number: PED 108 **Site Location:** PRINCE EDWARD, VA

MFC Mfg: TYLAN MFC ID Number: 02044

Readout ID Number: 01725

Transfer MFM Mfg: TYLAN MFM ID Number: AW801135

Transfer Last Calibration Date: 6/26/98 Readout ID Number: FP 9304007/02951

Transfer MFM Calibration Slope: 1.0044 Intercept: -0.0296

Rotameter Existing: 1.6

	TRANSFER FLOW		MFC DISPLAY	3260 VOLTAGE	3260L VOLTAGE
	Display	STP*			
Pump Off (Zero Value)	0.02	0.00	-0.02	0.003	0.003
Existing Flow	1.46 (RD)	1.48	1.53	0.306	0.306
Adjusted Zero Value		0.00			
LEAK CHECK	0.02	—	-0.02	0.004	0.004

* STP = 25°C, 760mm Hg.

3260 OUTPUT = (0.306) v (4.70) + 0.06 = 1.50 lpm Δ% = 1.4

OUTPUT = 3260v (Full Scale - Zero Value) + Zero Value

Existing DSM Full-Scale Value: 4.76 Existing Zero: 0.06 Existing ~~Potentiometer~~ DISPLAY Setting: 1.53

Full-Scale = (1.00 - Intercept)/Slope Zero = (0.00 - Intercept)/Slope

Pump Max. Flow: +5 slpm

Comments: REPLACED BALSTON FILTER 3d PUMP DIAPHRAM AND RE- LEAK CHECKED /OK

THEN PERFORMED FULL CALIBRATION

Performed by: [signature] Date: 10/15/98

Reviewed by: [signature] Date: 10-25-98

FORMS7 91182

White: Site File Yellow: QST Pink: EPA

Figure B.5.17 Sample Flow Calibration Data Form

HOWMATIC KAN FOR 0.57 HOURS DURING CALIBRATION.

ESE Environmental Science & Engineering, Inc.

FLOW CALIBRATION DATA FORM

Site Name/Number: PED 108 Site Location: PRINCE EDWARDS, VA

MFC Mfg: TYLAN MFC ID Number: 02044

Readout ID Number: 01725

Transfer MFM Mfg: TYLAN MFM ID Number: AW801135

Transfer Last Calibration Date: 6/26/98 Readout ID Number: 02951

Transfer MFM Calibration Slope: 1.0044 Intercept: -0.0296

	TRANSFER FLOW		MFC DISPLAY	3260 VOLTAGE	3260L VOLTAGE
	Display	STP*			
Leak Check	0.02	—	-0.02	0.004	0.004
Pump Off	0.02	0.00	-0.02	0.003	0.003
	0.77	0.80	0.79	0.158	0.158
	1.01	1.04	1.05	0.211	0.210
	1.23	1.25	1.29	0.258	0.258
	1.48	1.50	1.56	0.312	0.312
	1.76	1.78	1.87	0.375	0.375
	1.98	2.00	2.12	0.424	0.424
	2.20	2.22	2.38	0.475	0.474
Post Calibration Check	1.49	1.51	1.57	0.314	0.314

* STP = 25°C, 760mm Hg. Final Rotameter: 1.6

3260 Voltage vs STP Slope: 0.22264 Intercept: -0.02067 R^2: 0.99997

Final DSM Full-Scale Value: 4.58 Final Zero: 0.09

Full-Scale = (1.00 - Intercept)/Slope Zero = (0.00 - Intercept)/Slope

MFC Display vs STP Slope: 1.11602 Intercept: -0.10837 R^2: 0.99993

MFC Display for 1.50 lpm or 3.00 lpm: 1.56/1.57 (1.565) MFC ~~Potentiometer~~ DISPLAY Setting: 1.57

Final 3260 Output = (0.314)(4.49)+(0.09) = 1.50 lpm Δ% = -0.7

3260 Output = 3260v (Full Scale - Zero Value) + Zero Value

Performed by: [signature] Date: 10/15/98

Reviewed by: [signature] Date: 10-25-98

FORMS7 91183

White: Site File Yellow: ESE Pink: EPA

Figure B.5.18 Sample Data Acquisition System Calibration Form

Environmental Science & Engineering, Inc.

DATA ACQUISITION SYSTEM CALIBRATION FORM

Site Name / Number: PED 108 Site Location: PRINCE EDWARD, VA

Primary DAS / Model: ODESSA 3260 S / N: 810176

Backup DAS / Model: ODESSA 3260L S / N: 01130

Voltage Source / Model: DATEL 350A S / N: 04021

Voltage Source Output (VDC)	Primary DAS Reading		Backup DAS Reading	
	Unadjusted (VDC)	Adjusted (VDC)	Unadjusted (VDC)	Adjusted (VDC)
0.0000	-0.000	-0.001	0.000	
0.1000	0.100	0.100	0.100	
0.2000	0.199	0.200	0.200	
0.3000	0.299	0.300	0.300	
0.4000	0.399	0.400	0.400	
0.5000	0.498	0.500	0.500	
0.6000	0.598	0.600	0.600	
0.7000	0.698	0.700	0.700	
0.8000	0.798	0.800	0.800	
0.9000	0.897	0.900	0.900	
1.0000	0.997	1.000	1.000	

REMARKS: #2 WAS 2 MIN SLOW - RESET @ 0940 - STATUS O.K. BUT KNOBS ON FRONT WERE WRONG FOR CHANNELS TO RECORD TO CART. - CORRECTED. HAS E-301 FIRMWARE, SO J DAY IS CORRECT, BUT CALENDER DATE IS ONE DAY BEHIND. #1 TIME, DATE, STATUS ALL O.K. PERFORMED WATER T/ΔT CAL PRIOR TO ADJUSTING PRIMARY DAS. BACKUP BATT = 13V, CHARGER WORKING. CLIM MAINFRAME ± 12V. BACK UP SYSTEM OK

Performed by: [signature] Date: 10/14/98 Calibrated ☑

Reviewed by: [signature] Date: 10/25/98 Audited ☑

White Copy: Site Log *Yellow Copy: ESE* *Pink Copy: USEPA*

NDDN 2/Data 4 990LB

Figure B.6.1 Laboratory Operations for Filter Packs

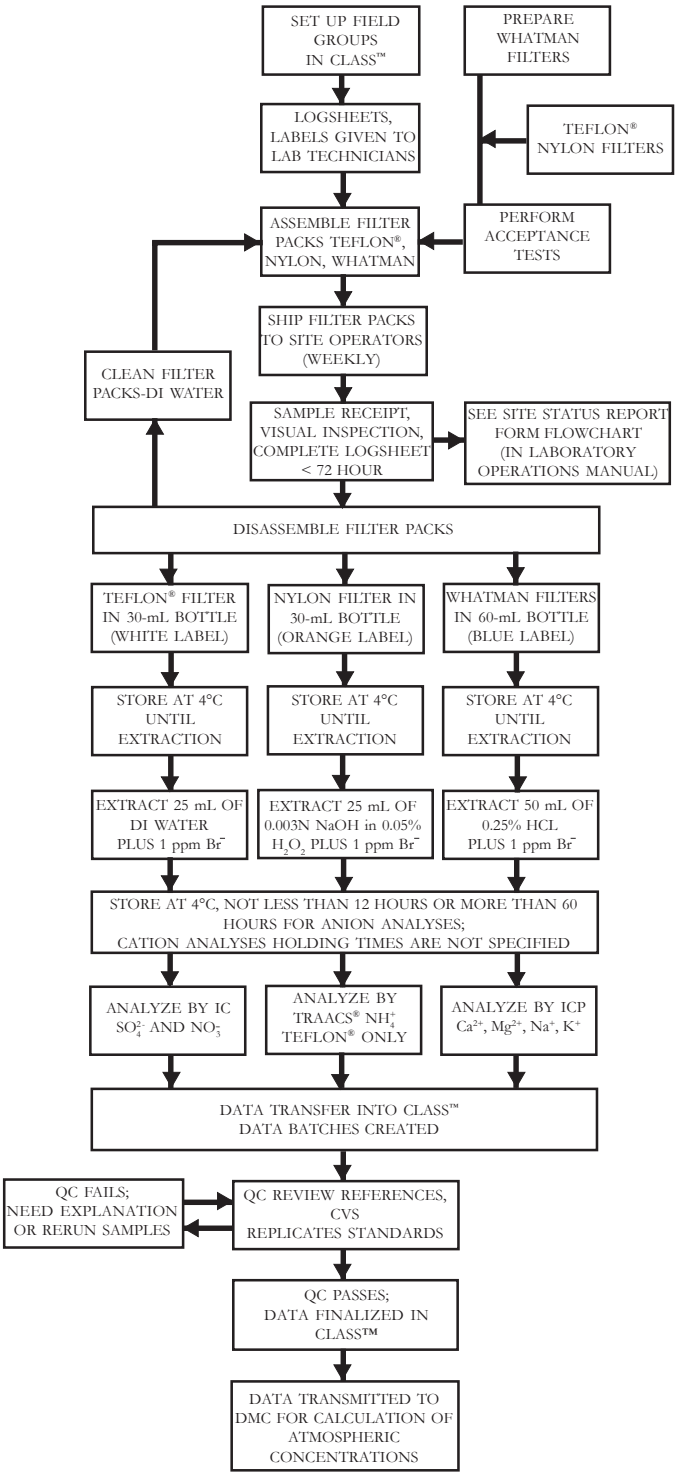


Figure B.6.2 Laboratory Operations for Visibility Samples

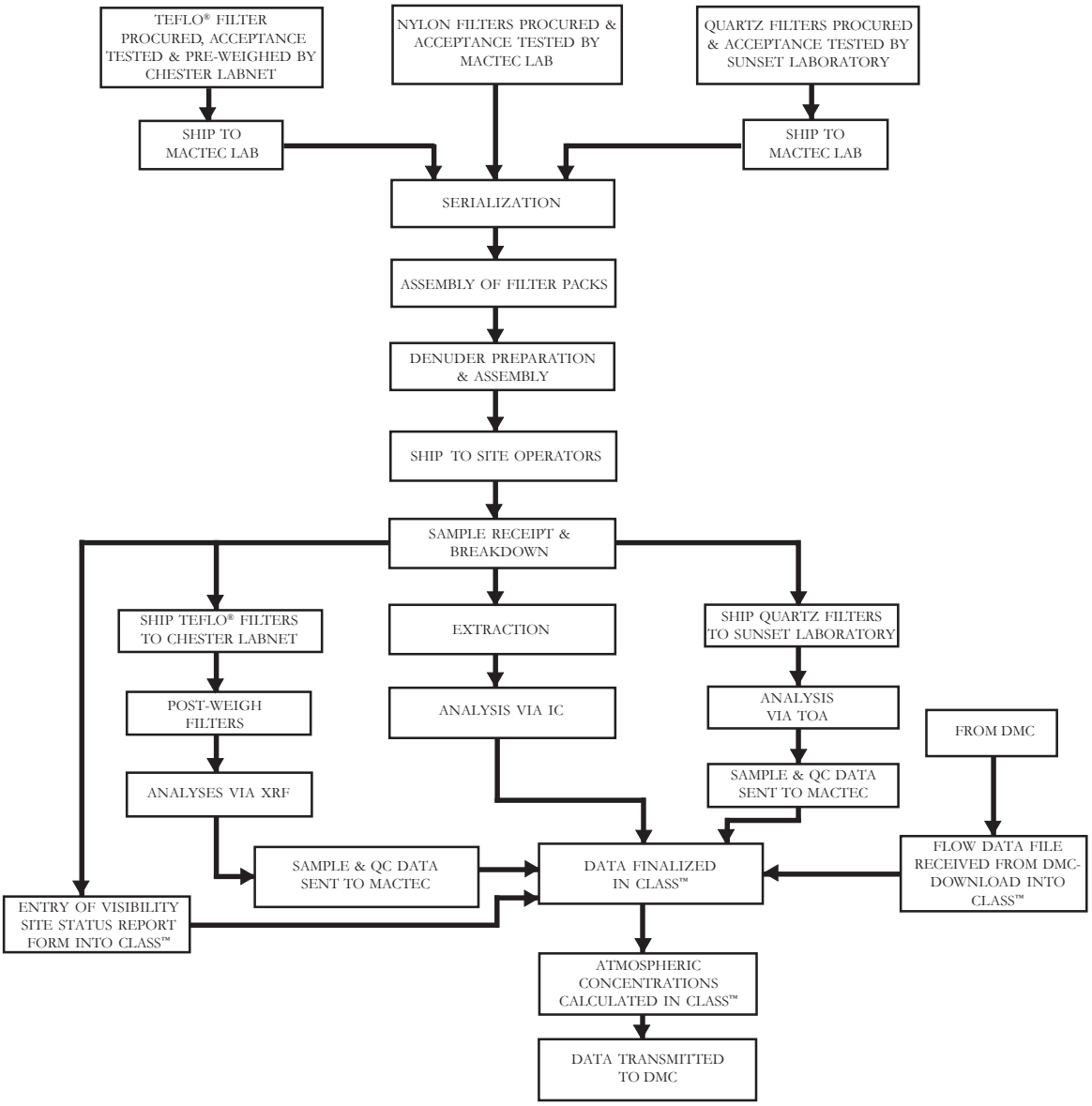


Figure B.6.3 Laboratory Operations for Wet Deposition Samples

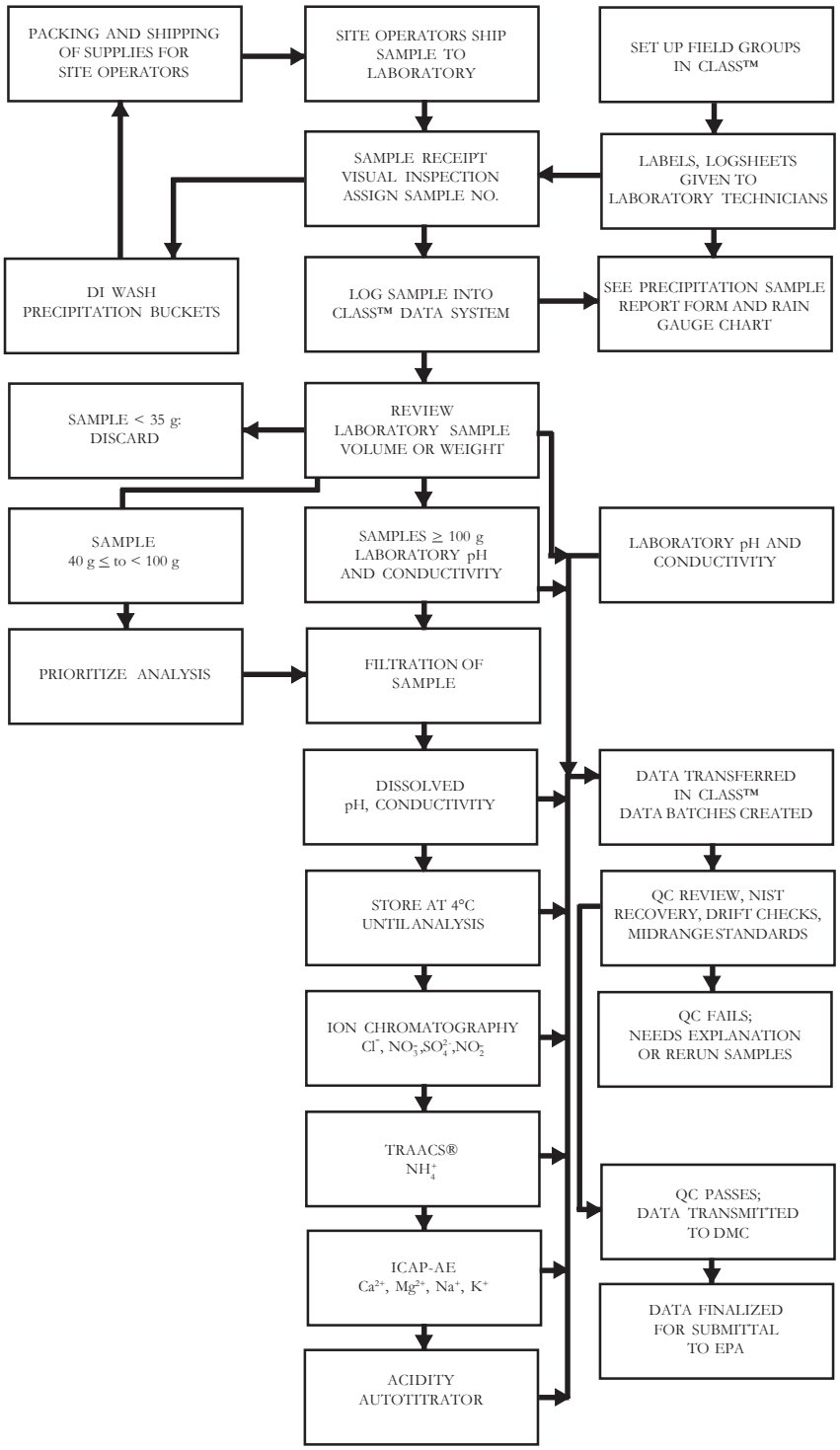


Figure B.7.1 Flow of Data, Dry and Wet Deposition Sites

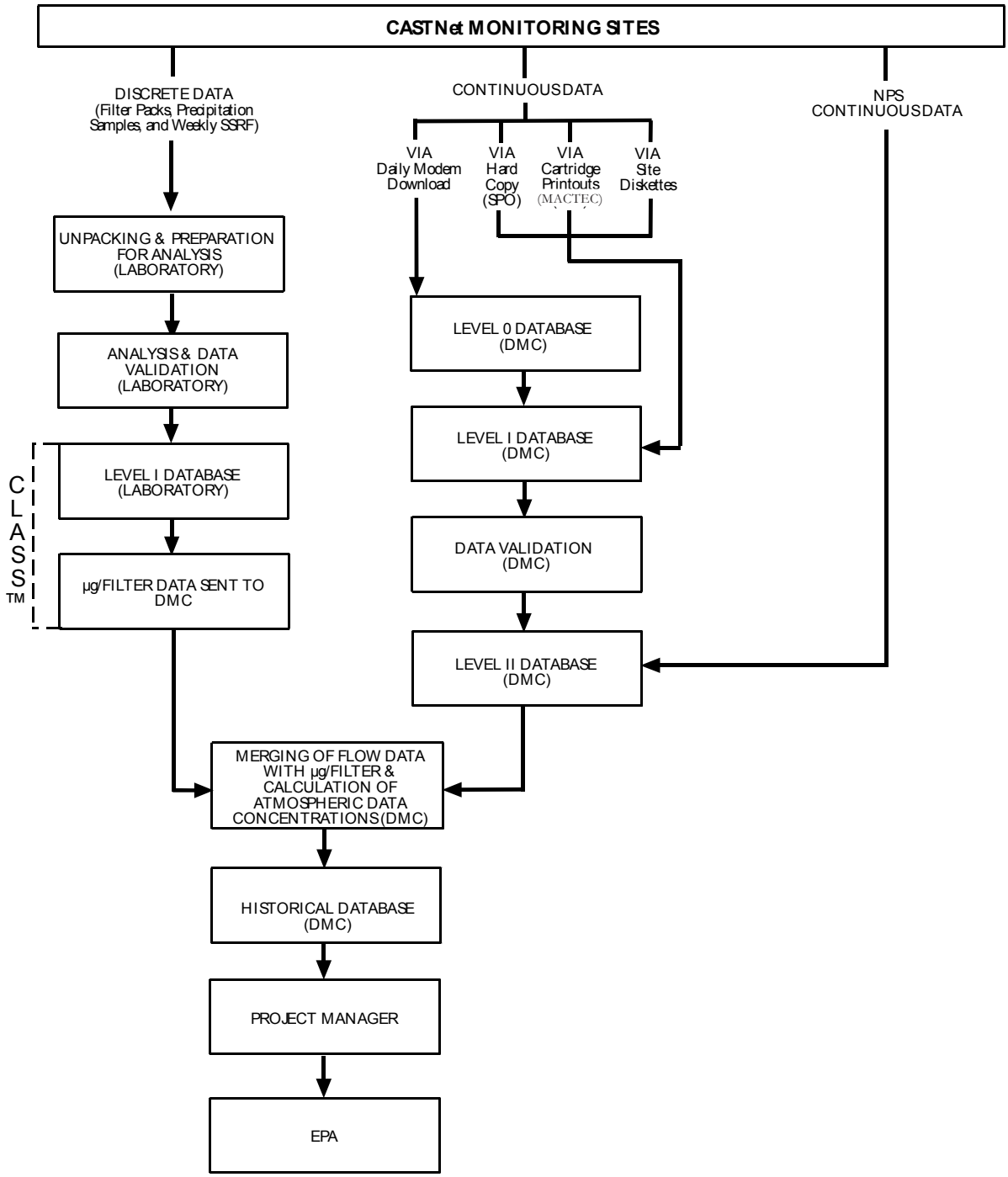


Figure B.7.2 Flow of Data, Visibility Monitoring Sites

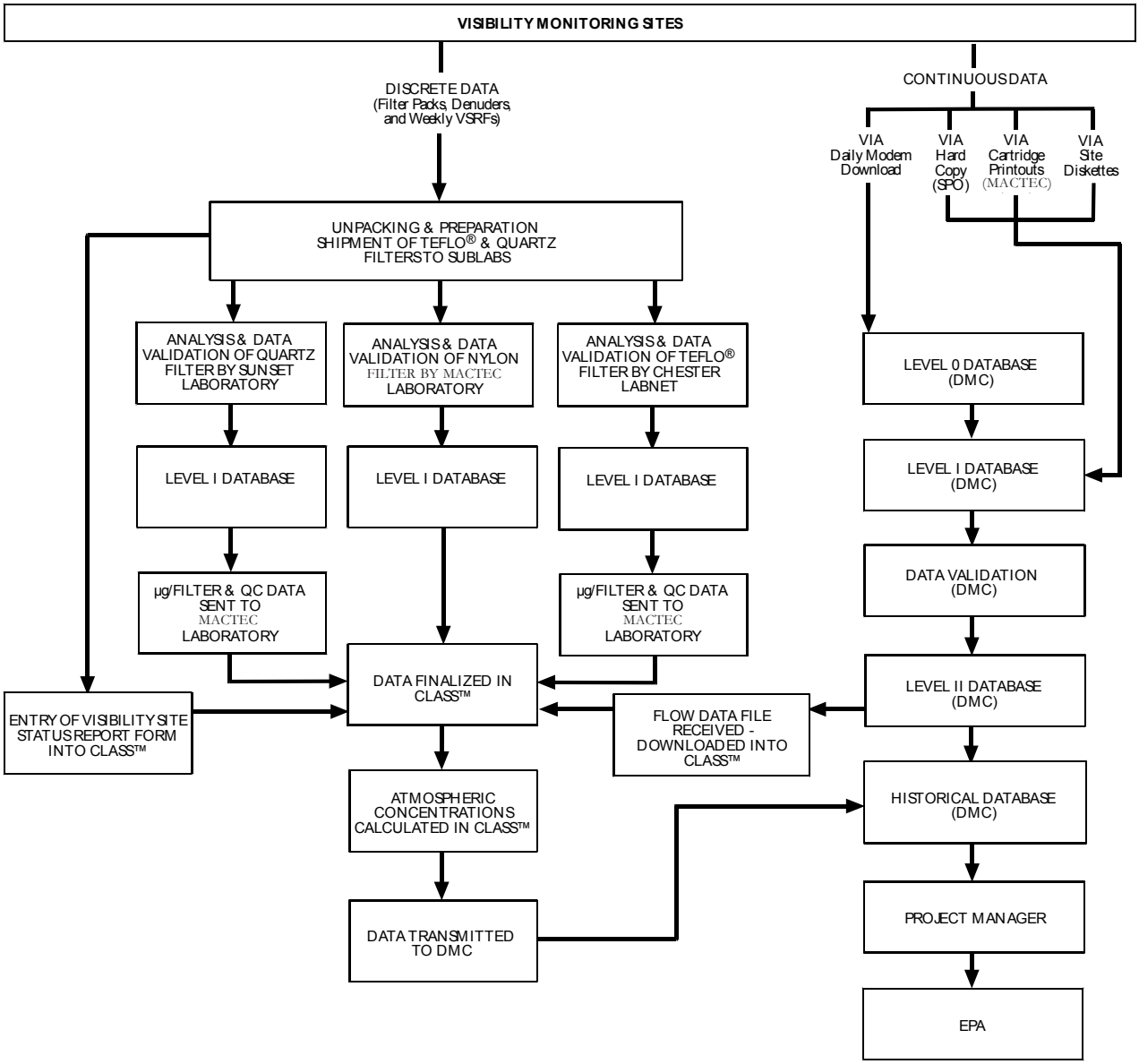


Figure B.7.3 Data Traceability of a Datum for a Continuously Recorded Parameter

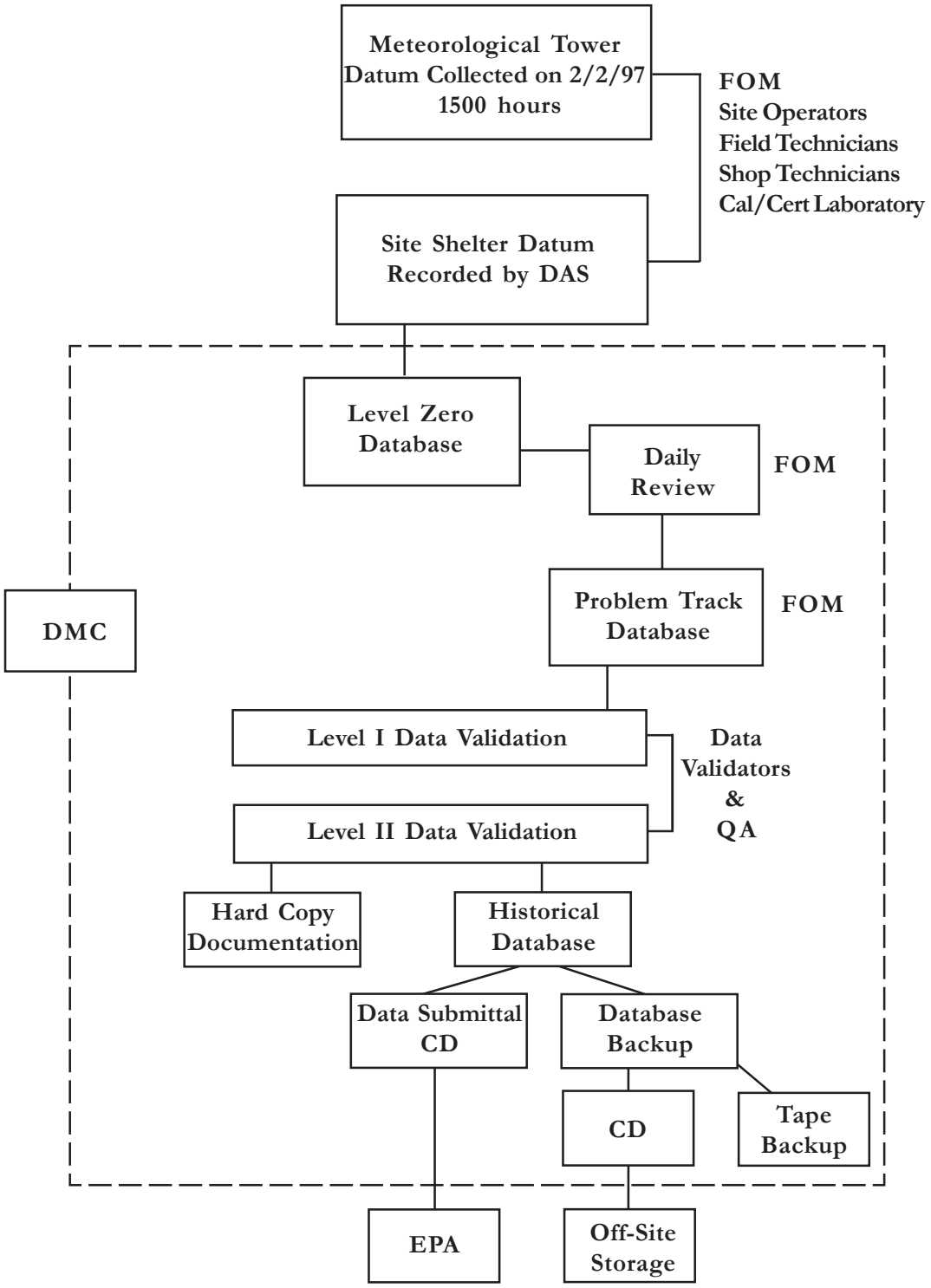


Figure B.7.4 Flowchart of the CLASS™ Program

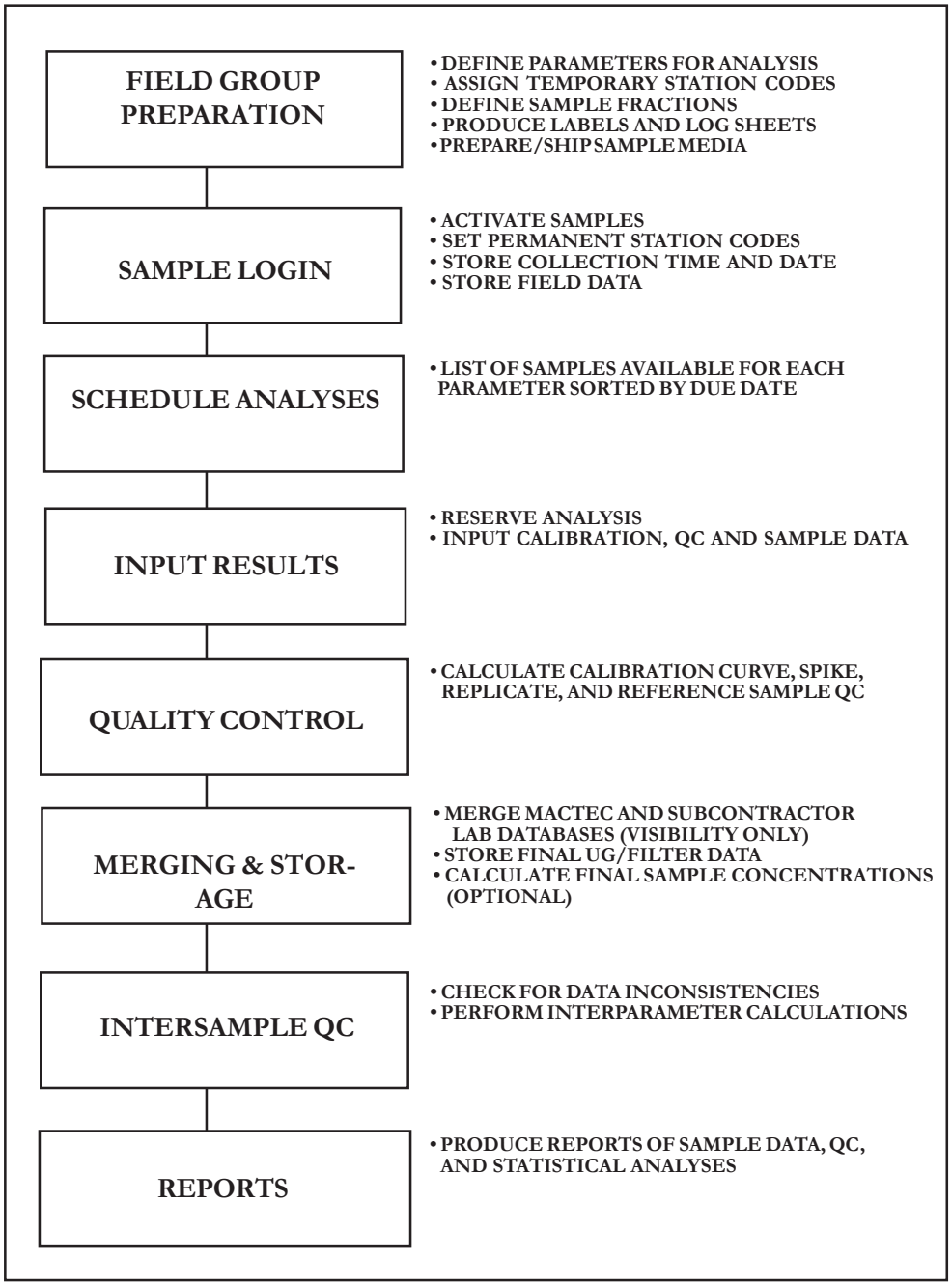


Figure B.7.5 Sample Batch Update Form

HARDING ESE, INC./GNV ANALYTICAL LAB/BATCH UPDATE FORM

BATCH # _____ **ANALYSIS** _____ **DEPT. #** _____

Request to (circle one) DEFINALIZE or CHANGE

Initiated by: _____ In Order to:

APPROVED/ACKNOWLEDGED by:

Dept. Manager: _____ Date : _____

Lab Coordinator: _____ _____

Changes Processed By: _____ _____

Updated Batch Reviewed and Approved by : _____ _____

Batch Refinalized by: _____ _____

UPDATED (1/24/01)

C. Assessment/Oversight

C.1 Assessments and Response Actions

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 checks 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 the achievement and maintenance of project DQO. This team is comprised of the MACTEC Project Manager, QA Supervisor, QA Manager, and operations managers; the EPA QA Officer; ARS Program Manager and QA Manager; and other agencies and organizations, as needed (Section A.4).

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 C.1.1. 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:

- Management systems reviews
- Readiness reviews
- Surveillance
- Technical Systems Audits
- Performance Evaluations
- Assessments of DQI
- Data quality assessments
- Peer review of project deliverables
- Review, revision, and approval of CASTNet QAPP and SOP

These internal and independent assessments are summarized in Table C.1.1 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 above. The CASTNet project DQO are defined in Section A.7 and summarized in Table A.7.1. The CASTNet DQI used in assessment of the DQO are precision, accuracy, bias, completeness, representativeness, and comparability. DQI and the associated measurement criteria are described in Section A.7.1 and summarized in Tables A.7.2 and A.7.3.

Scope of Authority

The scopes of authority for the members of the QA Management Team are described in Section A.4.2 and Table A.4.1. 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 MACTEC QA Supervisor, QA Manager, and Project Manager, or designees, have the authority to issue a Stop Work Order. The EPA Project Officer and the MACTEC 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 MACTEC QA Manager, or designee, performs a follow-up audit to verify and document that the response actions were implemented effectively. The EPA Project Officer and MACTEC 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.

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 C.1.2 for standard response actions for each of the specific assessments. See Figure C.1.2 for a depiction of the NCAF.

Documentation

To provide a complete record, all QC problems and corrective actions are documented. Management uses 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 C.1.2). 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. Laboratory Operations documents short-term corrective actions in batch narratives. In addition to on-line documentation, the

DMC utilizes forms such as the Continuous Data Review Form (CDRF) and Continuous Data Validation Summary (CDVS) to document short-term corrective actions.

C.1.1 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 C.1.2.

C.1.2 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. Personnel who are invited to this readiness review include the Project Manager, QA Manager, FOM, LOM, DOM, Work Assignment 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.

C.1.3 Surveillance

Frequent monitoring of the project status is performed to ensure that all project requirements are being fulfilled. During weekly project meetings, all 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, DOM, field coordinators, and Work Assignment 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.

C.1.3.1 Field Operations Surveillance

The FOM and field coordinators monitor the status of field operations through:

1. Weekly project meetings with the Project Manager, QA Manager, LOM, and DOM;
2. Weekly Tuesday call-ins from site operators;
3. Calibration results summaries review;
4. Data review; and
5. Scheduled site visits to determine if the sites and equipment continue to operate such that project DQO are met.

C.1.3.2 Laboratory Operations Surveillance

The LOM monitors the status of laboratory operations through weekly project meetings with the Project Manager, QA Manager, FOM, and DOM, and through data review to determine if laboratory analytical procedures and instrumentation continue to meet project DQO.

C.1.3.3 Data Operations Surveillance

Data for the CASTNet project are acquired and transferred into the database from several sources. The DOM performs frequent monitoring of the data and the transfer processes to ensure that the integrity of the database is maintained. The DOM 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 D to determine if data meet project DQO.

C.1.4 Technical Systems Audits

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 used for the field, laboratory, and data operations components of the project are described in the following subsections.

C.1.4.1 Field Operations TSA

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 the following TSA:

- Internal TSA performed by MACTEC field operations or management personnel,
- Independent TSA administered by EPA at its discretion, and
- External TSA performed by EPA, at its discretion.

These TSA are used to verify conformance of field sampling activities with the CASTNet Field SOP (Appendix 1) and this QAPP.

C.1.4.1.1 Field Operations Internal TSA

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. Site operators visit CASTNet sites each Tuesday and as directed by the FOM or field coordinator. Prior to the transfer of visibility sampling and analysis to IMPROVE, visibility sites were visited at a minimum of once every six days, coinciding with the 6-day sample schedule. Site operators report findings at the weekly Tuesday call-in with the FOM or field coordinator. Detailed procedures performed by the field operations personnel for equipment checks, preventive and corrective maintenance, sample media collection, DAS operation, filter pack change-outs, documentation, and shipment of samples are described in the CASTNet Field SOP (Appendix 1). Table B.5.2 summarizes the site operator's responsibilities for routine site visits. Additionally, MACTEC, ARS, or AQS 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 C.1.3. Field TSA components are summarized in Table C.1.4.

Transfer standards used to evaluate CASTNet instrumentation (Table C.1.5) are certified by an approved certifying agency. Certification documentation for transfer standards and NIST audit standards is maintained by the FOM.

C.1.4.1.2 Field Operations Independent TSA

Independent TSA of the sampling sites are managed and executed by EPA or its designee at its discretion. Independent TSA are performed in conjunction with independent PE and are generally described in Table C.1.4. Audits conducted by EPA or its designee are conducted outside the auspices of this program and are not further discussed in this section.

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 are maintained by the FOM.

C.1.4.2 Laboratory Operations TSA

Although the laboratory TSA are similar in philosophy to the field TSA, the procedural activities differ substantially. While the field TSA are site specific, the laboratory TSA encompass both laboratory analysis and data processing activities. The laboratory operations 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
- 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.

C.1.4.2.1 Laboratory Operations Internal TSA

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 C.1.6. The following audits and procedures are components of an internal laboratory TSA. References to audit and review of aerosol $PM_{2.5}$ measurement activities refer to activities prior to the May 2001 transfer of visibility network to IMPROVE. References to audit and review of wet deposition activities refer to activities prior to the January 1999 transfer of wet deposition sampling and analysis to NADP/NTN.

- **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 procedure is as

follows:

1. A method is selected either at random, or in response to observed problems.
2. One group of samples scheduled for the analysis method is selected. The extraction process is observed.
3. Standard preparation procedures for the appropriate analytical instrument (IC, ICP-AES, or TRAACS®) are observed. This portion of the audit may include review of analytical balance calibration and maintenance logs; standard preparation logs; DI water system operation and maintenance logs; glassware cleaning procedures; and acquisition, quality, and storage of reagents.
4. 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.
5. 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.

- **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:

  1. Acceptance testing is audited. All pertinent logbooks, records, and other documentation are reviewed.
  2. A sample or group of samples is selected at random. The procedures for preparation, shipment, receipt, and extraction are observed.
  3. Standard preparation procedures for each analytical instrument (IC, ICP-AES and TRAACS®) are observed. This portion of the audit includes a review of analytical balance calibration and maintenance logs; standard preparation logs; DI water system operation and maintenance; cleaning procedures for glassware; and acquisition, quality and storage of reagents.
  4. 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.
  5. 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.

- **Filter Acceptance Audits**

  Filter acceptance audits are performed quarterly as follows:

  1. All acceptance test data for Teflon®, nylon, and Whatman filters are reviewed to ensure that only batches of filters that meet the acceptance criteria are used for sample collection.

2. If analyses are 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.

- **Chain-of-Custody Audits**
  Chain-of-custody audits are performed quarterly via review of SSRF for selected sites. If chain-of-custody documentation is incomplete, best efforts are made to use other documentation for tracking custody data.
- **Combined Database Internal Audit**
  The combined database audit reviews the atmospheric concentration data calculated from the field flow volumes and laboratory total microgram data. The specific audit procedures are described in Section D.5.2 and include checks on both laboratory and data operations.

C.1.4.2.2 Laboratory Operations Independent TSA

An independent TSA is performed and evaluated every two years by an independent laboratory. Additional audits are performed as directed by the Project Manager or EPA Project Officer. The following tests and procedures are components of an independent laboratory TSA. References to audit and review of aerosol $PM_{2.5}$ measurement activities refer to activities prior to May 2001 when visibility network was transferred to IMPROVE. References to audit and review of wet deposition activities refer to activities prior to January 1999 when the wet deposition network was transferred to NADP/NTN.

- **Substrate Procurement and Acceptance Testing**
  This audit applies to filter substrates, buckets, 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.
- **Documentation Review**
  The laboratory documentation is examined to determine that:
  1. SOP exist for routine procedures.
  2. Maintenance logs and analysis run logs are in place for instrumentation and supporting equipment (i.e., DI systems).
  3. Verifiable chain-of-custody documentation exists for samples and data packages.
  4. Documentation is conveniently located for use by laboratory personnel.
- **SOP 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 Supervisor, 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:

1. Are most critical for acquisition of valid data,
2. Reflect recent changes in procedures, or
3. Have exhibited problems in previous audits.

- **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.
- **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.
- **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, which 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).

C.1.4.2.2.1 Laboratory Operations Independent TSA 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.

C.1.4.3 Data Operations TSA

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 D 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 C.1.7 and are generally described as follows:

- Identify data maintained only on the hard drive;
- Locate and identify data maintained on hard copies;

- Verify that QA/QC data referenced to sample results are protected and sufficient to associate with the individual sample results;
- Review if data outside acceptance criteria are flagged and actions are taken as described;
- Determine whether the detection limits for target analytes are clearly defined or referenced in the raw laboratory data. Verify that these limits are accurately represented in the final concentration report with adjustments made to reflect dilutions and other calculations required; and
- Confirm that data reduction steps are defined in a written procedure that is sufficient to recalculate results, verify results, and identify errors found in the data.

C.1.4.3.1 Data Operations Internal TSA

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 DOM 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 DOM and QA Manager. The primary components of a data operations TSA are described in Table C.1.7.

- **Data Operations – Field Data Internal TSA**
  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 II 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:
  1. Field data are validated in monthly groups. Validation documentation includes a CDRF and a CDVS on which all validation decisions are documented (see Figures C.1.3 and C.1.4, respectively).
  2. A minimum of ten percent of the sites in the monthly validation groups is audited per quarter.
  3. Manual data entries noted on the selected CDRF are verified by inspection of the Level II database.
  4. To detect undocumented or inadvertent changes to the Level II database, selected sites are reviewed to ensure that all data source flags agree with CDRF entries.
- **Data Operations – Laboratory Data Internal TSA**
  In addition to the redundancies built into the data validation process, internal TSA of laboratory data trace the process from sample analysis through Level II validation. Laboratory data processing and QC activities are summarized in Section D.2 and in Table D.2.1.
- **Data Operations – Combined Database Internal Audit**
  The combined database audit reviews the atmospheric concentration data calculated from the field flow volumes and laboratory µg/filter data. The specific audit procedures are described in Section D.5 and include checks of both laboratory and data operations.

C.1.4.3.2 Data Operations Independent TSA

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 a data operations TSA are described in Table C.1.7.

C.1.5 Performance Evaluations

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.

C.1.5.1 Field Operations PE

The objective of a field PE is to physically challenge each gaseous analyzer, deposition monitor, particulate sampler, meteorological sensor, visibility sensor (prior to May 2001), 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 MACTEC field operations personnel and independent 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 under the CASTNet Base Program is summarized as follows:

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

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 B.5.5).

C.1.5.1.1 Field Operations Internal PE

The semiannual calibrations of field instrumentation also serve as internal PE (Table C.1.8) and provide information on instrument accuracy. Every six months MACTEC, ARS, or AQS 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 B.5.5. Through monthly review of field calibration results (Figure B.5.2), the FOM and QA Manager monitor field data for completeness, accuracy, and conformance with SOP, DQI and DQO. Field calibrations are critical to achieving and maintaining project DQI.

MACTEC has developed calibration criteria (Table B.5.5) with stricter limits than project DQI (Table A.7.2). Calibration results are entered on the individual calibration data forms (Figure B.5.3) and are reviewed by the FOM and field coordinators. See Section B.5 for a detailed 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 II continuous database verifies the thoroughness and accuracy of validation decisions prompted by field QC failures.

C.1.5.1.2 Field Operations Independent PE

Independent PE of the sampling sites are managed and executed by EPA or its designee at its discretion. Independent PE are performed in conjunction with independent TSA. All instruments at each site are evaluated according to the methods listed in Table C.1.8. Audits conducted by EPA or its designee, are conducted outside the auspices of this program and are not further discussed in this section.

C.1.5.1.3 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.

C.1.5.2 Laboratory Operations PE

Laboratory PE include 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.

C.1.5.2.1 Laboratory Operations Internal PE

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 CVS. Laboratory precision is estimated via analysis of replicate samples. The precision and accuracy requirements of these samples are listed by analyte in Table A.7.3. The results of the reference sample analyses are reviewed by the LOM and QA Manager and are reported to EPA quarterly and annually. Refer to Table C.1.9 for a summary of laboratory PE components and acceptance criteria.

C.1.5.2.2 Laboratory Operations Independent PE

The CASTNet laboratory participates in laboratory intercomparison studies conducted by the ECAN National Water Research Institute (NWRI) National Laboratory for Environmental Testing (NLET) and USGS Interlab for Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, NH_4^{+}, Cl^{-}, NO_3^{-}, SO_4^{2-}, pH, 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 website, http://www.nwri.ca/nlet/nlet.html, describes their program thusly:

> The Institute provides interlaboratory performance evaluation (PE) testing studies for a wide

> range of inorganic constituents in water and sediments. These PE studies include priority parameters such as total phosphorus and inorganic mercury. Performance evaluation studies are important as part of accreditation and in practical terms, as part of the continuing improvement of the quality of analytical results. Analytical results are evaluated for quality using systematic bias and precision. Elaborate techniques quantify each of these two important data quality factors. Areas in need of improvement become apparent, thus facilitating corrective action.

The USGS website, http://bqs.usgs.gov/precip/project_overview/frameil.htm, describes the Interlab program :

> The objectives of the interlaboratory-comparison program are: (1) To estimate the analytical precision of participating laboratories, and (2) to determine if statistically significant differences existed 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. National Institute of Standards and Technology (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 the CASTNet instrumentation (Table C.1.9) 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.

C.1.5.3 Data Operations PE

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 described in Table C.1.1 and Section D.5. The primary components of data operations PE are listed in Table C.1.10.

C.1.5.3.1 Data Operations Internal PE

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 DOM and QA Supervisor. The components of the data operations PE are described in Table C.1.10 and are generally described as follows:

1. Verification that data were reported accurately in correct units and were appropriately flagged, and
2. Determination if data can be traced back to the original measurements.

C.1.5.3.2 Data Operations Independent PE

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 C.1.10 and Section C.1.5.3.1.

C.1.6 Assessments of DQI

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, and bias are quantitative measures; representativeness and comparability are qualitative measurements; and completeness is a combination of both quantitative and qualitative measures. The DQI and their associated measurement criteria are defined in Section A.7.1 and as follows:

- **Precision**
  The overall precision of meteorological variables, flow rate, and O_3 is assessed quarterly 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. The overall precision of filter pack concentration (and formerly, wet deposition data and visibility data) is assessed quarterly by calculating the MARPD of values for simultaneous samples at collocated sites. Analytical precision methods include random replication of filter pack samples and replication of internal standards. Specific precision assessment methods are described and presented in Sections B.5 and B.6. Review of these precision results are performed by QA staff and CASTNet management on a quarterly basis. If precision results are not within acceptance criteria, possible causes are identified and investigated immediately. An NCAF is issued, if warranted, for resolution of the problem. Please note that when a problem is identified it shall not be corrected until a network-wide solution is created or until regularly scheduled maintenance is performed, as appropriate, to preserve collocated results as a measure of network precision.
- **Accuracy**
  Accuracy results are viewed routinely during the field and laboratory systems audits. Refer to Sections B.5 and B.6 for detailed descriptions of methods and corresponding equations for assessment of accuracy.
- **Bias**
  Analytical bias is assessed by monitoring reference sample recoveries over time via graphics 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.
- **Completeness**
  Adherence to completeness criteria is calculated and reviewed quarterly. The completeness criteria by parameter and for data aggregations are summarized in Table A.7.4. If completeness criteria are not met, possible causes are investigated and corrective actions are issued when applicable.

- **Representativeness**
  The definition of representativeness with respect to the CASTNet program is presented in Section A.7.1.5. Within CASTNet there are several types of representativeness and each addresses a different question:
  1. Regional: Are sampling sites representative of the surrounding area? A site's ongoing representativeness is monitored via internal and independent TSA.
  2. 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 (e.g. with CAPMoN and NPS as discussed in Section A.7.1.5).
  3. Laboratory analytical methodology: Are analytical method results representative of the collected sample? MACTEC is not aware of any study confirming representativeness of ambient air analysis results.
- **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 A.7.1.6 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 and day/night sampling for CASTNet. The collocated EPA/NPS site at Rocky Mountain National Park also provides data for evaluation of comparability.

C.1.7 Data Quality Assessments

All ambient monitoring methods or analyzers used for CASTNet field and laboratory operations are tested periodically to assess quantitatively the data quality. Measurements of accuracy and precision are estimated for both field and laboratory parameters at regular intervals and are specified for each type of monitor or method. Quarterly summaries of all precision and accuracy measurements are submitted to EPA.

Working or transfer standards and equipment used for auditing must not be the same as the standards and equipment used for calibration and spanning, but may be referenced to the same NIST SRM. The auditor should not be the operator or analyst who conducts the routine monitoring, calibration, and analysis.

Data quality assessments of reported data are also discussed in Section D.5. Final deposition velocities, fluxes, and O_3 concentration data are reviewed by the Project Manager prior to submittal to the EPA.

C.1.8 Peer Review and Presentation of Data

Peer review is not strictly an internal QA function as it 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.

C.1.9 Review, Revision, and Approval of CASTNet QAPP and SOP

The QA Manager conducts continual review of QA/QC procedures and achievement of project DQO. Since the QAPP is a working document, in essence a blueprint to the operations and coordination of the entire project, it will be updated and revised to incorporate changes and additions to the program. At a minimum, the QAPP and project SOP will be reviewed annually to incorporate necessary updates and revisions identified throughout the previous year (Section A.9.1).

C.2 Reports to Management

C.2.1 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 and 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 A.6.4.

C.2.2 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. The fourth quarter QA report doubles as the Annual QA Report;
- 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; and
- Annual QA Reports – submitted 30 days after the end of the fourth quarter. The fourth quarter report doubles as the annual report.

C.2.3 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:

1. Summary of QA activities,
2. Changes to the QA program,
3. Results of any QA systems and performance audits,
4. Assessment of data quality,
5. Out-of-control incidents and corrective actions,
6. Resolution of issues, and
7. Responses to EPA comments on previous reports, if any.

Contents of the quarterly QA reports, while containing minimal text, include:

1. DQI results (as graphs),
2. Count of QA samples by QA code,
3. Percentage of samples suspect or invalid by QA code (i.e., failure type),
4. Count of field problems/resolutions with length of time to resolution (outstanding, 30 – 60 – 90 days), and
5. Calibration failure by location and parameter.

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, listed above, 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 and contains control charts (24 per quarter including blanks printed four to a page). Contents of the Annual QA Report also include the same components of a regular quarterly QA report:

1. DQI results (as graphs),
2. Count of QA samples by QA code,
3. Percentage of samples suspect or invalid by QA code (i.e., failure type),
4. Count of field problems/resolutions with length of time to resolution (outstanding, 30 – 60 – 90 days), and
5. Calibration failure by location and parameter.

At the end of a project, a report documenting the data quality assessment findings will be prepared and submitted to EPA.

Table C.1.1 Project Assessments Summary (Page 1 of 2)

Assessment Type	Number	Frequency	Audit Schedule/ Criteria for Assessment	Assessment Personnel
Management Systems Review	Variable	As needed	See Section C.1.1	Project Manager, QA Manager or QA Supervisor
Readiness Review	Variable	As needed	See Section C.1.2	Project Manager, QA Manager, FOM, LOM, DOM, Work Assignment Managers, Field Coordinators
Surveillance				
• Field Operations	Ongoing	Weekly	See Section C.1.3.1	Site Operators, FOM, Field Coordinators
• Laboratory Operations	Ongoing	Weekly	See Section C.1.3.2	Laboratory Supervisor, LOM
• Data Operations	Ongoing	Weekly	See Section C.1.3.3	DOM
Technical Systems Audits				
• Field Operations				
Internal	2	Biannually	See Section C.1.4.1.1	MACTEC, ARS, AQS Field Technicians
Independent	As determined by EPA	As determined by EPA	As determined by EPA	As determined by EPA
External	As determined by EPA	As determined by EPA	As determined by EPA	As determined by EPA
Technical Systems Audits				
• Laboratory Operations				
Internal	1	Annually	See Section C.1.4.2.1	QA Manager
Independent	1	Every 2 years	See Section C.1.4.2.2	TBD*
External	As determined by EPA	As determined by EPA	As determined by EPA	As determined by EPA
Technical Systems Audits				
• Data Operations				
Internal	1-12	Depends on audit type	See Sections C.1.4.3.1	DOM, QA Manager
Independent	1	Every 2 years	See Section C.1.4.3.2	TBD*
External	As determined by EPA	As determined by EPA	As determined by EPA	As determined by EPA

* To be determined

Table C.1.1 Project Assessments Summary (Page 2 of 2)

Assessment Type	Number	Frequency	Audit Schedule/ Criteria for Assessment	Assessment Personnel
Performance Evaluations • Field Operations Internal	2	Biannually	See Section C.1.5.1.1	MACTEC, ARS, AQS Field Technicians
Independent	As determined by EPA	As determined by EPA	As determined by EPA	As determined by EPA
External	As determined by EPA	As determined by EPA	As determined by EPA	As determined by EPA
Performance Evaluations • Laboratory Operations Internal	Ongoing	Per analytical batch	See Section C.1.5.2.1	Laboratory Analysts
Independent	Ongoing	Approx. bimonthly	See Section C.1.5.2.2	ECAN, USGS
External	As determined by EPA	As determined by EPA	As determined by EPA	As determined by EPA
Performance Evaluations • Data Operations Internal	1	Annually	See Section C.1.5.3.1	DOM, QA Manager
Independent	1	Every 2 years	See Section C.1.5.3.2	TBD*
External	As determined by EPA	As determined by EPA	As determined by EPA	As determined by EPA
Assessment of DQI	4	Quarterly	See Section C.1.6	DOM, FOM, LOM, QA Manager, Project Manager
Data Quality Assessments	Variable	Ongoing	See Section C.1.7	DOM, FOM, LOM, QA Supervisor, QA Manager Project Manager
Peer Review and Presentation of Data	Variable	Minimum of once per year	See Section C.1.8	Qualified Reviewers
Review, Revision, and Approval of CASTNet QAPP	1	Annually	Yearly update of procedures	QA Manager

* To be determined

Table C.1.2 Response Actions

Assessment Type*	Response Action to Nonconforming Condition
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.
Readiness Review	Arrangements are made by the appropriate personnel to include any and all missing components prior to commencement of work.
Surveillance	For Field Operations actions, see Table B.5.4. For Laboratory Operations actions, see Tables B.5.4 and D.2.1 For Data Operations actions, see Table D.1.1. For combined database actions, see Tables D.1.1 and D.2.1
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 MACTEC Project Manager.
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 MACTEC Project Manager.
Peer Review of Deliverables	The condition is discussed with the reviewers. Appropriate action is thereby determined, assigned, and verified by the MACTEC Project Manager. The deliverable is revised accordingly.
Review, Revision, and Approval of QAPP/SOP	Review is performed annually by the QA Manager. Revision and approval is a team effort involving all operations managers, the QA Manager and the MACTEC Project Manager as described in Section A.9.1.

* Described in text. All assessments are reported to the MACTEC Project Manager and QA Manager.

Table C.1.3 Sample Internal Field Calibration Schedule

Month	Sites to be Calibrated				
January/July	PED108, VA COW137, NC SND152, AL	VPI120, VA PNF126, NC	CDZ171, KY ESP127, TN	BFT142, NC SPD111, TN	CND125, NC GAS153,GA
February/August	CTH110, NY BWR139, MD CHE185, OK	WSP144, NJ IRL141, FL	ARE128, PA SUM156, FL	PSU106, PA CAD150, AR	BEL116, MD CVL151, MS
March/September	DCP114, OH ALH157, IL	OXF122, OH BVL130, IL	CKT136, KY STK138, IL	MCK131, KY PRK134, WI	VIN140, IN KNZ184, KS
April/October	ASH135, ME CAT175, NY UVL124 MI	HOW132, ME ABT147, CT LYK123, OH	WST109, NH EGB181, ON SAL133, IN	LYE145, VT ANA115, MI	HWF187, NY HOX148, MI
May/November	KEF112, PA QAK172, OH ROM206, CO	LRL117, PA PND165, WY	MKG113, PA CNT169, WY	CDR119, WV CON186, CA	PAR107, WV GTH161, CO

Table C.1.4 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 MACTEC 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 MACTEC QA Management Team of inconsistencies or changes.
Procedures Review	Review field-related SOP. Observe operator performing most critical site visit procedures (filter changes, 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 MACTEC 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; and • General site conditions. Inventory all instrumentation (model number, serial number, last calibration date).	Complete audit report and site inventory.	Notify MACTEC QA Management Team of noted inconsistencies.

UTM = Universal Transverse Mercator

Table C.1.5 Calibration Standards

Parameter	MACTEC Calibration Standard
Wind Speed	R.M. Young 18802 Anemometer Drive
Wind Direction	Brunton 5008 Pocket Transit R.M. Young Vane Alignment Fixture - Tower Mount
Temperature	Brooklyn Calorimeter Thermometers
Delta Temperature	Brooklyn Calorimeter Thermometers Eutechnics 4600 RTD Platinum
Relative Humidity	Rotronic PA1 GTL Hygrometer Standard Salts
Precipitation (Tipping Bucket)	250 mL Graduated Cylinder
Precipitation (Weight Gauge)	Standard One-Inch Weights
Solar Radiation	LiCor PY Photodiode R.M. Young Translator 70101X
Ozone	Thermo Environmental 49/49C
Mass Flow Meters	BIOS DryCal Lite Nexus
Primary Flow Meter	BIOS DryCal Lite Nexus
Multimeter	Fluke 8060A
Data Acquisition System	Calibrators, Inc. DVC-350A
Audit Data Storage	3-Part Forms
Wetness	OHmite 3420 Decade Box

Table C.1.6 Laboratory Technical Systems Audit Components

Systems Parameters	Audit Component	Acceptance Criteria	Reporting Procedure
Laboratory Facilities	Cleanliness and organization of work areas.	Samples and standards should be stored separately. All containers should be properly labeled.	Complete audit report and notify MACTEC 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 MACTEC 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, chains-of-custody).	Verify adherence to CASTNet QAPP/SOP.	Notify MACTEC 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.	Complete site inspection and audit report.	Notify MACTEC QA Management Team of noted inconsistencies.

Table C.1.7 Data Operations Technical Systems Audit Components (Page 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, and • Hardware assessment.	Adequate documentation exists and is readily accessible.	Complete audit report and notify MACTEC 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; and • Testing procedures.	Compare on-site documentation to most recent network documentation/ configuration and verify adherence to CASTNet QAPP.	Complete audit report and notify MACTEC 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, and • Identification of input/output fields.	Adequate documentation exists and is readily accessible.	Complete audit report and notify MACTEC 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, and • Documentation of software revisions.	Adequate documentation exists and is readily accessible.	Complete audit report and notify MACTEC QA Management Team of any deficiencies.

Table C.1.7 Data Operations Technical Systems Audit Components (Page 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: who 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; and • The program alerts provide clear understanding as to what requests will do to the data to ensure the expected or desired results are attained.	Documented procedures exist and are readily accessible.	Complete audit report and notify MACTEC 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 MACTEC 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 MACTEC QA Management Team of any deficiencies.
System Testing	Confirm if system delays hamper testing.	Testing can be effectively performed.	Complete audit report and notify MACTEC QA Management Team of any deficiencies.
Data Entry – Manual Entry	Review the answers to the following questions: • Are error messages given for entry errors? • Does the system prevent entry of data that are out of range? • Are there prompts if fields are missed that are required for data manipulations? • Does the system carry over data from one screen to the next to minimize entry errors? • Were data that were manually entered into the database validated for accuracy through double entry?	All observations are affirmative.	Complete audit report and notify MACTEC QA Management Team of any deficiencies.

Table C.1.7 Data Operations Technical Systems Audit Components (Page 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 which 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 MACTEC 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 MACTEC QA Management Team of any deficiencies.

Table C.1.7 Data Operations Technical Systems Audit Components (Page 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; and • Retrieval of backups: — Arrangement for expedient retrieval, — Off-site storage or different location from original data, and — Security of storage area including limited access, fire protection, and environmental controls.	All components verified.	Complete audit report and notify MACTEC 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; and • Impact of downtime on project.	Adequate documentation exists and is readily available.	Complete audit report and notify MACTEC 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, and • Determination of time down until restored after a system failure.	All components verified.	Complete audit report and notify MACTEC QA Management Team of any deficiencies.

Table C.1.8 Field Performance Evaluation Components and Acceptance Criteria (Page 1 of 2)

Measured Parameter	Measurement Method	Instrumentation	Audit Method	Acceptance Criteria	Standards Traceability	*Standards Certification
Meteorological Measurement Systems						
Wind Speed • Velocity	Cup Anemometer Propeller/Vane Anemometer	Climatronics 100075 R.M. Young Wind Mark AQ	Variable RPM Motor Variable RPM Motor	± 0.5 m/s < 5 m/s or ± 5% of input ≥ 5 m/s ± 0.5 m/s < 5 m/s or ± 5% of input ≥ 5 m/s	NIST NIST	Manufacturer Manufacturer
†Wind Direction • Alignment	Vane Propeller/Vane	Climatronics 100076 R.M. Young Wind Mark AQ	Transit Compass Transit Compass	± 5 degrees from true north ± 5 degrees from true north	Military Military	Manufacturer Manufacturer
• Linearity	Vane Propeller/Vane	Climatronics 100076 R.M. Young Wind Mark AQ	Vane Alignment Fixture Vane Alignment Fixture	± 5 degrees ± 5 degrees	– –	– –
Temperature	Thermister RTD Platinum	Climatronics 100093 R.M. Young 43347	Immersion in temperature baths with reference thermometers	± 0.5°C	NIST	Manufacturer
Delta Temperature	Thermister RTD Platinum	Climatronics 100093 R.M. Young 43347	Immersion in temperature baths with reference thermometers	± 0.5°C	NIST	Manufacturer
Relative Humidity	Peizoresistive Capacitance	Climatronics 100098 Rotronic MP-100	Collocated in ambient air or humidity chamber with reference humidity standard Same as above.	± 20% rel. hum. ≤ 85% ± 5% rel. hum. > 85% ± 20% rel. hum. ≤ 85% ± 5% rel. hum. > 85%	NIST NIST	Manufacturer Manufacturer
Solar Radiation	Pyranometer	Li-Cor LI-200 SZ	Collocated comparison to reference radiation sensor	± 10% of average	WMO	Manufacturer

Table C.1.8 Field Performance Evaluation Components and Acceptance Criteria (Page 2 of 2)

Measured Parameter	Measurement Method	Instrumentation	Audit Method	Acceptance Criteria	Standards Traceability	*Standards Certification
Meteorological Measurement Systems (continued)						
Precipitation	Heated Tipping Bucket Weighing	Climatronics 100508-2 Belfort 5915-R-12	Known volume of water introduced at 2 inches per hour rate Challenge with on-site weights, weighed with scale on-site	± 10% of input ± 5% of input	Volumetric flask Weighing with on-site balance	– –
Wetness	Conductivity Bridge	Water Mist	Dry conditions, apply water Wet conditions, dry it	Confirm response Confirm response	– –	– –
Deposition and Aerosol Systems						
†Dry Deposition	Three-Stage Filter Pack	Mass Flow Controller	Verify flow with primary flow device, i.e., BIOS or certified mass flow meter	± 5% of designated	NIST	Manufacturer
Wet Deposition	Wet/Dry Collector	Wet/Dry Sampler	Spray mist water and dry	Pass - Fail	–	–
Ozone and Data Acquisition Systems						
†Ozone	UV Photometric	UV Photometric Analyzer	Comparison to certified reference standard	Slope ≥ 0.9 and ≤ 1.1 Intercept ± 5 ppb Correlation ≥ 0.995	MACTEC: EPA	EPA
Data Acquisition	Data logger	Odessa DSM3260/3260L ESC 8816	Input reference voltages in 2 channels, one between 0 and 8 and one between 9 and 16; Verify with certified digital volt meter	± 0.003 VDC	NIST	Manufacturer

† Please see Table B.5.5 for MACTEC calibration criteria.
* 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.

Note:

Military = MIL-C-58052C
WMO = World Meteorological Organization
CARB = California Air Resources Board
RPM = revolutions per minute
gm/cm = grams per centimeter

Table C.1.9 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	IC - Dionex 4000I, DX-300 or DX-500 IC with autosampler	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^+, K^+, Mg^{2+}, Na^{2+}	ICAP-AE: modified EPA method 6010B	Perkin-Elmer Optima 3000 DV	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^+	EPA method 350.1	TRAACS® Autoanalyzer™	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	IC - Dionex 4000I, DX-300 or DX-500 IC with autosampler	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^+, K^+, Mg^{2+}, Na^{2+}	ICAP-AE: modified EPA method 6010B	Perkin-Elmer Optima 3000 DV	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^+	EPA method 350.1	TRAACS® Autoanalyzer™	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 C.1.10 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 MACTEC 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; and • Timely generation of output and data reports	All answers are affirmative.	Complete audit report and notify MACTEC QA Management Team of any deficiencies.

Figure C.1.1 Overview of CASTNet QA/QC Tasks (highlighted)

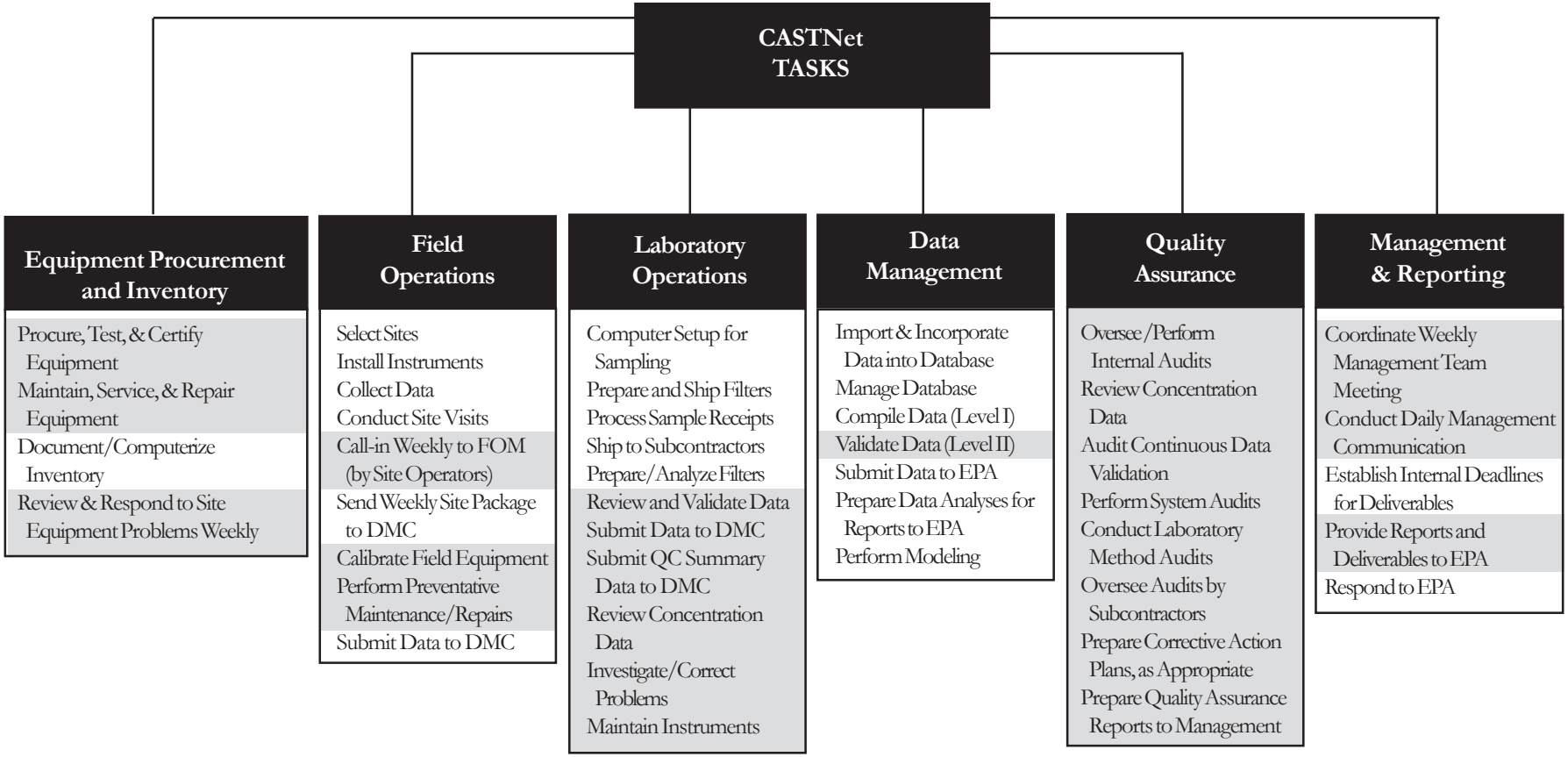


Figure C.1.2 Sample Nonconformance/Corrective Action Form

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MACTEC

CONTROL NO. 026

NONCONFORMANCE / CORRECTIVE ACTION FORM

1. Identification of Nonconformance:

Originator: M. Stewart **Date: 5/30/03**

See the report for the Group 2 Continuous Data Validation Audit (Feb Calibrations).

ARE128 and BEL116: SR calibration was not performed. No reason was provided in the calibration documents. Review of SR data showed that light levels were too low.

Description of Nonconformance: **Project:** CASTNet **SOP No.: NA** **Date Range: NA**

Recommended Action:

Calibration documents should note any problems affecting calibration or the performance thereof. The calibration folder should be updated and the calibrator notified of the documentation requirements.

2. Determination and Implementation of Required Action:

Responsibility Assigned to: E. Hebert, M. Stewart **Due Date: 5/30**

Action to Be Taken:

See the above recommended action.

3. Assuring Effectiveness of Action Taken:

Responsibility Assigned to: E. Hebert, M. Stewart **Due Date: 5/30**

Procedure to Assure Effectiveness:

Action has been performed and verified as of 5/30/03.

4. Verifying Implementation of Action: (Quality Assurance, Internal Use Only)

Verified by: **M. Stewart** **Due Date: 5/30**

Comments:

Finding closed on 5/30/03. - MS

Approved By [Print and Sign]: **Date:** 5/30/03

cc: HKH TFL

For Quality Assurance Use Only:

Pertains to: (Please indicate the projects or groups affected.)**
☐ CONTRACT REQUIREMENTS ☐ COMPANY POLICY/PROCEDURE** ☐ DOCUMENTATION**
☐ DATA NETWORK (☐ Software repair ☐ Software update) ☐ OTHER

Form Date 02/24/03

Figure C.1.3 Sample Continuous Data Review Form (CDRF)

CASTNet

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Continuous Data Review Form

Site ID KEF112 **Review Period** 5/28/02 - 11/22/02

PARAMETER	DATE/TIME	Flag I	Flag M	Flag S	Remove B	Other	REASON
Wetness	6/5 16:00	x					↑ Rain, sensor not reading
ozone	7/16 8:00 - 7/18 12:00	x					Per problem rpt fm last SOP ✓
wetness	9/10 10:00	x					Site op check
Rain, wet	7/28 14:00					x	no action, One hour rule

Validated by: CHodge **Date:** 1/15/03 **Approved by:** _____ **Date:** __/__/__

Figure C.1.4 Sample Continuous Data Validation Summary (CDVS) Form

CASTNet Continuous Data Validation Summary

Site ID: KEF112 **RM Young** X **Climatronic** **Period Reviewed:** 5/28/02 19:00 - 11/22/02 17:00

Basic/Global Changes Performed: **Yes** X **No** ___
(basic/global changes include the following: Rh >100.0 set to 100.0; Solar Radiation <0.00 & >-14 set to 0.00; Wetness full-scale drift >1.00 set to 1.00; Wetness zero drift < .10 *set to 0.00)*

Level II Validation Checklist:
Narrative logs X Site Status Report Form X Problem Report X

Calibration Information: Calibration Date: 11/22/02 Did All Parameters Pass? Yes X No _ (explain)

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

Comments: last calibration: 5/28/02.
SolRad passes however, all values tested are/were <250w/m². Will verify data validity, equipment w/ next ARS and/or Wortec Calibration.

External Audit Information: Date of Audit: __/__/__ Did all Parameters pass? Yes ___ No ___

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

Comments:

Validated by: CHodge **Date:** 1/15/03
QA Performed by: _____ **Date:** _____

D. Data Validation and Usability

Overview

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 A.4 and A.7). To accomplish CASTNet objectives, MACTEC 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, forms used in support of data review and validation, and steps taken both manually and with a computer to verify each level of validation. An objective of the DMC is to provide accurate data that meet end-user needs.

The CASTNet database is maintained at the DMC in the Jacksonville, FL office. Data are stored in tables using MS SQL Server™ 7.0. The system is described in Section B.7, and the table definitions and structure are summarized in Table B.7.1. The flow of data through the CASTNet data management system for the dry and wet deposition sites is shown in Figure B.7.1 and for the visibility monitoring sites in Figure B.7.2. As discussed in Section B.7.6.1, 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 DOM 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 A.7.2 through A.7.4 and B.5.5. CASTNet DQI are discussed in Section A.7.1. The validation process, discussed in Sections D.1, D.2, and D.3, attempts to recover as much data as possible by including adjustments and/or status flags based on calibration results, audits, and other supporting information.

D.1 Validation of Continuous Data and Supporting Information

The database of continuous measurements is composed of tables generated at each validation level beginning at Level 0 and ending at Level II, the final validation level. Data are inserted into archive data tables after completion of Level I validation procedures and then again after completion of Level II validation procedures. 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 II validation. Table D.1.1 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. Prior to the transfer of visibility monitoring activities to IMPROVE in May 2001 and wet deposition monitoring activities to NADP/NTN in January 1999, field information was also documented on VSRF and PSRF, respectively. The information recorded on these forms is utilized in both the continuous and discrete data validation processes detailed in this section and in Section D.2, respectively. Various aspects of the processing and review of these forms are discussed in both sections.

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

1. Corrective Actions for both Numerical Values and Data Status Flags:

- Incorrect numerical values recorded during data logger power failures are addressed during Level I and Level II validation. During power failures, the current date and time are reset to the January 01 default value, and the 1-hour averaging interval setting is often reset to the 5-minute averaging interval setting. To correct these inaccuracies, the date and time associated with the record must be updated, and the values must be reaveraged using the correct interval. Missing numerical values and data status flags resulting from power failures are also entered.
- Missing numerical values and data status flags resulting from problems other than power failures are also entered/corrected during Level I and Level II validation.

2. Instrument Drift Correction and Flow Rescaling for Numerical Values:
   - Numerical values are adjusted for flow and O_3 as a result of corrective action initiated from the review of semiannual calibration data during Level II validation (Section D.1.4.1). Flow data are rescaled if the semiannual calibration resulted in changes to full-scale and zero readings.
3. Corrective Actions for Data Status Flags:
   - Data status flags are corrected during Level II validation if actual site activities are not properly flagged during routine instrument checks.
   - Data status flags are corrected by replacing the flags with an "I" flag if data are evaluated as invalid or with an "S" flag if data are evaluated as suspect.

D.1.1 Level 0 Data Processing

Level 0 procedures for processing the continuous measurements involve transferring the collected raw monthly binary data from each site to the appropriate data table in the CASTNet database at the DMC. In addition to the support of the polling process, several forms of information are acquired and processed by the DMC during Level 0.

Daily, the dedicated polling computer calls and initiates an automatic polling of the continuous data from each site. This process uses the ENVICOM or 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. ENVICOM translates the voltages into engineering units and inserts the values and status flags into a raw binary data file and status file, respectively. Approximately 95 percent of the CASTNet data are acquired using this method. After the two binary files for each site are completed for each month, the DOM uses the Binaryi import program to read and translate the contents of the files. Binaryi is written in Visual Basic™ and is a part of the CDMSA (Section B.7.3.1.2). Binaryi is also used to insert the records into the METDATA_L0 table in the *castnet_temp* database. A query is run against the data table to verify the presence of one record for every hour of the month for each site. The DOM reviews the query output, corrects problems as needed, and inserts the records for the month into the METDATA_L1 table in the *castnet_working* database.

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

- SPO for that week (Figure D.1.1),
- Narrative logs of activities,
- SSRF (yellow copy), and
- Supply requests.

The documentation packages are received by a CASTNet data analyst who records the contents of the packages on a hard copy Continuous Data Receipt Log before filing the documentation in designated locations in the DMC. The SPO are placed in chronological order before filing, and the narrative logs and yellow SSRF are filed together in the Site History Notebooks as a source of backup.

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 and LEAF_STATUS tables 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.

Monthly, each site operator mails diskettes containing the continuous data for the month from both the primary and secondary site data loggers to the DMC. The two diskettes are filed by site number at the DMC and are used as a source of backup data in the event data are missing following the polling process performed by ENVICOM.

D.1.2 Level I Data Processing

The purpose of Level I procedures is to develop a complete database. Attainment of this level of validation is achieved through:

- Generation of reports to establish data completeness and define time periods of missing data;
- Recovery of missing data using SPO, site diskettes created from the primary data logger (all measured parameters), and site diskettes created from the secondary data logger (the majority of backup data loggers record eight of the eleven measured parameters); and
- Electronic documentation of all actions related to these procedures.

Monthly, the DOM generates a missing field data report (Figure D.1.2) and sends it to the data analyst responsible for Level I validation. 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 retrieves the site data from the DMC filing system, checks the SPO and, if necessary, the primary and secondary data logger diskettes to find the missing data. Using the CDMSA, the data analyst enters all missing data that are found into the database. All data manually entered into the database are validated for accuracy through double entry.

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 I process. When manual entry is complete, new daily reports are printed as needed (Figure D.1.3). 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.

Quarterly, the DOM generates a report (Figure D.1.4) 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
- Total microgram records from the laboratory without associated FILTER_PACK records.

The report is sent to the QA Manager, LOM, and DMC data analyst. 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 parties. 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 I and Level II procedures are recorded on hard copy forms using a combination of CDRF (Figure C.1.3) and/or CDVS (Figure C.1.4) forms.

D.1.3 Level 1x Data Validation

Level 1x is a pre-validation procedure for flow and ozone data and Problem Report field validation recommendations. A data analyst performs this pre-validation of data after Level I and before Level II validation.

Level 1x consists of the following validation procedures:

- Flow pre-validation
- Ozone pre-validation and
- Problem Report field validation

These activities are performed using the CASTNet Metdata Editor. Changes are submitted and inserted into the METDATA_L2 table in the *castnet_working* database.

D.1.3.1 Flow Pre-Validation

During the flow pre-validation, the data analyst reviews flow data for the validation period. Inaccuracies and the associated data are updated as appropriate. All data manually entered into the database are validated for accuracy through double entry. Examples of some inaccuracies and the associated actions include:

- Data missing (“M” flag) – Data are assumed and entered at nominal value and the M flags are removed. Flow data that are missing in the database are available from information entered on the SSRF. At the Tuesday site visit, the site operator records the total number of hours that the filter pack was on the sampling tower in the flow section of the SSRF. The site operator obtains this information from the hour-meter on the flow equipment. Ideally, a filter pack is on the tower for a total of 168 hours (seven days). The data analyst calculates the correct number of valid missing hours for data assumption. Entry of the nominal value for the site is performed using the CASTNet Metdata Editor.
- “B” flag status, may indicate a downed channel after a manual check by a site operator, field technician, or external auditor – Data may or may not be valid. If valid, the data analyst manually

removes the B flag and replaces it with a null flag status indicating valid data. If the data are determined to be invalid, the B flag remains. This validation change, which uses the CASTNet Metdata Editor, is submitted and inserted into the METDATA_L2 table in the *castnet_working* database.

- Low or high flow values (± 10% of the nominal value) caused by inaccurate scaling – Data are re-scaled. New full scale and zero settings on the flow equipment result in low or high flow values (refer to section D.1.4.1.2). The data analyst manually changes the incorrect value to the correct value of 1.50 Lpm for the eastern sites or 3.00 Lpm for the western sites using the CASTNet Metdata Editor. Data are submitted and inserted into the METDATA_L2 table in the *castnet_working* database.

D.1.3.2 Ozone Pre-Validation

Ozone pre-validation includes reviewing all ozone data for the designated validation period. While reviewing the ozone data, the data analyst flags the data as follows:

- Any values < 0 ppb – The data are flagged with "alarm low" status. Due to circumstances in certain areas, very low ozone readings can occur. At such times, the ozone values will poll with numerical values of less than zero (e.g., -1 ppb). Data with such low values are not necessarily invalid and are flagged with "alarm low" status. Data are submitted and inserted into the METDATA_L2 table in the *castnet_working* database
- Any values > 120 ppb – The data are flagged with "alarm high" status. Any ozone value > 120 ppb occurring after a gradual increase of value between hours will be flagged with as having "alarm high status using the CASTNet Metdata Editor. Data are submitted and inserted into the METDATA_L2 table in the *castnet_working* database.
- Any incorrect B flag status – Data with B flag status may be valid or invalid. If invalid, the B flag status remains. If valid, the B flag status is removed and replaced with a null value using the CASTNet Metdata Editor. Data are submitted and inserted into the METDATA_L2 table in the *castnet_working* database.

D.1.3.3 Problem Report Field Validation

Problem report field validations are recommendations to data validators that are entered by the FOM or other designated person into the FIELD_VALIDATION table in the *castnet_application* database. Figure D.1.5 is an example of the Field Validation Criteria window that is used to enter, select and run data validations.

The recommendations are based on daily site review findings, site operator contact each Tuesday and calibration findings by the FOM. After the recommendations are entered into the database, the data analyst selects the records for the period being validated and applies the recommended changes. The changes occur in the METDATA_L1 table and remain at a Level 1x QA code.

D.1.4 Level II Data Validation

Level II validation consists of the following activities:

- Standard data changes (Section D.1.4.2.1), and
- Adjusting or flagging data after review of all field documentation (Section D.1.4.2.2).

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

1. Six-month data packet including daily reports, SPO, and CDVS and CDRF data forms;
2. Site history notebook containing field data forms such as the site call-in log, SSRF, and narrative logs;
3. Independent audit results;
4. Calibration results recorded in the calibration folder; and
5. Field problem reports.

This site documentation is used to determine the corrective actions required for the validation process and to verify the validity of the data for the site. Calibration and audit results are important sources of information about the accuracy of data. Each site is calibrated semiannually and audited annually. Unadjusted calibration results (Figure D.1.6) are checked for all parameters using the criteria shown in Table B.5.5. Audit results are used to confirm the accuracy of the calibration results and to help determine adjustment time periods. Prior to 2000, if precalibration results failed acceptance criteria, the data corresponding to the failing parameter were adjusted if appropriate. After 2000, 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 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 O_3 or flow rate data are adjusted.

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

1. Confirming Level I validation activities;
2. Establishing and performing necessary corrective actions to the data affected by defined and documented deviations from the acceptable ranges of all sampling equipment;
3. Reviewing all available documentation pertaining to the validation time period to establish validity of collected data;
4. 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;
5. Documenting performance of all actions that result in changes to data points, data status flags, or both; and
6. Archiving hard copy documentation in the appropriate location and inserting final Level II continuous data into the METDATA table in the *castnet* database.

All changes to continuous data completed during the Level II validation process are made by utilizing the Metdata Editor program within the CDMSA. Metdata Editor offers Level II data analysts an interface to directly access the METDATA_L1 table in the *castnet_working* database. As data are edited within the Metdata Editor and changes are submitted, data are inserted into 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

- 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.

In addition, when a record is inserted into the METDATA_L2 table, a database trigger archives the Level I record from the METDATA_L1 table in *castnet_working* database by inserting it into the METDATA_LEVEL1 table in the *castnet* database. The record is then deleted by the trigger from the METDATA_L1 table in the *castnet_working* database. The archival process maintained by the database trigger produces a historical database of Level I continuous data that allows a specific record to be tracked through the complete validation procedure.

Monthly, continuous data for all NPS sites are delivered via e-mail by ARS. Data are considered final, or validated at Level II, upon receipt. MACTEC performs no additional corrective actions associated with the validation of these data. See Section D.4.8.3 for an explanation of the verification process used to screen data submitted by ARS. Annually, ARS sends updates to the continuous data for NPS sites that undergo further validation based on calibration results and/or additional QC actions. Similarly, prior to the transfer of the nephelometers to IMPROVE, continuous nephelometer data were submitted quarterly by ARS via e-mail. Again, as with the continuous data, nephelometer data were considered validated at Level II upon receipt.

Hourly flow data associated with the visibility sampling system were validated similarly to the data associated with the dry deposition sampling system, except a different software was used during the processing. While continuous data for the dry deposition component are handled using the Level I and Metdata Editors within the CDMSA, visibility continuous data were edited by Level II data analysts using the ENVAID software package. ENVAID directly accessed the binary files created from the site polling process. As with dry deposition validation, associated continuous data and supporting documentation were gathered. This documentation included the VSRF, technical problem report, and calibration folders. In particular, the start and stop times documented on the VSRF were reviewed. Generally, flow pumps automatically ran for a 24-hour period. However, occasionally the site operator was required to perform a manual run when the pumps did not activate on schedule. Low hourly flow values were investigated and then verified, adjusted or invalidated. After validation was completed using the ENVAID software, the Level II data analyst prepared a report for the LOM using the QARPT report generator, and submitted the Level II binary files for each site to the DOM for incorporation into the VISFLOW table in the *castnet* database.

D.1.4.1 Data Continuity and Reasonableness Checks

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 reviews the data for discrepancies and inconsistencies but only invalidates data if one or more of the following occur:

1. Failure of a semiannual calibration,
2. Apparent equipment malfunction,
3. Apparent DAS malfunction, or
4. Apparent contamination 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 D.1.2 lists the current validation criteria and the type of adjustment by parameter

(flow and O_3, only), and Table A.7.2 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 and O_3. Flow and O_3 data are adjusted within this range. Data associated with precalibration results outside of the two times criteria range are flagged as invalid.

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; 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.

D.1.4.1.1 Ozone

Measurement Criteria: ±10.0% of slope = 1.0; Intercept < 5.0.
Adjustment Methods: Slope/Intercept, Percent.

Unadjusted manual checks of the O_3 analyzer versus transfer response consist of O_3 concentrations measured at approximately: 0, 60, 100, 200, 300, and 400 ppb. In addition, every Sunday the analyzer performs automatic checks of 0 ppb level for zero check, 90 ppb level for precision check, and 400 ppb level for span check.

Results are recorded by the data logger in a binary calibration file and on a hard copy (SPO) created daily at the site. Precalibration check results listed on the calibration forms are used to correct data by analyzer drift, and internal calibration results listed on SPO are used to determine the time frame of a drift.

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. An "alarm low" flag is attached to any negative O_3 value. An "alarm high" flag is attached to any O_3 value ≥ 120 ppb if it is valid. Section D.3 describes uses and meanings of data status flags.

Types of Adjustment

- Percent Adjustment: Adjustment is based on a multiplication factor calculated from an average percent difference of several unadjusted calibration checkpoints of sensor versus transfer. The typical limit is ± 10.0%. The smallest adjustment factor is used to correct the error. Final results of the previous calibration are checked to assure the validity of the adjustment.
- Slope/Intercept Adjustment: Adjustment is based on slope/intercept values calculated from the unadjusted results. Slope/intercept values are calculated when unadjusted results indicate a nonlinear error and no single numerical factor will correct all ranges. To calculate the slope/intercept, at least three checkpoints representing ~75% of full range are used. Before performing the adjustment, the proposed adjustment must correct ranges that are incorrect while

maintaining final results listed on the previous calibration form. To perform an adjustment, the following formula is used:

$$\text{Adjusted Value} = \frac{\text{Unadjusted Value - Intercept}}{\text{Slope}}$$

D.1.4.1.2 Flow

Measurement Criterion: ±5% of expected Lpm flow.

Adjustment Method: Percent value.

The calibration procedure for flow incorporates three main checkpoints:

1. Pump off - zero value,
2. Existing flow at standard temperature and pressure (STP), and
3. 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.

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.

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.

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 0.2 Lpm) are left as valid until concentration calculations are processed to determine if there were any measurable influence on the data. Data affected by large leaks (> 0.2 Lpm) are invalidated.

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 as 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 ENVICOM. 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
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 fell off the tower or was not properly secured to tower) 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, site operator comments in the narrative site log, and the Field Problem Report are useful guides in determining the starting point for the invalidation.

D.1.4.1.3 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.

D.1.4.1.4 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.

Defined as the difference in temperature between the 2 m (T1) and the 9 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.

CASTNet uses temperature probes from two different manufacturers, Climatronics and R.M. Young. Differences between the two systems affect how delta temperature data are validated. Climatronics systems calculate delta temperature using the equation T2-T1 while R.M. Young systems calculate delta temperature using the equation T1-T2. As a result, all Climatronics delta temperature data must be multiplied by –1. Climatronics delta temperature

probes have an operating range of –5°C to 5°C. Any values outside of this range are flagged as invalid. R.M. Young delta temperature probes have an operating range of –3°C to 7°C. Any values outside of this range for R.M. Young sites are flagged as invalid.

D.1.4.1.5 Relative Humidity

Measurement Criterion: ± 5.0% of full scale at relative humidity ≥ 85% and ± 20.0% of full scale at relative humidity < 85%.

All relative humidity values should fall between 0 and 100%. The data >100 and ≤ 102.5% are corrected to 100%. Extremely low values (e.g., < 20% for eastern sites and < 10% 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.

D.1.4.1.6 Precipitation

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

An unadjusted check of tipping bucket response is done 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.
Precalibration results are recorded on semiannual calibration forms. Prior to 2000, these results were used to adjust data. Currently weekly 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.

D.1.4.1.7 Wind Direction and Wind Speed

Measurement Criterion: – Wind Direction: ± 0.5° 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% difference between readings recorded by transfer and unadjusted readings of a sensor for values ≥ 5.0 m/sec.

Sites using Climatronics and R.M. Young 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; 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, SPO and calibration logs 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."

Occasionally, the site operator neglects to down the wind system channels when performing an electronic zero and span check on a Climatronics system. This may be 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:

1. Error is nonlinear. Three parameters, vector wind direction, vector wind speed, and sigma theta, are invalidated (Table D.1.3).
2. Error is linear. Sigma theta is reported, and vector wind direction and vector wind speed values are invalidated. (Table D.1.3).
3. Wind speed data results are invalid. Three parameters, scalar wind speed, vector wind speed, and vector wind direction, are invalidated. (Table D.1.4).

D.1.4.1.8 Solar Radiation

Measurement Criterion: ±10.0% 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. This requires further investigation in order to determine whether to invalidate (sensor failure), to flag "alarm low" (excessive zero drift or improper sensor calibration), or to rescale the data in question (improper DAS calibration).

A special case occurs when precalibration results are > 10% 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.

D.1.4.1.9 Surface Wetness

Measurement Criteria: ≥ 0.50 VDC. Percent undefined. As 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, SPO, 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 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 are dew point readings. 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.

A wetness sensor may exhibit positive zero drift, reading a constant value when all other parameters indicate dry conditions. Positive readings due to zero drift are adjusted to zero during validation for all values less than 0.50 VDC when dry conditions have been verified. Readings below 0.50 VDC are not used for MLM calculations.

D.1.4.2 Uncertainty Levels of the Validation Process

The reproducibility of results related to Level II 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 A.7.2).

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%. During calibration, the flow rate is found to be 8 percent above the standard for the site, representing a failure of + 3%. Flow data for the corresponding time period 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%, 1.50 Lpm * 1.05 = 1.58
Minimum correction factor	=	1.62 Lpm – 1.58 Lpm = 0.04 Lpm/1.50 Lpm = 3%
Maximum correction factor	=	Allowed deviation = 5%
Uncertainty	=	5% - 3% = 2%

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 D.1.2 lists the possible uncertainty ranges for all parameters. The table also summarizes the adjustment procedures for O_3 and flow, and the adjustments made to meteorological parameters prior to 2000.

D.1.4.2.1 Standard Data Changes

The routine changes performed to correct values either above or below the full scale of instrument response or to standardize delta temperature data are shown in Table D.1.5 and are described in the following subsections. Standard data changes are made by utilizing the *auto adjust* feature in the CDMSA Metdata Editor and are confirmed using a SQL query to screen the corrected data.

D.1.4.2.1.1 Rescale Delta Temperature

For sites using R.M. Young equipment, the data for delta temperature are calculated by subtracting the temperature value measured at 9 m from the temperature value measured at 2 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 R.M. Young sensor. Therefore, delta temperature values for all 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.

D.1.4.2.1.2 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 "__" (alarm low).

D.1.4.2.1.3 Set Maximum Relative Humidity

The relative humidity translator has a full-scale output of 1.024 V, which corresponds to a full-scale reading of 102.4 instead of 100.0. This voltage output occurs when the sensor is completely saturated with moisture. Relative humidity values > 100.0 and ≤102.5 are replaced with 100.0.

D.1.4.2.1.4 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.

D.1.4.2.2 Editing Procedures

D.1.4.2.2.1 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.

D.1.4.2.2.2 Setting Status Flags

Data status flags (Table D.1.6) 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 II 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 D.1.4.2.2.1. 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.

D.1.4.2.3 Example Adjustment During Level II Validation

The data validation/adjustment process is illustrated by an O_3 datum of 33.75 ppb collected at midnight on March 16, 1998 at STK138, IL.

The subsequent unadjusted calibration results from March 18, 1998 (Figure D.1.6) indicated that the O_3 analyzer output was 10 to 12 percent low. After performing all necessary checks, maintenance, and documentation, the analyzer output was adjusted by increasing the span setting. Another calibration documented the performance of the site analyzer following the adjustment (Figure D.1.7). Although the adjustment corrected the analyzer output, the setting was near the maximum allowable range recommended by the analyzer manufacturer (Table B.5.7). To ensure against further degradation of the O_3 signal, the analyzer was replaced on March 25, 1998 with the O_3 transfer standard. This sequence of events was documented in the Field Problem Report (Figure D.1.8).

During the data validation process, the calibration results were reviewed. Based on the unadjusted calibration results, the O_3 datum for 1998-03-16 00:00 was adjusted by applying a slope and intercept correction (Figure D.1.9).

D.2 Validation of Discrete Data and Supporting Information

Data management within the CASTNet laboratory encompasses the entire information transfer process, from planning sample collection to reporting data. Table D.2.1 illustrates the sequence of validation steps for the discrete laboratory measurements. The CASTNet laboratory uses CLASS™ to manage all data for this project. A complete description of CLASS™ is given in Section B.7.2.

D.2.1 Level 0 Data Processing

D.2.1.1 Dry Deposition

In the laboratory, Level 0 procedures begin before shipment of sample collection media to the sites. The laboratory data assistant sets up weekly field sampling groups in CLASS™. These field groups are assigned a field group number based on the scheduled sampling date for each site. As the field group numbers are assigned, CLASS™ 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 field group have been generated, the filter packs are prepared and shipped to the sites according to the procedures described in Sections B.3.2 and B.3.4.

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 B.3.2.1. Exposed filter pack samples from EPA-sponsored sites must be received by the CASTNet laboratory within two weeks of removal from the sampling tower. The MACTEC 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 field group and sequence number to the filter pack by using the on date recorded on the SSRF. This laboratory sample number (field group + 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 B.3.5 and B.3.6 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 CLASS™ 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 B.3.6.1, each of the filters (Teflon®, nylon, and Whatman) 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 D.2.2 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 CLASS™. 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. Once a week, the corresponding SSRF that accompanied the logged in filter packs are sent to the DMC for entry into the database. All data manually entered into CLASS™ and/or the database are validated for accuracy through double entry. The discrete data validation process is summarized in Table D.2.1.

D.2.1.2 Visibility

The procedures summarized below were followed by MACTEC until May 2001 when IMPROVE assumed responsibility for the visibility network sampling and analysis. More information about IMPROVE may be found on their web site: http://vista.cira.colostate.edu/improve.

Laboratory Level 0 procedures for aerosol sampling began before sample collection media were shipped to the sites. As with the dry deposition filter packs, Level 0 procedures for the visibility network began with the setting up of the weekly field sampling groups in CLASS™. However, since a visibility sampling kit consisted of three single-stage filter packs, ID labels were generated for each filter type (i.e., denuder/nylon filter pack, Teflo® filter Petri dish, and the quartz filter Petri dish) in addition to the laboratory sample labels, chain-of-custody labels and shipping labels (Section B.3.2.2). The ID labels for the filters in a visibility sampling kit were all labeled with the identical laboratory sample number and a letter to designate the filter type (i.e., N for nylon, T for Teflo®, and Q for quartz). The laboratory data assistant assigned a field group number to each visibility sampling kit based on the scheduled sampling date for each site. This process allowed each site to have a unique sample number for each sampling event.

Once the single-stage filter pack was loaded with the unexposed nylon filter and attached to the denuder assembly, a laboratory sample number label was attached to the outer ring. This label contained the laboratory sample number, filter designation, and site number. The individual Petri dishes containing the unexposed Teflo® and quartz filters were also labeled with their respective labels. A corresponding chain-of-custody label bearing the same laboratory sample number with filter designations and site number plus the employee number of the person who prepared the denuder/nylon filter pack was attached to the VSRF (Figure B.3.4). The visibility sampling kit was prepared and shipped to the field according to the procedures described in Sections B.3.2.2 and B.3.4.1.2.

After sample collection, the site operator returned the sampling kit with its corresponding VSRF to the CASTNet laboratory in Gainesville, FL, according to the procedures described in Section B.3.4.1.2. The MACTEC receiving clerk delivered the sealed shipping container to the sample custodian who examined the shipping container for damage and opened the shipment. The sample custodian verified that the sample number labels and site numbers attached to the filter pack/denuder assembly, Teflo® filter Petri dish, and quartz filter Petri dish matched the chain-of-custody label on the VSRF. The visibility sampling kit was then assigned the correct sample number following the same steps described for the dry deposition filter pack in Section D.2.1.1, except problems were documented on the VSRF. Samples were unpacked and entered in the Filter Pack Receipt Log according to the procedures described in Sections B.3.5 and B.3.6 and in CASTNet laboratory SOP GLO 3180-008 for Receiving, Unpacking, and Log in of Visibility Samples (Appendix 4). The nylon filters were assigned sample numbers and activated in the same manner as described for the dry deposition filters in Section D.2.1. The yellow copies of the VSRF were given to the DMC on a monthly schedule. The laboratory data assistant entered data from the white copies of the VSRF into CLASS™ monthly.

The sample numbers on the Teflo® and quartz filters were verified before being stored prior to shipment to the subcontractor laboratories for analysis. The Teflo® and quartz filters were shipped to Chester and Sunset, respectively, on a monthly schedule. The shipment contained a chain-of-custody form listing all of the filter sample

numbers for each filter included in the shipment and the corresponding site number and on date. The discrete data validation process for the visibility samples is summarized in Table D.2.1.

D.2.1.3 Wet Deposition

The procedures summarized below were followed by MACTEC through 1998. NADP/NTN assumed responsibility for wet deposition measurements in 1999. More information about NADP/NTN may be found on their web site: http://nadp.sws.uiuc.edu.

In the laboratory, Level 0 procedures began before shipment of sample collection media to the sites. The laboratory data assistant set up weekly field sampling groups in CLASS™. These field groups were assigned a field group number based on the scheduled sampling date for each site. As the field group numbers were assigned, CLASS™ generated unique sample labels and a laboratory field group log sheet that was used after receipt of the precipitation samples from the field. The laboratory field group log sheet contained all assigned sequence numbers for each wet deposition site. This process provided each site with a unique sample number for each sampling event. Once all of the labels and log sheets were generated, a wet deposition sampling kit consisting of a pre-weighed bucket and lid and a 1-L sample bottle were shipped to the sites according to the procedures described in Section B.3.4.2.

At the end of the sample collection week, the site operator completed the PSRF and recorded the gross weight of the bucket, lid, and sample. The weights of the bucket and lid were recorded directly on the outside of the bucket and lid allowing the site operator to calculate the net weight of the sample and complete the PSRF. The sample was then transferred to a 1-L sample bottle and returned, with the bucket and lid, to the CASTNet laboratory as described in Section B.3.5.2. Unpacking and log in procedures proceeded as described in the previous sections for the dry deposition and visibility samples, except that comments were documented on the PSRF. After the samples were assigned a sample number (field group + sequence number), it was written on the PSRF and the 1-L sample bottle. The sample custodian used the laboratory field group log sheet to record the on date and receipt date next to the correct sample number. The PSRF were sent to the DMC in weekly batches for entry into the database. The laboratory field group log sheet was submitted to the laboratory data assistant who logged in the sample by entering the sample number, on date, receipt date, and parameter list into CLASS™. The sample number was activated and placed on the laboratory's available number report to notify the laboratory analysts that the sample was in-house and ready to undergo analytical procedures. The discrete data validation process for wet deposition samples is summarized in Table D.2.1.

D.2.2 Level I Data Processing

D.2.2.1 Dry Deposition

Level I procedures begin with extraction of the Teflon®, nylon and Whatman 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, CVS, and replicates. Each laboratory batch that is analyzed by the CASTNet Gainesville, FL laboratory is assigned a sequential number beginning with the letter "G" 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, CLASS™ 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 B.6.1. The CLASS™ system has various automated checks to alert the analyst to any outlier flags or possible problems. Figure D.2.1 is an example of the automated CLASS™ Data Batch QC Checklist that is completed for each analytical run. The CLASS™ system also generates a Manual Data Batch QC Checklist for the analyst to complete (Figure D.2.2). Any non-standard or negative answer to any of the questions on either of the checklists requires a documented explanation or comment by the analyst. The comment is then peer reviewed to determine if the analytical run should be repeated. Level I validation ends when sample analysis meets the criteria listed in Table B.6.2. Once the analyst has thoroughly reviewed the analytical batch and has signed and dated the CLASS™ data batch checklists, the data batch folder is complete.

At this time, the data batch folder containing all documentation is turned over 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. Documentation of any outliers is further reviewed for justification and acceptance. If the reviewer accepts the data results documented in the batch folder, the folder and its contents will be signed, dated, and submitted to the laboratory data assistant for entry into CLASS™. All data manually entered into CLASS™ are validated for accuracy through double entry. If the reviewer does not accept the data batch folder, any additional requirements are documented prior to returning the data batch folder to the original analyst for completion of the requirements.

As an additional QC check, every week each analyst manually calculates one random sample through the entire process from instrument output to final concentration. This procedure verifies that data point and validates that the CLASS™ batch system is working correctly.

When a batch is approved, the batch will be finalized in CLASS™. Once a batch has been finalized, the batch is locked, and data cannot be changed. If during data review and validation, a change to a finalized (locked) batch is identified as necessary, a Batch Update Form (Figure B.7.5) must be initiated. The form requires the following documentation:

- Batch number,
- Analysis type,
- Person requesting the change,
- Reason the change is necessary, and
- Signature of the analytical group leader or LOM.

The laboratory data assistant “definalizes” the batch and documents the action, change, and reason electronically in the notes section of the batch. After the analyst makes the changes, the new batch printout, along with the completed update form, are given to the laboratory data assistant for finalizing. 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.

D.2.2.2 Visibility

The procedures summarized below were followed by MACTEC until May 2001 when IMPROVE assumed responsibility for the visibility network sampling and analysis.

Analysis and Level I data validation procedures for the visibility nylon filters were the same as that described for the dry deposition nylon filters in Section D.2.2.1.

The data were received from the subcontractor laboratories on a monthly basis and were considered to be validated at Level I upon receipt. The analytical and data verification and documentation procedures used by Chester and Sunset to produce the data submitted to MACTEC are described in the corresponding SOP (see Appendix 5 of the CASTNet QAPP, Revision 1.0, January 2003). The Chester data were received in a dBASE® file that was loaded directly into CLASS™ using a specially designed CLASS™ program. The Sunset data were received in an Excel® spreadsheet and were manually entered into CLASS™. A data batch folder was created for the Sunset data that contained a printout of the Sunset e-mail transferring the data to MACTEC, the Excel® data report, and the CLASS™ data batch.

D.2.2.3 Wet Deposition

The following procedures were followed until January 1999, when NADP/NTN assumed responsibility for wet deposition sampling and analysis.

Level I validation procedures for the wet deposition data began with laboratory measurement and filtration of the samples prior to analysis as described in SOP GLO3180-004 (Appendix 4). The samples were analyzed according to the methods described in Section B.6 and Table B.6.1. The analytical results were subject to the same review process as described for dry deposition data in Section D.2.2.1.

Historically, for wet deposition samples, a second laboratory data validation check involved two interparameter consistency checks. This check was done only on finalized data results:

- Percent difference of cations versus anions, and
- Percent difference of predicted-versus-measured conductivity.

The evaluation of these interparameter consistency checks provided a method for determining whether the analysis should be repeated or investigated further.

CLASS™ calculated the concentrations of cations and anions and predicted conductivity and hydrogen ion. CLASS™ then calculated the percent difference between the measured conductivity value and the predicted value. The percent difference between the cation and anion values was also determined. CLASS™ calculated the percent difference using the following equation:

$$Percent\ Difference = \left[\frac{V_1 - V_2}{V_1 + V_2}\right] * 200$$

The guide for reanalysis is:

- Percent ionic difference of cations (Value 1) versus anions (Value 2):

If pH $\leq$ 4.5, then criterion = $\pm$ 5%

If pH > 4.5, then criterion = $\pm$ 15%

- Percent conductivity difference for predicted (Value 1) versus measured (Value 2) conductivity:

  If conductance $\leq$ 10, then criterion = $\pm$ 30%

  If conductance > 10, then criterion = $\pm$ 10%

When the batch was approved, it was finalized in CLASS™ according to the procedures described in Section D.2.2.1.

D.2.3 Level II Validation

D.2.3.1 Dry Deposition

Level II 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. Following approval, the samples are run through a specialized CASTNet export program. This program retrieves all of the samples and QC data associated with the samples to create 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 same batch of samples is also run through the CASTNet comment code program that groups the comment codes with each respective sample number. This program creates a text file that is saved as a Basic ASCII file. The dBASE® and corresponding ASCII transfer files are submitted to the DMC on a weekly schedule. Upon receipt, the DOM utilizes the *import labdata* function in the CDMSA to import the dBASE® and ASCII transfer files submitted for the week. 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 in CLASS™ for all of the analytical batches generated during the quarter. The following items are checked to verify compliance with internal and external (client) requirements for each method:

- Calibration curves
- Reference samples
- Continuing verification samples
- Replicates
- Method blanks
- Filter acceptance tests
- Laboratory blanks
- Field blanks

This review is done with various preprogrammed CLASS™ subroutines that retrieve and summarize the results. The laboratory Level II validation process is completed upon submittal of the transfer files to the DMC and summary of the quarterly QC information.

D.2.3.2 Visibility

Prior to the May 2001 transfer of the visibility network to IMPROVE, Level II validation procedures for the visibility data were similar to those used for validation of the dry deposition data (Section D.2.3.1). However, in addition to 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, the laboratory also calculated the atmospheric concentrations (Meter Cubed Report) for the three single-stage filter pack samplers (denuder/nylon, Teflo®, and quartz).

After the laboratory batch data was finalized, the LOM calculated the Meter Cubed Report. For the first step, the laboratory data assistant entered information from the VSRF into CLASS™. This information included the site number, sample number, run date, on date and time, off date and time, and the recorded comment codes. Then, the LOM received a field flow data file from the DMC, and a preprogrammed CLASS™ subroutine loaded the flow data into CLASS™. Once the laboratory finalized the total microgram data file, the VSRF field information, and the field flow data were entered into CLASS™, a preprogrammed subroutine merged the data to generate the atmospheric concentrations. A separate report was generated for each type of aerosol sampling filter pack: nylon/denuder, Teflo®, and quartz. All three reports were checked for completeness and reasonableness by the LOM who confirmed that the number of laboratory sample records matched the number of field records. If the quantity of records did not compare, the problem was investigated by verifying that the sample in question was submitted and that the data from the VSRF were correct. Any other problems that were noted were traced back to their origin and resolved by the LOM. When all the data were deemed acceptable, the LOM created the transfer files using a CLASS™ subroutine. The transfer files were then submitted to the DMC for incorporation into the database. Upon receipt, the DOM imported the transfer files and formatted the resulting tables using established macros and queries. Data were then inserted into the VISCHEM table in the *castnet* database. Additional screenings were performed based on the specific flow volume for each filter. If the actual flow volume was < 75% or > 125% of the expected flow volume for the runtime of the filter pack, the concentration values for the specific filter(s) failing these criteria were invalidated.

D.2.3.3 Wet Deposition

The following procedures were followed until January 1999, when NADP/NTN assumed responsibility for wet deposition sampling and analysis.

During the year prior to transfer to NADP/NTN, the Level II validation procedures for the wet deposition data were similar to those used for validation of the dry deposition data (Section D.2.3.1). Through 1997, however, the Level II validation procedures for wet deposition were handled in a manner similar to that of the visibility network. All procedures were completed by the laboratory. When all the data were deemed acceptable, the LOM created the transfer file. The transfer file was then submitted to the DMC for incorporation into the database. The DOM imported the data into the historical data table for wet deposition.

D.3 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.

D.3.1 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 II 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 can be found in Table D.1.6.

D.3.2 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 the CLASS™ system 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 Meter Cubed Report for the dry deposition data (Figure D.3.1). The explanation of the codes that were used for visibility and wet deposition samples are found in Figures D.3.2 and D.3.3, respectively.

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

D.4 Calculations

D.4.1 Calculation of 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:

1. Field flow data from EPA sites: Values are imported into the database and validated using the procedures described in Section D.1.
2. Field flow data from NPS sites: Values are sent to the DMC via e-mail from ARS (Section D.1.4).
3. Total microgram data from EPA and NPS sites: Values are sent to the DMC from the laboratory via e-mail.

Once all of the data are available in the MS SQL Server™ 7.0 CASTNet database, the DOM utilizes the *dry chemistry calculation process* feature in the CDMSA to complete the calculation procedure. First, the DOM 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 I data validation process for SSRF entry detailed in Section D.1.2. Second, using the EPA and NPS 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 Meter Cubed Report (Section D.5.2) for distribution to the QA Manager, LOM, and Work Assignment Manager.

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:

$$\text{Volume (in } m^3) = \frac{\text{total sample time (hr) x average flow x 60}}{1{,}000}$$

$$\text{Atmospheric Concentration (in } \mu g/m^3) = \frac{\mu g \text{ of analyte/filter x analyte dependent constant}}{\text{Volume}}$$

$$\text{Constant} = \frac{\text{molecular weight of analyte in air}}{\text{molecular weight of analyte in solution}}$$

Conversion constants applied to obtain atmospheric concentrations are listed in Table D.4.1. The calculations performed to obtain total NO_3^- and total SO_2 are listed in Table D.4.2.

D.4.2 Modeling Dry Deposition

The MLM, which has been described and evaluated by Meyers *et al.* (1998) and Finkelstein *et al.* (2000), is used to estimate V_d. The modeled V_d are combined with the atmospheric concentration values (Section D.4.1) to estimate the dry deposition of pollutants. 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:

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

where the overbars indicate an average over a suitable time period (e.g., one hour).

The influences of meteorological conditions, vegetation, and chemistry are simulated by V_d. Dry deposition processes are modeled as resistances to deposition:

$$R = R_a + R_b + R_c = 1/V_d$$

The meteorological variables used to determine R_a and R_b are obtained from the 10-m meteorological tower at each of the sites and are imported and validated as described in Section D.1. Data on vegetative species, LAI, and percent green leaf out used to determine R_c are obtained from site surveys and observations by the site operator. Actual LAI measurements were taken during 1991, 1992, and 1997 at times of summer maximum leaf out. LAI values used in the MLM are extrapolated from these measurements by using weekly percent leaf out observations

recorded by the site operators. The resistance terms (R_a, R_b, and R_c) are calculated for each chemical species and major vegetation/surface type for every hour with valid meteorological data. The V_d for a site is then calculated as the area-weighted V_d over vegetation types within 1.0 km of the site.

D.4.2.1 Deposition Flux Calculations

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 assumed to be equal to the filter pack sample concentration and 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 concentrations 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 D.4.5.

D.4.3 Rolling 8-hour Average Ozone Concentrations

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, 1997). 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 85 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 (85 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 with fewer than 75 percent valid hours but with fourth-highest values exceeding the threshold (85 ppb) are considered valid.

D.4.4 SUM-06 Ozone

SUM06 is calculated as the sum of hourly O_3 concentrations above 0.06 parts per million (ppm) that occur between the hours of 8 a.m. to 8 p.m. during a three-month period. The three-month period must fall within the ozone season for the state where a particular site is located. In order for the calculation for the three-month period to be valid, 70 percent of the hours during the day must be valid, and 70 percent of the days during the month must be valid. Valid monthly values are corrected for missing hours by multiplying the number of hours with concentrations above 0.06 ppm by the fraction of total number of hours in the month over the number of valid hours. Missing months with adjacent valid monthly values are replaced by interpolating the missing value and then weighting the result according to the number of days during the month. The peak SUM06 value for the year, displayed in the CASTNet annual report, is found by taking the max of all three-month SUM06 values during the ozone season for the site.

D.4.5 Aggregations

Analyses are performed for multiple tasks 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 other 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.

D.4.5.1 Data Averaging Conventions

CASTNet concentration data are analyzed and presented for several averaging times. This section summarizes the averaging conventions.

- Hourly O_3 concentrations, b_{scat}, and meteorological data:
  - Minimum of nine valid 5-minute averages;
- Filter pack concentrations:
  - Valid flow for 168 hours of sample period $\pm$ 10%: concentration is calculated and reported with no flag;
  - Valid flow for 168 hours of sample period $\pm$ 25%: 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.
- Aerosol concentrations:
  - Valid flow for 24 hours of sample period $\pm$ 25%: concentration is considered valid;
  - Quarterly mean: eight valid 24-hour samples; and

  - Annual mean: three valid quarterly means.
- Filter pack concentrations used in trend analyses (Harding ESE, 2002):
  - 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.

D.4.5.2 Filter Pack Dry Deposition Velocities and Fluxes

The rules used for calculation of V_d are as follows:

- Weekly mean:
  - For calculations of weekly means by site, 70 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, 70 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.

D.4.6 Reconstructed Mass

Using atmospheric concentrations from sites incorporating visibility components, fine mass was "reconstructed" in terms of the following parameters (Sisler *et al.,* 1996):

Ammonium Sulfate = $1.375 * SO_4^{2-}$

Ammonium Nitrate = $1.29 * NO_3^-$

Soil	=	(2.2*Al) + (2.49*Si) + (1.63*Ca) + (2.42*Fe) + (1.94*Ti)
Organic Carbon	=	1.4*OCTC
Elemental Carbon	=	ECTC

The SO_4^{2-} and NO_3^- concentrations were measured on the nylon filter, the soil parameter concentrations on the Teflo® filter, and the carbon concentrations on the quartz filter. Reconstructed fine mass was compared to the fine mass measured on the Teflo® filter. Results of this comparison were routinely included in the quarterly and annual reports prior to the transfer of the visibility sites to the IMPROVE network in May 2001.

D.4.7 Precipitation Concentration and Depositions

Prior to the transfer of wet deposition sampling and analysis to NADP/NTN, the rule used for calculation of precipitation concentrations and depositions required 75 percent completeness for the time period.

D.4.8 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, MACTEC has checking routines in place for all transfers to and from the database.

D.4.8.1 Continuous Data Verification

The process used to collect continuous data and import it into the MS SQL Server™ 7.0 CASTNet database is described in Section D.1.1. The collection and monthly import of these data are verified by the DOM through:

- Archiving the binary files in a separate directory marked “read only,”
- Running a query that lists the number of records per site to ensure that all data were transferred correctly, and
- Reviewing the results of the query.

Other sources of continuous data for a site include the weekly SPO and monthly diskettes from the primary and backup DAS, which are sent to the DMC by the site operators. The redundant methods of data storage enable the capture and cross checking of all data possible. Based on the results of the monthly missing field data report, these sources are used by a data analyst to obtain and enter as much data as possible into the database.

Documentation for data changes made by the data analyst as a part of Level I or Level II validation processes are recorded both electronically and on hard copy reports. This documentation includes the name of the analyst, the reason changes are necessary, and in the case of Level I changes, the source of the replacement data. For a detailed explanation of data changes made during the validation process, see Sections D.1.2 through D.1.4.

Contents of the weekly documentation package received from each site by the CASTNet DMC are described in Section D.1.1. 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.

D.4.8.2 Laboratory Data Verification

Weekly, the LOM, uses specially developed CASTNet data transfer software in CLASS™ to create a dBASE® file of validated laboratory data. The data set is checked by the LOM for completeness and reasonableness. This file is e-mailed to the DMC for transfer to the database along with a text file containing the laboratory comment codes. Quarterly the Meter Cubed Report (see Figure D.3.1) 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 D.4.1. The LOM uses 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 Meter Cubed Report is generated for verification. All data manually entered into the database are validated for accuracy through double entry.

D.4.8.3 NPS Data Verification

Monthly, ARS sends continuous data for one month for all NPS sites to the DMC. The submittal is formatted as a space-delimited text file and is sent via e-mail. 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 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.

D.4.8.4 Transfers to and from the Database

In addition to the procedures detailed above, the DOM 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. For instance, for every submittal of a data table to EPA, there are two files related to the checksum which are produced and included:

- <tablename>.chk is the checksum query of the table.
- <tablename>.out is the result of the MACTEC calculated checksum for the data sent.

These files verify that the outgoing submittal matches the data in the historical table. They also enable EPA to verify the transfer by running the same checksum query on the data after delivery and import into the EPA CASTNet database. 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.

D.5 Data Quality Assessments

At each level of data review, extensive efforts are made to verify that the data used are correct and to validate that the data set meets the needs of end users by being complete and representative according to project goals. See Section C.1.7 for an additional discussion of Data Quality Assessments.

D.5.1 Data Accuracy Significant Digits

All of the data reduction steps are verified to ensure that the transformed data can be traced back to the original raw data. The accuracy of all polled parameters consists of up to four significant digits, which are maintained throughout the entire database. To prevent any loss of precision, all numerical values (direct measures and calculated measures) are reported and archived in the CASTNet database with a maximum of eight significant digits.

D.5.2 Dry Deposition Data Review and Validation

After the Level II concentration data (µg/filter) are received from the CASTNet laboratory and the atmospheric concentrations are calculated, the concentrations are assessed for reasonableness. This process includes the following steps:

1. A Meter Cubed Report (Figure D.3.1) showing the information needed to assess the validity of the concentration data is generated by the DOM. This report is generated quarterly and consists of data for the specific quarter. It combines field and laboratory data to calculate atmospheric concentrations as described in Section D.4.1.
2. Within the Meter Cubed 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.
3. Expected ratios 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.
4. 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 Work Assignment Manager. All documentation for these samples is checked including SSRF and laboratory data batch folders. For field problems, the FOM furnishes the DOM with the corrected data to be entered in the database. The Work Assignment Manager uses the printout of the Meter Cubed Report as a work sheet to mark those samples that are to be investigated.
5. If laboratory procedures were suspect, the sample is reanalyzed. 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 DOM. The Work Assignment Manager is sent a report with recommendations as to which samples should be updated or flagged in the database. The Work Assignment Manager reviews the report with the Project Manager and then instructs the DOM accordingly.
6. After a sample is reanalyzed, the same criteria described above are used to review the rerun sample data. Final data concentrations are the original data, the rerun data, or the original concentration value with a corresponding data status flag. The Project Manager reviews the data, flags, reruns, and

documentation to make the final determination of usable data and flags. The Work Assignment Manager sends an e-mail to the DOM listing the samples that he recommends be updated with new data. A copy of this e-mail and the original printout of the Meter Cubed Report worksheet with investigated samples marked are filed by quarter in the Work Assignment Manager's office.

D.5.3 Visibility Network Data Review and Validation

After concentration data from the CASTNet, Chester and Sunset laboratories were received and finalized in CLASS™, the concentrations were assessed for completeness and reasonableness. The finalized concentrations were merged with the field information and flow file to calculate the atmospheric concentrations. This process included the following steps:

Checks made prior to the merging of the data files (laboratory, field and flow):

1. Laboratory data – Data from all laboratories were checked for completeness and reasonableness. Subcontractor laboratory data were additionally verified for correct site ID numbers and sample run dates.
2. Field data – Data were checked for accuracy. Recorded on/off dates and times and sample run dates were verified and compared to the number of valid hours.
3. Flow data – Data were verified for correct format, status flags and dates.

Checks made following the merging of the data and calculation of the atmospheric concentrations:

1. The Meter Cubed Report (Figure D.3.2) showing the information needed to assess the validity of the concentration data was generated by the LOM. The atmospheric concentration report was generated on a quarterly schedule and consisted of data for the specific quarter.
2. LOM reviewed the report and verified that the merging of the data files was done correctly. This process involved verifying that the valid hours on the report agreed with the VSRF and flow file. The run dates on the report were verified to be in agreement with the VSRF.
3. Concentrations of outlier samples identified by this procedure were reviewed by the LOM for outliers. Any outliers were further researched by focusing on field sampling, laboratory handling, and processing. This research included additional review of related documentation including the VSRF, field narrative logs, laboratory data batch folders, comment codes, subcontractor data files, and flow files.
4. Problems related to the field data were corrected by resubmission of the corrected flow file by the DMC. Problems related to subcontractor data were corrected by resubmission of the corrected data file by the appropriate subcontractor. If a laboratory procedure was suspect, the sample was reanalyzed for verification. Following reanalysis, the data were retained as originally submitted, the data were retained and flagged, or the rerun data were used in place of the original data.
5. The final atmospheric concentration report was submitted to the Project Manager for review.
6. Following acceptance of the report, the transfer files were created and submitted to the DMC.

D.5.4 Wet Deposition Data Review and Validation

These practices were followed for wet deposition monitoring until January 1999, when responsibility for wet deposition sampling and analysis was turned over to NADP/NTN.

Historically, before transfer to NADP/NTN, the precipitation concentration data from the CASTNet laboratory were assessed for reasonableness. This process included the following steps:

1. A report (see Figure D.3.3) with the information needed for the assessment was generated. This report was produced quarterly and consisted of data for the specific quarter in question.
2. Within this precipitation report, certain checks were made before the data were reviewed. The on/off dates and times of the wet buckets were checked for accuracy. The validity of the samples was then evaluated based on the data status flags and comment codes.
3. Expected ratios of cations versus anions were used to help determine outliers for the data concentrations (Table D.5.1).
4. Concentrations of the outlier samples identified by this procedure were compared to concentrations from other surrounding sites for the same time period and/or to previous quarterly final concentrations for the site in question. At this point, a list of suspect samples was compiled, and the suspect values were researched. The research focused on field sampling, laboratory handling, and sample analysis procedures. The same procedures were followed as for the dry deposition (Section D.5.2).
5. If laboratory procedures were suspect, the sample was reanalyzed. If the sample did not warrant reanalyzing because of comment codes or other circumstances such as contamination of the entire sample, the sample was assigned the appropriate data status flag.

D.6 Data Submittals to EPA

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.

D.6.1 Electronic Data Submittals

Data from the database are submitted to EPA on CDs on a regular basis. Data files are sent monthly, quarterly, and annually depending on the type of data being sent.

For each submittal of a data table delivered to the EPA, four files are included:

- <tablename>.csv is a comma-delimited text file containing the data;
- <tablename>.txt is a create table statement for the table;
- <tablename>.chk is a checksum query for the table; and
- <tablename>.out is the result of the MACTEC calculated checksum for the data sent.

The use and value of the checksum routine is discussed in Section D.4.8.4.

D.6.1.1 Monthly Data Submittals

The following data tables are sent in the monthly data submittals:

- Level II continuous meteorological data (METDATA);
- Level I continuous meteorological data (METDATA_LEVEL1);
- Level 1x continuous meteorological data (METDATA_LEVEL1x);

- Level II dry chemistry concentrations (DRYCHEM and DRYCHEM_DAYNIGHT);
- 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 sites).

Approximately 10 EPA and 30 NPS sites are submitted each month. In order to complete the draft annual report by the contractual deadline, no calibrations are performed in December or June. As a result no monthly data submittals 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 sites approximately 90 days after the end of the month. MACTEC 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 sites are sent with the September monthly data submittal.

Occasionally, ARS is unable to deliver data for a specific NPS site for the month being submitted. Reasons may include lack of availability of state-collected data (specifically for the sites at ACA419, ME and THR422, ND) or delays in receiving necessary field information from the site operators. Data for other NPS sites are still submitted to EPA on schedule. When available, data for the missing site are included in the next scheduled monthly submittal.

D.6.1.2 Quarterly Data Submittals

The following data tables are submitted to EPA quarterly:

- Raw total microgram laboratory values (LABDATA);
- Laboratory comments (LAB_COMMENTS);
- SSRF data (FILTER_PACK and LEAF_STATUS);
- Continuous data validation changes (TRANSACTION_LOG); and
- Visibility network data (VISCHEM, VISFLOW, and VISNEPH).

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.

D.6.1.3 Annual Data Submittals

The following data tables are submitted annually to the EPA:

- Dry deposition values (VELHR, VELWK, VELQR, and VELAN);
- Inventory information (EQUIPMENT_INVENTORY);
- Ozone values including rolling 8-hour averages (OZONE); and
- Ozone SUM06 values (OZONE_SUM06).

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, ozone data for year 2000 is delivered in mid-August 2001. Inventory data are delivered following the end of the fiscal year, usually packaged with the October monthly data submittal and second quarter data submittal.

D.6.2 Hard Copy 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, pollutant concentrations, and aerosols;
- Precision results for collocated sampling;
- Laboratory precision and accuracy estimates;
- Maps of pollutant concentrations;
- Trends analysis for 34 eastern CASTNet sites;
- Maps of 1-hour and rolling 8-hour ozone concentrations; and
- Data analyses, interpretations, and supporting text.

Prior to the May 2001 transfer of the visibility network to IMPROVE, the reports also included maps and analyses of aerosol concentrations and reconstructed mass. Analyses of the visibility data set were presented in the 2000 Annual Report (Harding ESE, 2002). Sections D.4.5 and D.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, DOM, FOM, LOM, and QA Manager.

D.6.3 Response Actions

All questions to MACTEC 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, DOM, 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.

D.7 Data Submittals to NPS

Data submittals are made to NPS upon request. There is no formal schedule established; however, filter pack concentrations for NPS sites are usually requested annually. 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.

D.8 Reconciliation with User Requirements

The basic CASTNet objectives as stated in Section A.4.1 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.

MACTEC 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 A.6.2),
- Quality objectives and criteria for measurement data (Section A.7),
- Special training for personnel (Section A.8),
- Documents and records (Section A.9),
- Sample handling (Section B.3),
- Data collection (Section B.7),
- QA Assessments/Oversight (Section C),
- Ozone and continuous data validation (Section D.1),
- Laboratory data validation (Section D.2),
- Data submittals to EPA (Section D.6),
- Data set usability (Sections D.1, D.2, D.3, and D.5).

Table D.1.1 Continuous Data Validation Process

DATA VALIDATION LEVEL	SOURCE OF DATA FILES	DATA PROCESSING AND QC ACTIVITIES	DATA STORAGE FORMAT
Level 0 Data Polling	Raw monthly binary data and status files.	• Check completeness of automated daily poll activities. • Daily data review.	Raw monthly binary data and status files.
Level 0 Data Input	Raw monthly binary data and status files.	• Pull binary files into MS SQL Server™ Level 0 Data Table.	MS SQL Server™ Level 0 Data Table containing one month of data.
Level I	MS SQL Server™ Level 0 Data Table containing one month of data.	• Locate all missing data points using MS SQL Server™ queries. • Ingest missing data points using site diskettes, binary files from primary DAS, backup DAS, manual entry from SPO. • Record counts for completeness of binary data transfer. • Corrective action initiated if erroneous data are detected. May result in changing values and/or status flags.	MS SQL Server™ Level I Data Table.
Level 1x	MS SQL Server™ Level I Data Table containing one month of data.	• Flow Pre-Validation • Ozone Pre-Validation • Problem Report Field Validation	MS SQL Server™ METDATA_L2 Data Table in the *castnet_working* Data Table*.
Level II	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 II Data Table.	• Confirmation of Level I 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 II Data Table.
Level II Final Statistical Review	MS SQL Server™ Level II Data Table.	• Final review of all statistical results generated by site and validated data set inserted into Archive Level II Data Table.	MS SQL Server™ Archive Level II Data Table.
Data Transfer File	MS SQL Server™ Archive Level II Data Table.	• Verification of all numerical fields and data status flags present in program generated transfer text file.	Transfer text file and supporting files are copied onto CD and transmitted to EPA each month.

* All other referenced tables are in the *castnet* database

Table D.1.2 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	± 5.0% of full scale at rel. hum. ≥ 85% ± 20.0% of full scale at rel. hum. < 85%	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

Note: Beginning with 2000 data, MACTEC does not adjust meteorological measurements. However, the types of adjustments are listed in the table for historical perspective.

Table D.1.3 Summary Table of Wind Direction Invalidation Options

Parameter	Invalid (Nonlinear Error)	Invalid (Linear Error)
Vector Wind Direction	●	●
Vector Wind Speed	●	●
Sigma Theta	●	
Scalar Wind Speed		

Table D.1.4 Summary Table for Wind Speed Invalidation Options

Parameter	Invalid
Vector Wind Direction	●
Vector Wind Speed	●
Sigma Theta	●
Scalar Wind Speed	

Table D.1.5 Standard Data Changes

Parameter	Range	Corrected to:
Delta temperature (Climatronic sensors only)	All values	Multiplied by -1.0
Solar Radiation	> -14.0 and < 0.0	0.0
Relative Humidity	> 100.0 and < 102.5	100.0
Wetness	> 1.0 and < 1.025	1.0

Table D.1.6 Data Status Flags

Flags Present in Raw Binary Files	Flags Present in Edited Files	Flags Present in Transfer File	Meaning of the Status Flag
<	<	<	Less than 15 minutes of hourly sample missing
B	B	B	no sample
C	I	I	C – calibration I – not valid
D	D	D	Channel downed by operator
F	F	F	Power failure
M	M	M	Missing data
	^	^	Alarm high
	_	_	Alarm low
	S	S	Suspect due to calibration failure
null	null	null	Valid with no conditions
	I	I	Not valid

Table D.2.1 Discrete Data Validation Process

DATA VALIDATION LEVEL	DESCRIPTION	DATA PROCESSING AND QC ACTIVITIES	DATA STORAGE FORMAT
Level 0	Each sample is assigned to a field group based on the scheduled sampling date. This is then used for sample and data tracking.	• Creation of the field groups and associated labels. • Preparation of sampling media for the field; shipment to site operators. • Receipt of sampling media from field; Filter packs unpacked and assigned laboratory sample numbers. • Shipment of Teflo® and quartz filters to subcontractors. • Log in and activation of the laboratory sample numbers in CLASS™.	Stored electronically in CLASS™ and as hard copies in project files.
Level I	Validation performed during analysis activities.	• Activated laboratory sample number placed on the laboratory available numbers report. • Preliminary analytical procedures begin including extraction and filtration. • Filters for subcontractors are shipped in monthly batches. • Samples are analyzed in laboratory batches; data are downloaded into CLASS™. • Batches are processed through automated QC checking routine and results are printed out. • Documentation to support the analytical run is filed in associated batch folder. • Subcontractor analytical results are received; results are downloaded or entered into CLASS™. • Analyst reviews results of automated QC checklist; completes batch manual QC checklist. • Analyst signs and dates batch and submits the batch for peer review. • 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. • If the batch folder has any QC outliers the batch folder is submitted to the LOM for review and sign-off. • Sign-off batch is then given to the laboratory data assistant. • Batch is finalized in CLASS™ and the batch folder is placed in a filing cabinet.	Finalized analytical results are stored electronically in CLASS™ database with hard copy backups. All supporting documentation is filed in the data batch folders.
Level II	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.	• Review of documentation and QC sample results. • Submittal of analytical results to the DMC in dBASE® and ASCII files.	Stored electronically in CLASS™ and MS SQL Server™ databases.
Visibility Atmospheric Calculation		• Receipt of hourly flow file from DMC. • Laboratory entry of VSRF into CLASS™. • Merging of flow file and total chemistry data performed in CLASS™ to calculate the atmospheric concentration in $\mu g/m^3$. • Atmospheric concentration reviewed for suspect samples. • Atmospheric concentration report processed in CLASS™ to generate the transfer file. • Transfer file submitted to the DMC.	Stored electronically in CLASS™ and MS SQL Server™ databases.

Table D.2.2 Field Remarks (Determined by Laboratory)

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 Whatman 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 D.4.1 Conversion Constants

Teflon®		Nylon		Whatman	
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 D.4.2 Calculations for Total NO_3^- and SO_2

Parameter	Calculation
Total NO_3^-	Teflon® - NO_3^- + (nylon-HNO_3*0.984)
Total SO_2	Whatman- SO_2 + (nylon-SO_4^{2-}*0.667)

Table D.5.1 Ratio Tests for Dry and Wet Deposition Data

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^- / Whatman-NO_3^-	> 1.5
Teflon®-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

Figure D.1.1 Sample Site Printout

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	01	02	03	04	05	06	07	08	
CHAN	PRECIP	WDR	WSP	TEMP	DLTEMP	RELHUM	OZONE O3	DUM	SD1
UNITS	INCHES	DEG	M/S	DEG C	DEG C	%	PPB	PPB	DEG
FSCL	10.00	360	50.0	50.0	7.00	100.0	500	500	99.9
ZERO	0.00	0	0.0	-50.0	-3.00	0.0	0	0	00.0
01:00	0.00	149	2.6	1.9	-0.40	89.3	22	21	10.7
02:00	0.00	140	2.0	2.0	-0.40	89.3	20	20	14.0
03:00	0.00	126	2.3	2.0	-0.40	90.6	17	17	12.8
04:00	0.00	130	1.8	2.0	-0.40	91.6	16	16	13.4
05:00	0.00	125	2.0	2.1	-0.42	92.8	15	15	11.9
06:00	0.00	121	2.5	2.2	-0.43	94.2	16	16	13.1
07:00	0.00	128	3.1	2.2	-0.44	96.1	20	20	12.6
08:00	0.00	122	3.3	2.5	-0.42	96.1	21	21	12.1
09:00	0.00	122	3.6	2.7	-0.45	94.9	19	19	11.8
10:00	0.00	125	3.2	2.9	-0.47	95.6	16	16	14.5
11:00	0.00	112	3.7	3.2	-0.49	95.1	15	15	14.5
12:00	0.00	103	4.1	3.6	-0.53	94.2	14	14	13.5
13:00	0.00	102	4.4	4.2	-0.53	92.5	13	13	13.4
14:00	0.03	90	4.7	4.3	-0.50	93.0	10	10	12.4
15:00	0.01	94	5.8	4.3	-0.47	94.5	08	08	11.8
16:00	0.00	94	4.7	4.5	-0.48	93.5	06	06	12.4
17:00	0.00	88	4.8	4.5	-0.55	93.6	03	03	12.4
18:00	0.01	97	5.1	4.1	-0.53	94.7	01	01	13.4
19:00	0.01	99	5.5	4.3	-0.45	96.7	01	01	12.0
20:00	0.00	106	5.5	4.8	-0.44	97.6	01	01	13.6
21:00	0.05	119	5.8	5.3	-0.44	97.9	05	05	14.1
22:00	0.13	122	6.0	5.7	-0.45	97.9	09	09	15.0
23:00	0.00	124	6.5	6.2	-0.45	97.9	12	12	13.9
24:00	0.18	130	6.7	6.9	-0.45	98.1	14	14	12.1

	09	10	11	12
CHAN	SOLRAD	FLOW	SCAWSP	WETNES
UNITS	W/M2	LPM	M/S	ON/OFF
FSCL	1396	3.27	50.0	1.00
ZERO	0	-0.04	0.0	0.00
01:00	00	1.51	2.6	0.03
02:00	00	1.51	2.1	0.03
03:00	00	1.51	2.3	0.03
04:00	00	1.51	1.8	0.03
05:00	00	1.51	2.1	0.03
06:00	00	1.51	2.6	0.03
07:00	00	1.51	3.2	0.03
08:00	08	1.51	3.4	0.03
09:00	26	1.51	3.6	0.64
10:00	35	1.51	3.3	0.96
11:00	44	1.51	3.8	0.75
12:00	74	1.51	4.3	0.06
13:00	67	1.51	4.5	0.03
14:00	39	1.51	4.9	0.44
15:00	45	1.51	5.9	1.02
16:00	10	1.51	4.8	1.02
17:00	01	1.51	4.9	0.99
18:00	00	1.51	5.2	1.01
19:00	00	1.51	5.6	1.00
20:00	00	1.51	5.7	1.02
21:00	00	1.51	6.0	0.91
22:00	00	1.51	6.2	0.62
23:00	00	1.51	6.7	0.88
24:00	00	1.51	6.9	0.96

Figure D.1.2 Sample Missing Field Data Report

STATION ID: *WSP144*

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
9/14/01 0:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 1:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 2:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 3:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 4:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 5:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 6:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 7:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 8:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 9:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 10:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 11:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 12:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 13:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 14:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 15:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 16:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 17:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 18:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 19:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 20:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 21:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 22:00	M	M	M	M	M	M	M	M	M	M	M	M
9/14/01 23:00	M	M	M	M	M	M	M	M	M	M	M	M

Figure D.1.3 Sample Daily Report

DRY DEPOSITION NETWORK
WEDNESDAY, 28 OCT 1998

FRIDAY, 30 OCT 1998

STATION ID: SAL133
VALIDATION LEVEL:

TIME	TEMP (CENT)	DELTA TEMP (CENT)	REL HUMID	SOLAR RADIATION (WATTS/M2)	OZONE (PPB)	RAIN (MM/HR)	VEC WIND SPEED (METERS/SEC)	WIND VEC DIRECTION (DEGREES)	STD DEV DIRECTION (DEGREES)	FLOW LPM	SCALAR WIND SPEED (METERS/SEC)	WETNESS
01:00	14.0	-0.06	85.1	-2.	52.	1.52	4.3	223.	9.9	1.50	4.4	1.00
02:00	14.1	-0.11	87.0	-2.	49.	0.00	2.9	211.	12.8	1.50	3.0	1.00
03:00	14.1	-0.12	87.5	-2.	44.	0.00	3.8	224.	8.8	1.50	3.8	1.00
04:00	14.3	-0.14	88.1	-2.	40.	0.00	4.0	236.	5.4	1.50	4.0	0.85
05:00	14.6	-0.07	88.9	-2.	34.	0.00	3.6	250.	7.3	1.50	3.7	0.01
06:00	14.9	-0.04	89.9	-2.	27.	0.00	3.1	268.	9.7	1.50	3.2	0.01
07:00	14.9	0.02	90.8	-2.	22.	0.00	2.8	281.	11.1	1.50	2.8	0.01
08:00	14.9	-0.02	91.2	3.	18.	0.00	1.4	291.	7.5	1.50	1.5	0.01
09:00	15.1	0.08	91.1	47.	15.	0.00	2.4	274.	8.2	1.50	2.5	0.01
10:00	15.6	0.20	90.4	110.	15.	0.00	3.2	286.	9.5	1.50	3.3	0.01
11:00	16.3	0.20	87.8	131.	16.	0.00	3.3	297.	10.0	1.50	3.4	0.01
12:00	16.8	0.36	84.2	174.	19.	0.00	4.5	288.	9.5	1.50	4.5	0.01
13:00	16.7	0.28	83.6	110.	19.	0.00	4.6	286.	9.4	1.50	4.6	0.01
14:00	17.0	0.33	83.0	154.	21.	0.00	4.4	298.	11.1	1.50	4.6	0.01
15:00	17.4	0.65	75.2	252.	35.	0.00	5.1	323.	11.1	1.50	5.2	0.01
16:00	16.5	0.36	74.2	111.	35.	0.00	4.3	323.	9.0	1.50	4.3	0.01
17:00	15.7	0.19	75.3	42.	35.	0.00	4.1	320.	11.2	1.50	4.2	0.01
18:00	14.6	-0.06	77.8	6.	34.	0.00	3.3	309.	9.0	1.50	3.3	0.01
19:00	13.4	-0.69	81.4	-2.	31.	0.00	2.2	288.	7.8	1.50	2.4	0.10
20:00	12.5	-0.96	85.3	-2.	28.	0.00	2.3	270.	5.1	1.50	2.3	1.00
21:00	11.8	-0.60	87.6	-1.	23.	0.00	2.3	279.	6.0	1.50	2.3	1.00
22:00	10.7	-0.55	89.8	-1.	20.	0.00	1.9	293.	7.9	1.50	1.9	1.00
23:00	10.2	-0.57	91.0	-1.	20.	0.00	2.0	4.	12.5	1.50	2.1	1.00
24:00	9.7	-0.88	90.9	-1.	19.	0.00	2.3	34.	7.9	1.51	2.3	1.00
AVG:	14.4	-0.09	85.7	46.	28.	0.06	2.6	284.	9.1	1.50	3.3	0.38
MAX:	17.4	0.65	91.2	252.	52.	1.52	5.1	323.	12.8	1.51	5.2	1.00
TOTAL:				1115.		1.52				35.99		

Key to flags: < samples missing; B no sample; C calibration in process; D channel downed by operator; F power failure; M missing data; I not valid; ^ high alarm; _ low alarm;

Figure D.1.4 Sample SSRF Problem Report

Sites with gaps between filter installation

Site ID	Lab Key	Date On	Date Off	Prev Date Off	
BBE401	DD00-47*403	11/14/00 9:55	11/21/00 7:45	11/7/00 11:33	*need Jamie to check whether this SSRF is for BBE401 or JOT403*
BWR139	DD00-46*84	11/8/00 13:17	11/14/00 10:38	10/31/00 10:51	*missing week*
COW137	DD00-42*14	10/10/00 8:12	10/17/00 10:47	10/7/00 8:01	*off three days early*
HOX149	DD00-47*27	11/14/00 8:46	11/21/00 8:52	11/7/00 8:38	*missing week*

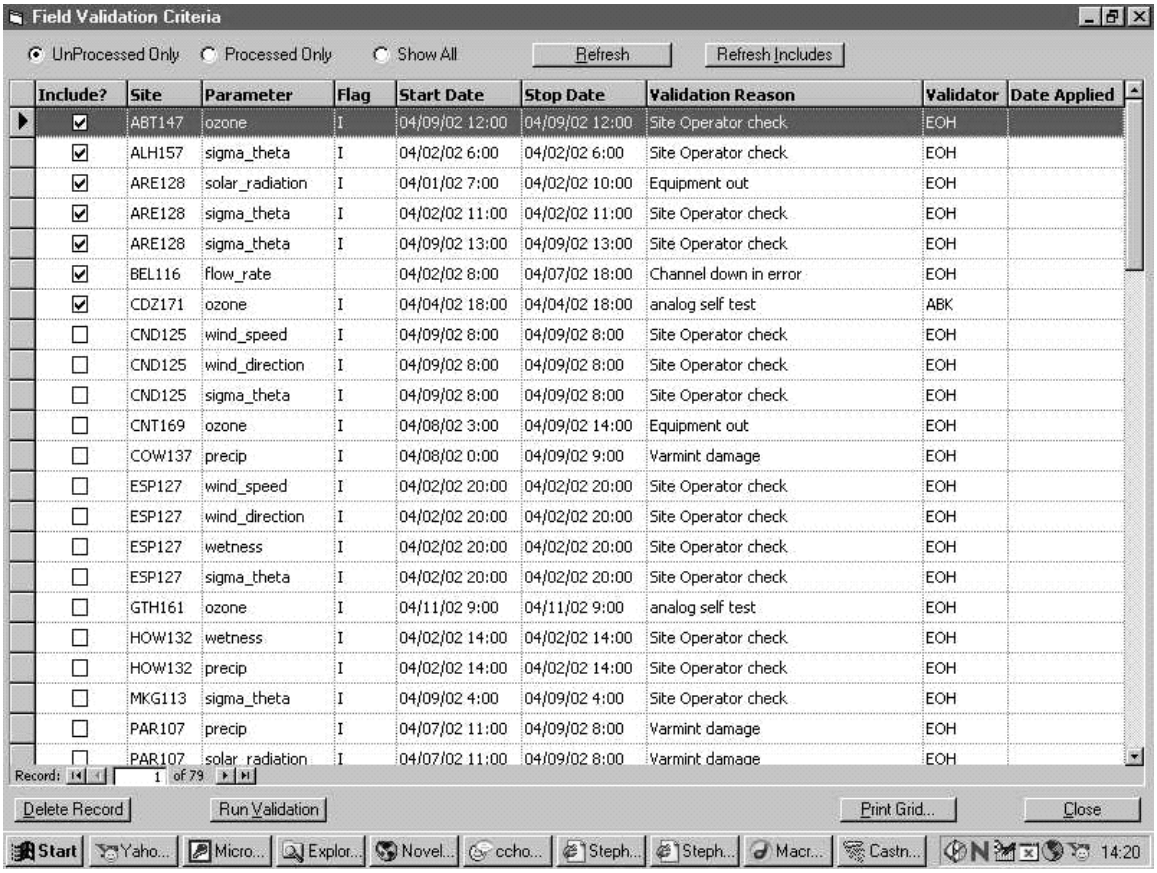
The SSRF's for these samples have been entered but there is no corresponding labdata - through week 44

Site ID	Lab Key	Date On	Date Off	Comments
COW137	DD00-43*14	10/17/00 10:52	10/31/00 10:07	FILTER PACK ON FOR TWO WEEKS
YEL408	DD00-43*408	10/17/00 11:45	10/24/00 18:40	
VII423	DD00-43*423	10/17/00 9:25	10/27/00 7:15	
CKT136	DD00-43*78	10/17/00 8:56	10/27/00 9:40	
LYE145	DD00-43*79	10/17/00 9:10	10/24/00 9:10	
VIN140	DD00-44*10	10/24/00 8:24	10/31/00 8:16	
GAS153	DD00-44*20	10/24/00 9:10	10/31/00 9:53	
KEF112	DD00-44*21	10/24/00 10:51	10/31/00 11:21	
MKG113	DD00-44*22	10/24/00 7:52	10/31/00 7:57	
UVL124	DD00-44*24	10/24/00 8:05	10/31/00 7:40	
CVL151	DD00-44*28	10/24/00 8:02	10/31/00 8:51	
SND152	DD00-44*29	10/24/00 16:30	10/31/00 13:51	
LYK123	DD00-44*31	10/24/00 10:11	10/31/00 9:48	
ARE128	DD00-44*35	10/24/00 13:00	10/31/00 14:10	
PRK134	DD00-44*38	10/24/00 6:33	10/31/00 7:26	
PNF126	DD00-44*40	10/24/00 6:52	10/31/00 7:56	
MEV405	DD00-44*405	10/23/00 12:55	10/31/00 10:00	FILTER PACK ON A DAY EARLY.
WST109	DD00-44*41	10/24/00 9:48	10/31/00 11:19	
NCS415	DD00-44*415	10/24/00 12:17	10/31/00 10:00	
GRS420	DD00-44*420	10/24/00 16:55	10/31/00 9:50	
PND165	DD00-44*43	10/24/00 8:50	10/31/00 9:30	
LYE145	DD00-44*79	10/24/00 9:16	10/31/00 9:33	
ABT147	DD00-44*82	10/24/00 7:07	10/31/00 7:46	

SSRF currently not entered:

CKT136 DD00-40*78

Figure D.1.5 Field Validation Criteria Window



Field Validation Criteria

UnProcessed Only | Processed Only | Show All | Refresh | Refresh Includes

Include?	Site	Parameter	Flag	Start Date	Stop Date	Validation Reason	Validator	Date Applied
☑	ABT147	ozone	I	04/09/02 12:00	04/09/02 12:00	Site Operator check	EOH	
☑	ALH157	sigma_theta	I	04/02/02 6:00	04/02/02 6:00	Site Operator check	EOH	
☑	ARE128	solar_radiation	I	04/01/02 7:00	04/02/02 10:00	Equipment out	EOH	
☑	ARE128	sigma_theta	I	04/02/02 11:00	04/02/02 11:00	Site Operator check	EOH	
☑	ARE128	sigma_theta	I	04/09/02 13:00	04/09/02 13:00	Site Operator check	EOH	
☑	BEL116	flow_rate		04/02/02 8:00	04/07/02 18:00	Channel down in error	EOH	
☑	CDZ171	ozone	I	04/04/02 18:00	04/04/02 18:00	analog self test	ABK	
☐	CND125	wind_speed	I	04/09/02 8:00	04/09/02 8:00	Site Operator check	EOH	
☐	CND125	wind_direction	I	04/09/02 8:00	04/09/02 8:00	Site Operator check	EOH	
☐	CND125	sigma_theta	I	04/09/02 8:00	04/09/02 8:00	Site Operator check	EOH	
☐	CNT169	ozone	I	04/08/02 3:00	04/09/02 14:00	Equipment out	EOH	
☐	COW137	precip	I	04/08/02 0:00	04/09/02 9:00	Varmint damage	EOH	
☐	ESP127	wind_speed	I	04/02/02 20:00	04/02/02 20:00	Site Operator check	EOH	
☐	ESP127	wind_direction	I	04/02/02 20:00	04/02/02 20:00	Site Operator check	EOH	
☐	ESP127	wetness	I	04/02/02 20:00	04/02/02 20:00	Site Operator check	EOH	
☐	ESP127	sigma_theta	I	04/02/02 20:00	04/02/02 20:00	Site Operator check	EOH	
☐	GTH161	ozone	I	04/11/02 9:00	04/11/02 9:00	analog self test	EOH	
☐	HOW132	wetness	I	04/02/02 14:00	04/02/02 14:00	Site Operator check	EOH	
☐	HOW132	precip	I	04/02/02 14:00	04/02/02 14:00	Site Operator check	EOH	
☐	MKG113	sigma_theta	I	04/09/02 4:00	04/09/02 4:00	Site Operator check	EOH	
☐	PAR107	precip	I	04/07/02 11:00	04/09/02 8:00	Varmint damage	EOH	
☐	PAR107	solar_radiation	I	04/07/02 11:00	04/09/02 8:00	Varmint damage	EOH	

Record: 1 of 79

Delete Record | Run Validation | Print Grid... | Close

Start | Yaho... | Micro... | Explor... | Novel... | ccho... | Steph... | Steph... | Macr... | Castn... | 14:20

Figure D.1.6 Sample Unadjusted Calibration Form

ESE Environmental Science & Engineering, Inc.

OZONE DATA FORM

Site Name: STK
Site Number: 138

Slope: 0.8950 Intercept: -0.9914 **
Correlation Coefficient: 0.9999

Level A Potentiometer Setting: N/A
Zero Air Pressure Reading: N/A

		1 Ozone Setting: Ø		2 Ozone Setting: 400		3 Ozone Setting: 300		4 Ozone Setting: 200		5 Ozone Setting: 100		6 Ozone Setting: 60	
		Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:
Values based on display	1	2 3	Ø Ø	362 364	404 406	269 270	303 304	175 175	199 201	100 101	113 114	59 58	64 65
	2	3 3	Ø Ø	362 363	406 407	269 269	304 305	174 175	200 200	100 101	113 114	58 58	65 65
	3	1 1	Ø Ø	362 363	405 405	269 269	304 304	175 175	199 200	101 100	113 115	58 58	65 65
	4	2 2	Ø Ø	362 363	405 407	268 269	303 305	175 175	200 201	100 101	113 114	58 58	64 65
	5	2 2	Ø Ø	361 362	405 407	268 269	303 305	175 175	200 201	101 102	113 114	58 58	65 65
	Total	10 11	Ø Ø	1809 1815	2025 2032	1348 1346	1517 1523	874 875	998 1003	502 503	565 571	291 290	323 325
	Average	2	Ø	362	406	269	304	175	200	101	114	58	65
	*Actual		2		405		304		201		115		66
	Percent Difference	—				-11.5		-12.9		-12.2		-12.1	
Values based on 5 minute DAS averages	Average	3	1	364	406	270	305	178	201	101	114	59	65
	*Actual		3		405		305		202		115		66
	Percent Difference	—		-10.1		-11.5		-11.9		-12.2		-10.6	

Voltage Output: (Unadjusted) Site Analyzer Zero: 0.000 Full Scale: 1.000
Transfer Analyzer Zero: 0.000 Full Scale: 1.000
Voltage Output: (Adjusted) Site Analyzer Zero: ____ Full Scale: ____

(A) Analyzer Mfg.: TECO
Offset: 52
Span: 500
DAS Mfg.: ODESSA
Model: 49
Sample Flow (A/B): 1.0/1.0
Barometric Pressure: 667/669
Model: 3260
Serial Number: 811712
Ozone Flow/Pressure: N/A
Cell Temperature (A/B): 28.8/28.8
Serial Number 810704
Sample (A) Frequency: 96K
Control (B) Frequency: 91K
Noise (A/B): 0.7/0.6
Previous Calibration: N/A

(B) Transfer Mfg.: TECO
Offset: 50
Span: 502
DAS Mfg.: ODESSA
Model: 49
Sample Flow (A/B): 1.0/1.0
Barometric Pressure: 725/726
Model: 3260
Serial Number: 808741
Ozone Flow/Pressure: 17 PSI
Cell Temperature (A/B): 28.9/28.9
Serial Number: 810704
Sample (A) Frequency: 98K
Noise (A/B): 0.9/0.7
Certification Date: 10/20/97
Control (B) Frequency: 94K
Slope: 1.0061
Intercept: -1.8113
Coefficient: 1.0000

Comments: DIRCONN TRANS 105 CORR 106 ANAL 94 Δ% -11.3

Performed By: [signature] Date: 3/18/98
Reviewed By: Sandy Kremillo Date: 4-2-98

* Actual for transfer is corrected to EPA SRP by: Actual = $\frac{\text{Average - Intercept}}{\text{Slope}}$

**Slope, intercept, and correlation coefficient based on DAS averages

WHITE: Site File YELLOW: ESE PINK: EPA

Figure D.1.7 Sample Adjusted Calibration Form

ESE Environmental Science & Engineering, Inc.

OZONE DATA FORM

Site Name: STK
Site Number: 138

Slope: 0.9976 Intercept: 2.2749**
Correlation Coefficient: 0.9999

Level A Potentiometer Setting: ~~457~~ 60 457
Zero Air Pressure Reading: 15 PSI

		1 Ozone Setting: Ø		2 Ozone Setting: 400		3 Ozone Setting: 300		4 Ozone Setting: 200		5 Ozone Setting:		6 Ozone Setting: 60	
		Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:	Analyzer:	Transfer:
Values based on display	1	2 1	Ø Ø	405 407	408 408	305 306	304 305	208 210	203 203	106 107	102 102	61 61	59 60
	2	2 1	Ø -1	405 406	407 408	305 306	304 305	208 211	202 203	107 108	102 103	64 59	59 54
	3	2 2	Ø Ø	405 406	407 408	306 307	305 305	209 210	202 203	107 108	102 103	63 60	59 60
	4	3 2	-1 Ø	405 407	407 408	306 307	305 305	208 209	202 203	106 108	101 102	63 61	60 59
	5	2 1	1 Ø	405 407	408 408	307 308	305 306	208 210	201 202	106 107	101 102	63 61	60 60
	Total	11 7	Ø -1	2025 2033	2037 2040	1529 1534	1523 1526	1041 1050	1010 1014	530 538	508 512	314 309	297 298
	Average	2	Ø	406	408	306	305	209	202	107	102	62	60
	*Actual		2		407		305		203		103		61
	Percent Difference	—		-0.2		+0.3		+3.0		+3.9		+1.6	
Values based on 5 minute DAS averages	Average	3	1	407	409	307	305	209	203	107	102	62	60
	*Actual		3		408		305		204		103		61
	Percent Difference	—		-0.2		+0.7		+2.5		+3.9		+1.6	

Voltage Output: (Unadjusted) Site Analyzer Zero: 0.000 Full Scale: 1.000
Transfer Analyzer Zero: 0.000 Full Scale: 1.000
Voltage Output: (Adjusted) Site Analyzer Zero: ____ Full Scale: ____

(A) Analyzer Mfg.: TECO Model: 49 Serial Number: 811712 Sample (A) Frequency: 104K Previous Calibration: ____
Offset: 52 Sample Flow (A/B): 1.0/1.0 Ozone Flow/Pressure: 15 PSI Control (B) Frequency: 101K
Span: 560 Barometric Pressure: 655/657 Cell Temperature (A/B): 26.0/26.0 Noise (A/B): 1.0/0.9
DAS Mfg.: ODESSA Model: 3260 Serial Number 810704

(B) Transfer Mfg.: TECO Model: 49 Serial Number: 808741 Sample (A) Frequency: 98K Control (B) Frequency: 94K
Offset: 50 Sample Flow (A/B): 1.0/1.0 Ozone Flow/Pressure: N/A Noise (A/B): 0.5/0.7 Slope: 1.0061
Span: 502 Barometric Pressure: 641/642 Cell Temperature (A/B): 31.7/31.7 Certification Date: 10/20/97 Intercept: -1.8113
DAS Mfg.: ODESSA Model: 3260 Serial Number: 810704 Coefficient: 1.0000

Comments: ADJUSTED SPAN LEAK CHECKS OK

Performed By: [signature] Date: 3/18/98 Reviewed By: Sandy Grenilli Date: 4/2/98

* Actual for transfer is corrected to EPA SRP by: Actual = $\frac{\text{Average - Intercept}}{\text{Slope}}$

**Slope, intercept, and correlation coefficient based on DAS averages

WHITE: Site File YELLOW: ESE PINK: EPA

Figure D.1.8 Sample Field Problem Report

National Dry Deposition
Network Detail Problem Report
Second Quarter 1998

SITE ID: **STK138**

DATE OPENED: **3/18/1998** DATE CLOSED: **3/25/1998**

PROBLEM: **During a routine site calibration, the ozone analyzer output was found to be 11% low.**

ACTION: **3/18/199** **The ozone analyzer was adjusted; however, it appeared that the adjustment would not hold.**

3/25/199 **The ozone analyzer was replaced.**

RECOMMENDATIONS: **Validate ozone data from first quarter '98 based on the calibrations from Dec '97, March 18, 1998 and March 25, 1998.**

SITE ID: **STK138**

DATE OPENED: **3/13/1998** DATE CLOSED: **3/18/1998**

PROBLEM: **The vector and scalar wind speed data are not matching, intermittently.**

ACTION: **3/18/199** **During a routine calibration visit the signal cable for vector wind speed was found to be loose and was tightened.**

RECOMMENDATIONS: **Validate wind speed data based on historical data and reasonableness.**

SITE ID: **STK138**

DATE OPENED: **3/13/1998** DATE CLOSED: **3/18/1998**

PROBLEM: **The delta temperature data indicates that the sensor may be operating outside of calibration criteria.**

ACTION: **3/18/199** **During a routine calibration visit, the delta temperature data were found to be outside of calibration criteria and were then adjusted.**

Figure D.1.9 Sample CDVS Noting Ozone Adjustment

NDDN Continuous Data Validation Summary

CALIBRATION SUMMARY INFORMATION

Parameter(s) Failed	Date	Transfer	Site
O_3	3/18/98	65, 114, 201	59, 101, 178
ΔT	3/18/98		-0.68, -0.94, -0.[illegible]
ΔT	6/14/98		-0.52, -0.52, 0.[illegible]
	/ /		
	/ /		
	/ /		

AUDIT SUMMARY INFORMATION

Parameter(s) Failed	Date	Transfer	Site
	/ /		
	/ /		

PARAMETER(S) ADJUSTED

Parameter(s) Adjusted	By	Date	Hour	To Date	Hour
O_3	x(See below) + ( )	1/1/98	0:00	3/18/98	1300
	x( ) + ( )	/ /		/ /	
	x( ) + ( )	/ /		/ /	
	x( ) + ( )	/ /		/ /	
	x( ) + ( )	/ /		/ /	
	x( ) + ( )	/ /		/ /	

COMMENTS

ΔT invalidated from 1/1/98 - to 3/18/98 9:00.
ΔT invalidated from 3/18/98 14:00 to 3/31/98 23:00.
O_3 fails 3/18 cal. by error between -10.6% and -12.2%
Adjusted data using slope/intercept method and values given below –

slope = 0.8950
intercept = -0.9914
Adj. value = $\frac{\text{Unadjusted Value} - \text{Intercept}}{\text{Slope}}$.

CS / NDDN 95135 6/95SS

Figure D.2.1 Sample CLASS™ Data Batch QC Checklist (page 1 of 2)

QST Environmental Analytical Services
Computer QC Checks

Batch No.: G96442 Analysis Date: 06/05/2001 Analyst: HEIDI SCHWING Report Date: 06/05/2001

	Yes	"Exceptions" No	See Batch Comments	
Are ALL units documented in batch?	X			
Analysis holding time within criteria?	X			
Method blank present?	X			
Method blank within acceptance criteria?	X			
RF present?	X			
RF within acceptance criteria?	X			
Sample replicate present?	X			
Sample replicate within acceptance criteria?		X	97550*DD	See comment
Standard matrix spike present?	X			
Standard matrix spike within acceptance criteria?	X			
Standard matrix spike duplicate present?	X			
Standard matrix spike duplicate within acceptance criteria?	X			

Note: Any "NO" answer requires a comment.

Figure D.2.1 Sample CLASS™ Data Batch QC Checklist (page 2 of 2)

Batch Narrative - G96442 Analysis:

Updated by 6966 (HEIDI SCHWING), 1996 (GARRY PRICE),

PROBLEM:

Sample replicate not within acceptance criteria:
97550*DD

EXPLANATION: For samples and replicates that are less than 5 times the reporting limit, the criteria is +/- the reporting limit; the sample/replicate in question pass that criteria.

HES/06/05/01

Analyst HES DATE 6/5/01

Reviewer DATE 6/5/01

6/6/01

Figure D.2.2 Sample CLASS™ Manual Data Batch Checklist

QST Environmental Analytical Services
Internal QA/QC Batch Checklist For Atmospheric Chemistry

Batch No.: G96442 Analysis Date: 06/05/2001 Analyst: HEIDI SCHWING

	N/A	Yes	No	"Exceptions" Comment/Corrective Action
Are reported values consistent with the required units?		✓		
Do the calibration standards bracket the concentration equivalent to the method detection limit and the upper certified concentration?		✓		
Is the calibration curve entered correctly?		✓		
If sample concentrations above the certified range are reported, were extracts diluted to within the certified range prior to reanalysis?	✓			
Are dilution factors entered correctly?		✓		
Have reported sample concentrations been adjusted for percent moisture and/or sample volume/weight and/or extract volume/weight?	✓			
Is the method blank free of contamination (Less than or equal to 2X the detection limit)?		✓		
If not, has the data been blank corrected?	✓			
If sample concentrations have been corrected for method blank contamination, was an appropriate explanation supplied?	✓			
Was the batch checked for data entry errors?		✓		
Were continuing calibration standards (CCV) analyzed at the appropriate frequency?		✓		
Were continuing calibration blanks (CCB) analyzed at the appropriate frequency?		✓		
Is an example calculation provided?	✓			
Has the lot table of contents/checklist been completed?		✓		
For TOX analyses only: Has the second-column measurement for any sample exceeded 10% of the two-column total measurement?	✓			
If yes, has the sample been reanalyzed?	✓			
Were the first extracts/digests prepped from this sample used for sample analysis?	✓			
If not, is an appropriate explanation provided?	✓			

Note: Any "NO" answer requires a comment.
Additional Comments:

Completed By Heidi Schwing
Date 6/5/01

Reviewed By [illegible]
Date 6/5/01

Notification of appropriate Laboratory Coordinators required for "Exceptions":

Signature	Date	Comments

BATCH OVERRIDE BY:

FINALIZED BY:

Figure D.3.1 Sample Dry Deposition Concentration Report (Meter Cubed Report)

CASTNet Dry Deposition Concentration Report

Fourth Quarter 2001

9/30/02

Site Id: STK138

Filter Pack Id	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	Nylon SO4 ug/m3	Nylon HNO3 ug/m3	Whatman SO2 ug/m3	Whatman NO3 ug/m3	Comment Code	Flow Valid Hours	Flow Volume m3
DD01-40*80	09/25/01 11:35	10/02/01 08:46	2.24	2.19	0.84	0.923	0.264	0.138	0.070	0.20	1.61	1.80	0.45		165	15.29
DD01-41*80	10/02/01 08:53	10/09/01 09:15	2.09	2.16	0.89	1.524	0.227	0.028	0.112	0.20	0.85	2.90	0.37		169	15.43
DD01-42*80	10/09/01 09:20	10/16/01 12:40	2.09	1.93	1.26	0.219	0.059	0.086	0.084	0.26	0.76	1.19	0.32		171	15.61
DD01-43*80	10/16/01 12:46	10/23/01 13:21	1.51	2.45	0.50	0.977	0.207	0.090	0.083	0.19	0.93	2.10	0.34		169	15.42
DD01-44*80	10/23/01 13:28	10/30/01 08:55	1.62	1.75	0.84	0.669	0.148	0.100	0.095	0.19	0.55	2.07	0.24		159	14.54
DD01-45*80	10/30/01 09:01	11/06/01 09:59	1.75	2.79	1.07	1.495	0.232	0.066	0.109	0.20	1.53	5.25	0.60		168	15.36
DD01-46*80	11/06/01 10:07	11/13/01 16:01	2.16	4.11	1.17	2.006	0.290	0.038	0.108	0.15	0.80	5.14	0.56		174	15.92
DD01-47*80	11/13/01 16:06	11/20/01 14:24	5.18	7.22	3.29	0.991	0.119	0.141	0.137	0.31	0.66	3.50	0.53		166	15.20
DD01-48*80	11/20/01 14:29	11/27/01 13:52	1.90	3.47	1.26	0.795	0.117	0.128	0.068	0.27	0.59	3.50	0.31		167	15.30
DD01-49*80	11/27/01 13:57	12/04/01 13:34	2.94	6.04	2.82	0.168	0.025	0.121	0.043	0.31	0.25	2.89	0.30		168	15.39
DD01-50*80	12/04/01 13:38	12/11/01 14:36	1.66	4.41	1.86	0.311	0.063	0.111	0.058	0.23	0.63	4.46	0.35		169	15.49
DD01-51*80	12/11/01 14:44	12/18/01 14:04	3.91	6.62	3.44	0.185	0.052	0.413	0.474	0.41	0.22	4.11	0.45		168	15.41
DD01-52*80	12/18/01 14:10	12/26/01 17:22	1.25	2.97	1.17	0.644	0.122	0.063	0.049	0.17	0.26	2.42	0.36	12	195	17.90
Filter Count:	13	**Mean**	2.33	3.70	1.57	0.839	0.148	0.117	0.115	0.24	0.74	3.18	0.40			
		Std. Deviation	1.10	1.86	0.98	0.57	0.09	0.10	0.11	0.07	0.43	1.29	0.11			

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
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

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

Figure D.3.2 Sample Visibility Aerosol Concentration Report (Nylon filter)

VISIBILITY NETWORK 3rd Quarter 2000
ESE REPORT DATE: 01/02/2001 PAGE 1

FIELD GROUP	#	SAMPLE ID	ACTUAL RUN DATE	NYLON SO_4 ug/m^3	NYLON NO_3 ug/m^3	DENUDER SO_4 ug/m^3	DENUDER NO_3 ug/m^3	TOTAL VALID HOURS	VALID FLOW LPM	COMMENT CODES
V00-32	18	BVL530	07/05/00	2.53	0.75	NA	NA	24	10.00	N1,N3
V00-33	18	BVL530	07/11/00	4.53	1.03	NA	NA	24	10.00	
V00-34	18	BVL530	07/17/00	7.69	1.05	NA	NA	24	9.99	
V00-35	18	BVL530	07/23/00	2.57	0348	NA	NA	24	9.99	
V00-36	18	BVL530	07/29/00	4.67	3.29	NA	NA	24	10.00	
V00-37	18	BVL530	08/04/00	2.30	0.70	NA	NA	24	9.99	
V00-38	18	BVL530	08/10/00	2.16	1.45	NA	NA	24	10.00	Q1
V00-39	18	BVL530	08/16/00	1.95	0.69	NA	NA	24	10.00	
V00-40	18	BVL530	08/22/00	8.38	0.93	NA	NA	24	10.00	
V00-41	18	BVL530	08/28/00	12.29	2.60	NA	NA	24	10.00	
V00-42	18	BVL530	09/03/00	16.19	1.86	NA	NA	24	10.00	T4,Q4
V00-43	18	BVL530	09/09/00	6.35	2.09	NA	NA	24	9.81	
V00-44	18	BVL530	09/15/00	0.58	0.25	NA	NA	24	9.99	
V00-45	18	BVL530	09/21/00	0.74	0.38	NA	NA	24	9.99	
V00-46	18	BVL530	09/27/00	2.36	3.07	NA	NA	24	10.00	
MEAN				5.02	1.37	0.0	0.0	24.00	9.98	
STANDARD DEVIATION				4.48	0.99	0.0	0.0	0.0	0.05	

STATUS FLAGS

'I' = less than 18 or more than 30 valid hours
'IV' = invalid data
'<' = value is less than detection limit
'NA' = sample not analyzed

ESE COMMENT CODES

1. Unidentified debris, insects on filter
2. Filter torn, ripped, hole noted upon unpacking
3. Filter excessively wet upon unpacking
4. Excessively dirty on outside filter/denuder sampler
5. Filterpack, denuder connections loose upon unpacking
6. Denuder broken upon receipt
7. Shipping endcaps missing/damage upon receipt
8. Petri dish cracked/opened upon unpacking
9. Filter/filterpack dropped in field
10. Filter/filterpack dropped in laboratory
11. Possible flow problem
12. Run date incorrect, not scheduled
13. Filter not run in field
14. Not used
15. Not used
16. Not used
17. Forest fire/heavy smoke during sampling
18. Construction/agricultural activity during sampling
19. Severe storms in area during sampling
20. Visibility Site Report Form (VSRF) not received
21. Chain of custody is incomplete or incorrect

ABBREVIATIONS – PREFIX CODES : N – Nylon filter, D – Denuder, T – Teflo filter, Q – Quartz filter

Figure D.3.3 Sample Precipitation Chemistry Report

CASTNet Deposition Network
Precipitation Chemistry Report

Site ID ARE128 03/20/98 11:02

Week	Site ID	On Date	Off Date	QST Sample No	Rain (in)	PH Diss	PH Unfilt	Cond Diss umho/cm	Cond Unfilt umho/cm	Sampler Volume (mL)	Collector Efficiency %	On Time	Off Time	Lid # open	Comments
1	ARE128	09/30/97	10/08/97	W97-40*9	0.000	NRQ	NRQ	NRQ	NRQ	1	0.0	13:01	16:30	0	
2	ARE128	10/08/97	10/14/97	W97-41*9	0.000	NRQ	NRQ	NRQ	NRQ	9	0.0	16:30	12:55	0	
3	ARE128	10/14/97	10/21/97	W97-42*9	0.350	4.05	4.05	41.8	41.0	612	101.4	12:55	13:30	0	
4	ARE128	10/21/97	10/28/97	W97-43*9	1.300	4.33	4.32	23.9	24.0	2195	97.9	13:30	14:45	0	F06
5	ARE128	10/28/97	11/04/97	W97-44*9	1.400	4.66	4.63	14.1	14.4	2437	101.0	14:45	14:00	0	
6	ARE128	11/04/97	11/11/97	W97-45*9	3.410	4.57	4.57	13.5	20.1	5196	88.4	14:00	13:35	0	
7	ARE128	11/11/97	11/18/97	W97-46*9	0.650	4.40	4.42	20.1	19.8	1137	101.5	13:36	17:13	0	
8	ARE128	11/18/97	11/25/97	W97-47*9	0.510	4.34	4.33	25.4	25.6	818	93.0	17:15	14:30	0	
9	ARE128	11/25/97	12/02/97	W97-48*9	0.430	4.30	4.14	36.5	41.9	702	94.7	14:30	13:40	0	
10	ARE128	12/02/97	12/09/97	W97-49*9	0.000	NRQ	NRQ	NRQ	NRQ	3	0.0	13:40	14:10	0	
11	ARE128	12/09/97	12/16/97	W97-50*9	0.540	4.13	4.12	40.8	40.2	945	101.5	14:10	14:20	0	
12	ARE128	12/16/97	12/23/97	W97-51*9	0.350	4.56	4.54	23.4	24.0	715	118.5	14:20	14:40	0	
13	ARE128	12/23/97	12/30/97	W97-52*9	1.020	4.40	4.45	16.9	17.0	1889	107.4	14:40	14:00	0	
Total					9.960					16659					

Week	Ca, Diss MG/L	Mg, Diss MG/L	K, Diss MG/L	Na, Diss MG/L	NO3, Diss MG/L- N	CL, Diss MG/L	SO4, Diss MG/L	NH4, Diss MG/L - N	NO2, Diss MG/L - N	Acidity UEQ/L	H, Diss UEQ/L	H, Unfilt UEQ/L	Cations UEQ/L	DCations - UEQ/L	Anions UEQ/L	Cations/ Anions	DCations/ Anions
1	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ							
2	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ							
3	0.09706	0.01430	0.01289	0.03530	0.570	0.125	3.30	0.310	< 0.004	109	89.125	89.125	119.107	119.107	113.067	1.053	1.053
4	0.04429	0.00575	0.00929	0.01075	0.361	0.095	1.84	0.353	0.005	72.7	46.774	47.863	76.413	75.324	66.902	1.142	1.126
5	0.05315	0.01038	0.01575	0.11777	0.231	0.195	1.51	0.343	0.007	51.8	21.878	23.442	56.923	55.358	53.607	1.062	1.033
6	0.02276	0.00875	<0.00500	0.04970	0.169	0.100	0.936	0.108	< 0.004	53.4	26.915	26.915	38.759	38.759	34.476	1.124	1.124
7	0.04709	0.00917	<0.00500	0.01273	0.312	0.065	1.33	0.208	0.007	68.0	39.811	38.019	56.631	58.423	51.976	1.090	1.124
8	0.04287	0.00533	0.01052	0.01737	0.535	0.050	1.76	0.447	0.007	77.2	45.709	46.774	82.238	81.173	76.439	1.076	1.062
9	0.84309	0.07213	0.21694	0.11801	0.864	0.346	3.88	0.656	0.009	91.4	50.119	72.444	177.887	155.563	152.492	1.167	1.020
10	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ	NRQ							
11	0.07096	0.00909	0.01913	0.02102	0.839	0.334	3.14	0.895	0.009	111	74.131	75.858	145.346	143.619	134.954	1.077	1.064
12	0.34532	0.03895	0.02226	0.09584	0.533	0.209	2.79	0.727	0.010	70.3	27.542	28.840	105.835	104.537	102.301	1.035	1.022
13	0.09217	0.00729	0.00738	0.02912	0.274	0.090	1.13	0.124	< 0.004	64.9	39.811	35.481	50.974	55.304	45.736	1.115	1.209
Volume Wgt Mean	0.094	0.012	0.018	0.051	0.341	0.136	1.643	0.302	0.006	66.773	38.008	38.913	68.827	67.921	62.523	1.103	1.102

Note: CATIONS includes unfiltered H+; DCATIONS includes dissolved (filtered) H+.

Data Status Flags: 'IV" invalid data
'NA' sample not analyzed
'<' value is less than detection limit

COMMENT CODES:

L01 Lab sample weight/field sample weight large difference
L07 Sample leaked during shipment
F02 Missing date on - date assumed
F04 Missing time on - time on assumed
F06 Missing or misread total rain gauge inches read by lab if possible
F27 Construction/site maintenance performed at site
F29 Bucket overflowed
F33 Severe thunderstorm/local tornadoes
F35 Rain gauge malfunction
F37 Event counter malfunction - assumed 1 opening needed
F39 Elapsed timer malfunction
F41 Sampling restarted after break in collection activities
L08 Laboratory accident
L09 Sample contaminated
L10 Suspected chloride contamination from IC vials
F03 Missing date off - date assumed
F05 Missing time off - time off assumed
F07 Missing total sample weight
F28 Forest fire/agricultural activity in area
F30 Sample spilled in field
F34 Hurricane sample
F36 Collector Malfunction
F38 Sample duration <6 or >8 days
F40 Rain gauge value suspect, probably underestimated

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U.S. Environmental Protection Agency (EPA). 1983c. *Methods for Chemical Analysis of Water and Wastes.* (EPA 150.1), EPA 600/4-79-020. http://www.epa.gov/cincl.

F. Revision Tracking Sheet

Revision 1.0	***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	Quality Assurance Manager – J. Lynch
	Replace	Project Manager – T. Lavery with
		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.

Revision 1.0	***Action***	***Change Description***
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.
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

Revision 2.0	***Action***	***Change Description***
A.1	Replace	Marcus O. Stewart title, Project QA Supervisor, replaced by title, MACTEC Quality Assurance Manager
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*

Revision 2.0	***Action***	***Change Description***
		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.
A.6.4.4	Replace	Chapter 5 discusses information on $PM_{2.5}$ 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

Revision 2.0	***Action***	***Change Description***
		• 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
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

Revision 2.0	***Action***	***Change Description***
		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.*
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*

Revision 2.0	***Action***	***Change Description***
		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
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.*
C.1.5.1	Replace	Replace the entirety of the subsections titled Base Program, Option A, and Option B with the following: ***Base Program***

Revision 2.0	***Action***	***Change Description***
		• *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 program*s* 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

Revision 2.0	***Action***	***Change Description***
		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	Add/ Replace/ Delete	Updated to match citations used in QAPP Sections A through E

Version 2.1	***Action***	***Change Description***
A.2	Add/ Delete	Add CASTNet Government Property Control Standard Operating Procedures as Appendix 9. Delete CASTNet Government Property Control Standard Operating Procedures from Appendix 5.
A.2	Replace	Figure B.2.1 Title Typical CASTNet Site Configuration replaced by *Typical EPA Sponsored CASTNet III Site Configuration.*
	Add/ Replace	Insert B.5.1 Figure Title *Schematic of an EPA sponsored CASTNet Site* and renumber Figure Titles B.5.1 through B.5.17