CASTNET
2015 Annual Report

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List of Acronyms and Abbreviations

% diff	percent difference
A/D	analog to digital converter
AQS	Air Quality System
ARS	Air Resource Specialists, Inc.
ASTM	American Society for Testing and Materials
BLM	Bureau of Land Management
CASTNET	Clean Air Status and Trends Network
DAS	data acquisition system
DC	direct current
deg	degree
DVM	digital voltmeter
EEMS	Environmental, Engineering & Measurement Services, Inc.
EPA	U.S. Environmental Protection Agency
ESC	Environmental Systems Corporation
FSAD	Field Site Audit Database
g-cm	gram centimeter
GPS	goblal positioning system
k	kilo (1000)
km	kilometer
lpm	liters per minute
MLM	Multilayer Model
m/s	meters per second
mv	millivolt
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OAQPS	Office of Air Quality Planning and Standards
QAPP	Quality Assurance Project Plan
SOP	standard operating procedure
TEI	Thermo Environmental Instruments
USNO	United States Naval Observatory
V	volts
WRR	World Radiation Reference

1.0 Introduction

The Clean Air Status and Trends Network (CASTNET) is a national air monitoring program developed under mandate of the 1990 Clean Air Act Amendments. Each site in the network measures acidic gases and particles and other forms of atmospheric pollution using a continuous collection filter aggregated over a one week period. Hourly averages of surface ozone concentrations and selected meteorological variables are also measured.

Site measurements are used to estimate deposition rates of the various pollutants with the objective of determining relationships between emissions, air quality, deposition, and ecological effects. In conjunction with other national monitoring networks, CASTNET data are used to determine the effectiveness of national emissions control programs and to assess temporal trends and spatial deposition patterns in atmospheric pollutants. CASTNET data are also used for long-range transport model evaluations and effects research.

Historically, CASTNET pollutant flux measurements have been reported as the aggregate product of weekly measured concentrations and model-estimated deposition velocities. The Multi-layer Model (MLM) was used to derive deposition velocity estimates from on-site meteorological parameters, land use types, and site characteristics. In 2011, EPA discontinued meteorological measurements at most EPA-sponsored CASTNET sites. Currently, average historical deposition velocities are used to estimate dry deposition fluxes (Bowker et al 2011).

As of 2011, nearly all CASTNET ozone monitors adhere to the requirements of 40 CFR Part 58, and ozone concentration and quality assurance data are submitted to the Air Quality System (AQS) database. Currently 80 sites at 78 distinct locations measure ground-level ozone concentrations.

As of January 2016, the network is comprised of approximately 94 active rural sampling sites across the United States and Canada, cooperatively operated by the Environmental Protection Agency (EPA), the National Park Service (NPS), Environment Canada, Wyoming's Bureau of Land Management (BLM-WY), and several independent partners. AMEC Foster Wheeler is responsible for operating the EPA and Environment Canada sponsored sites, and Air Resource Specialists, Inc. (ARS) is responsible for operating the NPS and Bureau of Land Management (BLM) sponsored sites. All sites collect filter samples for flux estimates.

2.0 Project Objectives

The objectives of this project are to establish an independent and unbiased program of performance and systems audits for all CASTNET sampling sites. Ongoing Quality Assurance (QA) programs are an essential part of any long-term monitoring network.

Performance audits verify that all evaluated parameters are consistent with the accuracy goals as defined in the CASTNET Quality Assurance Project Plan (QAPP). The parameter specific accuracy goals are presented in Table 2-1.

Due to budgetary necessity, the meteorological measurements were recently shifted to operating on an as-funded basis. The meteorological sensors were audited on an as directed basis.

Table 2-1. Performance Audit Challenge and Acceptance Criteria

Sensor	Parameter	Audit Challenge	Acceptance Criteria
Precipitation	Response	10 manual tips	1 DAS count per tip
Precipitation	Accuracy	2 introductions of known amounts of water	≤ ±10.0% of input amount
Relative Humidity	Accuracy	Compared to reference instrument or standard solution	≤ ±10.0%
Solar Radiation	Accuracy	Compared to WRR traceable standard	≤ ±10.0% of daytime average
Surface Wetness	Response	Distilled water spray mist	Positive response
Surface Wetness	Sensitivity	1% decade resistance	N/A
Temperature	Accuracy	Comparison to 3 NIST measured baths (~ 0° C, ambient, ~ full-scale)	≤ ± 0.5° C
Delta Temperature	Accuracy	Comparison to temperature sensor at same test point	≤ ± 0.50° C

Sensor	Parameter	Audit Challenge	Acceptance Criteria
Wind Direction	Orientation Accuracy	Parallel to alignment rod/crossarm, or sighted to distant point	≤ ±5° from degrees true
Wind Direction	Linearity	Eight cardinal points on test fixture	≤ ±5° mean absolute error
Wind Direction	Response Threshold	Starting torque tested with torque gauge	< 10 g-cm Climatronics; < 20 g-cm R. M. Young
Wind Speed	Accuracy	Shaft rotational speed generated and measured with certified synchronous motor	≤ ±0.5 mps below 5.0 mps input; ≤ ±5.0% of input at or above 5.0 mps
Wind Speed	Starting Threshold	Starting torque tested with torque gauge	< 0.5 g-cm
Mass Flow Controller	Flow Rate	Comparison with Primary Standard	≤ ± 5.0% of designated rate
Ozone	Slope	Linear regression of multi-point test gas concentration as measured with a certified transfer standard	0.9000 ≤ m ≤ 1.1000
	Intercept		-5.0 ppb ≤ b ≤ 5.0 ppb
	Correlation Coefficient		0.9950 ≤ r
	Percent Difference	Comparison with Standard Concentration	≤ ±10.0% of test gas concentration
DAS	Accuracy	Comparison with certified standard	≤ ± 0.003 VDC

In addition to the accuracy goals defined in the CASTNET QAPP the ozone monitors fall under the requirements of 40 CFR, Part 58 Appendix A, for quality assurance. To comply with Appendix A, the CASTNET audit program includes annual independent ozone performance evaluations (PE). The EEMS field scientists who conduct ozone PE maintain annual certification from the Office of Air Quality Planning and Standards (OAQPS). Methods and procedures used are compliant with the National Performance Audit Program (NPAP).

Performance audits are conducted using standards that are certified as currently traceable to the National Institute of Standards and Technology (NIST) or another authoritative organization. All standards are certified annually with the exception of ozone standards which are verified as level 2 standards at EPA regional labs at least twice per year.

Site systems audits are intended to provide a qualitative appraisal of the total measurement system. Site planning, organization, and operation are evaluated to ensure that good Quality Assurance/Quality Control (QA/QC) practices are being applied. At a minimum the following audit issues are addressed at each site systems audit:

- Site locations and configurations match those provided in the CASTNET QAPP.
- Meteorological instruments are in good physical and operational condition and are sited to meet EPA ambient monitoring guidelines (EPA-600/4-82-060).
- Sites are accessible, orderly, and if applicable, compliant with OSHA safety standards.
- Sampling lines are free of leaks, kinks, visible contamination, weathering, and moisture.
- Site shelters provide adequate temperature control.
- All ambient air quality instruments are functional, being operated in the appropriate range, and the zero air supply desiccant is unsaturated.
- All instruments are in current calibration.
- Site documentation (maintenance schedules, on-site SOPs, etc.) is current and log book records are complete.
- All maintenance and on-site SOPs are performed on schedule.
- Corrective actions are documented and appropriate for required maintenance/repair activity.
- Site operators demonstrate an adequate knowledge and ability to perform required site activities, including documentation and maintenance activities.

3.0 CASTNET Sites Visited in 2015

This report covers the CASTNET sites audited in 2015. Only those variables that were supported by the CASTNET program were audited. From February through December 2015, EEMS conducted field performance and systems audits at 55 monitoring sites at 53 separate locations. Eight of the sites audited operated a full complement of meteorological sensors. The locations, sponsor agency and dates of the audits along with states and EPA Regions are presented in Table 3-1.

Table 3-1. Site Audits

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
EVE419	NPS/EPA	Everglades NP	FL / R4	2/10/2015
CAD150	EPA	Caddo Valley	AR / R6	2/27/2015
CVL151	EPA	Coffeeville	MS / R4	2/28/2015
CDZ171	EPA	Cadiz	KY / R4	3/13/2015
MCK131	EPA	Mackville	KY / R4	3/15/2015
MCK231	EPA	Mackville (precision site)	KY / R4	3/15/2015
MAC426	NPS	Mammoth Cave NP	KY / R4	3/17/2015
CKT136	EPA	Crockett	KY / R4	3/18/2015
CHE185	EPA	Cherokee Nation	OK / R6	4/6/2015
ALC188	EPA	Alabama-Coushatta	TX / R6	4/8/2015
BBE401	NPS/EPA	Big Bend NP	TX / R6	4/13/2015
PAL190	EPA	Palo Duro	TX / R6	4/17/2015
SEK430	NPS	Sequoia NP - Ash Mountain	CA / R9	4/27/2015
YOS404	NPS	Yosemite NP	CA / R9	4/28/2015
PIN414	NPS	Pinnacles NM	CA / R9	4/29/2015
SAN189	EPA	Santee Sioux	NE / R7	4/30/2015
KIC003	EPA	Kickapoo Tribe	KS / R7	5/4/2015
KNZ184	EPA	Konza Prairie	KZ / R7	5/4/2015
LAV410	NPS	Lassen Volcanic NP	CA / R9	5/26/2015

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
OXF122	EPA	Oxford	OH / R5	5/31/2015
DCP114	EPA	Deer Creek St. Park	OH / R5	6/4/2015
QAK172	EPA	Quaker City	OH / R5	6/5/2015
GTH161	EPA	Gothic	CO / R8	7/2/2015
CNT169	EPA	Centennial	WY / R8	7/24/2015
GLR468	NPS	Glacier NP	MT / R8	7/28/2015
ROM206	EPA	Rocky Mountain NP	CO / R8	8/3/2015
ROM406	NPS	Rocky Mountain NP (NPS)	CO / R8	8/4/2015
THR422	NPS	Theodore Roosevelt NP	ND / R8	8/4/2015
PND165	EPA	Pinedale	WY / R8	8/10/2015
YEL408	NPS	Yellowstone NP	WY / R8	8/13/2015
BAS601	EPA	Basin	WY / R8	8/14/2015
SHE604	EPA	Sheridan	WY / R8	8/18/2015
BUF603	EPA	Buffalo	WY / R8	8/19/2015
NEC602	EPA	Newcastle	WY / R8	8/20/2015
WNC429	NPS	Wind Cave NP	SD / 58	8/21/2015
PRK134	EPA	Perkinstown	WI / R5	9/3/2015
VIN140	EPA	Vincennes	IN / R5	9/7/2015
VOY413	NPS	Voyageurs NP	MN / R5	9/8/2015
STK138	EPA	Stockton	IL / R5	9/11/2015
BVL130	EPA	Bondville	IL / R5	9/14/2015
ALH157	EPA	Alhambra	IL / R5	9/16/2015
WFM105	EPA	Whiteface Mountain	NY / R2	10/1/2015
NIC001	EPA	Nicks Lake	NY / R2	10/2/2015
UND002	EPA	Underhill	VT / R1	10/5/2015
GRS420	NPS	Great Smoky Mountains NP	TN / R4	10/26/2015

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
LRL117	EPA	Laurel Hill St. Park	PA / R3	11/1/2015
SHN418	NPS/EPA	Shenandoah NP - Big Meadows	VA / R3	11/6/2015
WSP144	EPA	Washington Crossing St. Park	NJ / R2	11/9/2015
VPI120	EPA	Horton Station	VA / R3	11/19/2015
PAR107	EPA/USFS	Parsons	WV / R3	11/21/2015
CDR119	EPA	Cedar Creek St. Park	WV / R3	11/22/2015
BWR139	EPA	Blackwater NWR	MD / R3	11/24/2015
CND125	EPA	Candor	NC / R4	12/1/2015
PED108	EPA	Prince Edward	VA / R3	12/3/2015
BFT142	EPA	Beaufort	NC / R4	12/4/2015

In addition to the sites listed in Table 3-1 that were visited for complete systems and performance audits, the 31 sites listed in Table 3-2 were visited to conduct NPAP Through-The-Probe (TTP) ozone Performance Evaluations (PE).

Table 3-2. Site Ozone PE Visits

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
SUM156	EPA/USFS	Sumatra	FL / R4	2/10/2015
IRL141	EPA/SJRWMD	Indian River Lagoon	FL / R4	2/11/2015
GAS153	EPA	Georgia Station	GA / R4	2/25/2015
SND152	EPA	Sand Mountain	AL / R4	3/1/2015
SPD111	EPA	Speedwell	TN / R4	3/19/2015
COW137	EPA/USFS	Coweeta	NC / R4	3/20/2015
ESP127	EPA	Edgar Evins St. Park	TN / R4	3/26/2015
CHA467	NPS/EPA	Chiricahua NM	AZ / R9	4/19/2015
PET427	NPS/EPA	Petrified Forest NP	AZ / R9	4/20/2015
GRC474	NPS/EPA	Grand Canyon NP	AZ / R9	4/21/2015

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
MEV405	NPS/EPA	Mesa Verde NP	CO / R8	4/21/2015
CAN407	NPS/EPA	Canyonlands NP	UT / R8	4/22/2015
JOT403	NPS/EPA	Joshua Tree NM	CA / R9	4/23/2015
GRB411	NPS	Great Basin NP	NV / R9	5/8/2015
ANA115	EPA	Ann Arbor	MI / R5	6/1/2015
DIN431	NPS	Dinosaur NM	UT / R8	6/30/2015
DEN417	NPS/EPA	Denali NP	AK / R10	7/16/2015
UVL124	EPA	Unionville	MI / R5	8/27/2015
HOX148	EPA	Hoxeyville	MI / R5	8/28/2015
SAL133	EPA	Salamonie Reservoir	IN / R5	9/8/2015
HWF187	EPA	Huntington Wildlife Forest	NY / R2	10/3/2015
HOW191	EPA	Howland AmeriFlux	ME / R1	10/6/2015
ASH135	EPA	Ashland	ME / R1	10/7/2015
CTH110	EPA	Connecticut Hill	NY / R2	10/23/2015
KEF112	EPA	Kane Experimental Forest	PA / R3	10/24/2015
MKG113	EPA	M. K. Goddard St. Park	PA / R3	10/25/2015
PSU106	EPA	Penn State University	PA / R3	10/27/2015
ABT147	EPA	Abington	CT / R1	10/28/2015
WST109	EPA	Woodstock	NH / R1	10/29/2015
ARE128	EPA	Arendtsville	PA / R3	11/2/2015
PNF126	EPA	Cranberry	NC / R4	11/4/2015
BEL116	EPA	Beltsville	MD / R3	11/19/2015

4.0 Performance and Audit Results

Table 4.1 summarizes the number of test failures by variable tested. All test results are those recorded from the site's primary logger.

Performance audit results are discussed for each variable in the following sections. Tables are included to summarize the average and maximum error between the audit challenges and site results as recorded by the on-site Data Acquisition System (DAS). Linear regression and percent difference (% diff) calculation results are included where appropriate. Results that are outside the CASTNET QAPP acceptance criteria are shaded in the tables.

The errors presented in the tables in the following sections, are reported as the difference of the measurement recorded by the DAS and the audit standard. Where appropriate, negative values indicate readings that were lower than the standard, and positive values are readings that were above the standard value. The errors appear to be random, and without bias. The results are also arranged by audit date. Viewing the results in this order helps to detect any errors that could have been caused by the degradation or drift of the audit standards during the year. The audit standards are transported and handled with care, and properly maintained to help prevent such occurrences. No known problems with the standards were apparent during the year. All standards were within specifications when re-certified at the end of the year.

Detailed reports of the field site audits, which contain all of the test points for each variable at each site, can be found in the Appendices of each 2015 Quarterly report. The variable specific data forms included in Appendix A of each quarter's report contain the challenge input values, the output of the DAS, additional relevant information pertaining to the variable and equipment, and all available means of identification of the sensors and equipment for each site.

Table 4-1. Performance Audit Results by Variable Tested

Variable Tested	Number of Tests	Number of tests Failed	% Failed
Ozone	79	0	0.0
Flow Rate	55	2	3.6
Shelter Temperature (average)	48	0	0.0
Wind Direction Orientation Average Error	8	1	12.5

Variable Tested	Number of Tests	Number of tests Failed	% Failed
Orientation Maximum Error	8	1	12.5
Wind Direction Linearity Average Error	4	0	0.0
Linearity Maximum Error	4	0	0.0
Wind Direction Starting Torque	4	0	0.0
Wind Speed Low Range Average Error	8	0	0.0
Low Range Maximum Error	8	0	0.0
Wind Speed High Range Average Error	8	0	0.0
High Range Maximum Error	8	0	0.0
Wind Speed Starting Torque	8	1	12.5
Temperature	54	1	1.9
2 Meter Temperature	5	0	0.0
Relative Humidity	7	0	0.0
Solar Radiation	7	0	0.0
Precipitation	7	0	0.0
DAS Analog to Digital	46	0	0.0

4.1 Ozone

Seventy nine ozone analyzers were audited during 2015. Each was challenged with ozone-free air and four up-scale concentrations. The ozone test gas concentrations were generated and measured with a NIST-traceable photometer that was verified as a level 2 standard by USEPA.

None of the analyzers tested failed the annual PE. Results of all ozone audits performed are included in Table 4-2.

All ozone challenges were conducted to comply with the OAQPS Standard Operating Procedures (SOP) which can be found at www.epa.gov/ttn/amtic/. The results of the ozone audits were uploaded to the AQS database at the end of each quarter for those sites for which EEMS is authorized to upload QA data to AQS.

4.2 Flow Rate

The dry deposition filter pack sampling system flow rates at 55 sites were audited. A NIST-traceable dry-piston primary flow rate device was used for the tests. Two sites were outside the acceptance criterion of ± 5.0%.

4.3 Shelter Temperature

At each site reporting ozone concentrations to AQS, the hourly average shelter temperature must be between 20 and 30 degrees C, or the hourly ozone data may be invalidated. Shelter temperature was audited at 48 of the sites visited. The method consisted of placing the audit standard in close proximity (in situ) to the shelter temperature sensor and recording either instantaneous observations of both sensors, or averages from both sensors. The audit sensors used are either a Resistive Temperature Detector (RTD) or a Thermocouple.

Most of the differences observed were due to the slow response of the site's shelter temperature sensors. Nearly all the site sensors lagged behind the audit sensor during the rapid changes in temperatures observed as the shelter air conditioning or shelter heating cycled on and off. The shelter temperature sensors never reached the minimum or maximum temperature measured with the audit sensor. This is not likely to add a large error to the hourly averaged shelter temperature measurements. However, since the output of the shelter temperature sensors follow a sine wave curve but the actual shelter temperature does not change following a sine wave curve, if the shelter temperature is set near the lower or higher allowable limits (20 to 30 degrees C) the actual hourly averages may be lower or higher than those measured by the site sensors.

The CASTNET QAPP does not make a distinction between shelter temperature and any other temperature sensor regarding accuracy criteria. However the sensors were evaluated using a 2 degree C acceptance criterion. This criterion better follows the EPA OAQPS guidelines.

The results are summarized in Table 4-2. Flow rate and shelter temperature data are reported only for the sites that were visited for complete systems and performance audits. Ozone results are included for all site visits.

Table 4-2. Performance Audit Results for Ozone, Shelter Temperature, and Flow Rate

	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	Shelter temp. average error (C)	Shelter temp. maximum error (C)	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
EVE419								2.983	3.000	0.57
SUM156	-1.6	-2.4	0.99871	-1.22779	0.99984					
IRL141	-2.8	-3.4	0.98102	-0.5518	0.99999					
GAS153	1.7	3.0	1.01553	-0.00623	0.99997					
CAD150	2.0	2.6	1.01673	0.00908	0.99992	0.42	0.54	1.503	1.500	-0.18
CVL151	-0.7	-1.9	1.00543	-0.58714	1	0.35	0.50	1.516	1.500	-1.07
SND152	-0.5	-1.4	0.99947	-0.18338	0.99999					
CDZ171	0.3	0.7	1.01264	-0.64212	0.99999	0.63	0.68	1.516	1.513	-0.18
MCK131	-2.3	-4.5	0.99746	-0.87322	0.99995	0.18	0.41	1.506	1.503	-0.16
MCK231	-0.7	-2.3	1.0075	-0.57296	0.99996	0.43	0.74	1.481	1.500	1.27
MAC426	-1.0	-1.6	0.99762	-0.33402	1	0.47	0.85	1.485	1.500	0.98
CKT136	-0.8	-2.2	1.00406	-0.50955	0.99998	1.29	**1.47**	1.504	1.503	-0.07
SPD111	-1.5	-2.3	1.00111	-0.84251	0.99998					
COW137	-0.1	-1.4	1.00572	-0.36743	0.99998					
ESP127	-1.6	-1.9	0.9807	0.19411	0.99999					
CHE185	6.3	8.9	1.03151	1.78712	0.99997	0.23	0.31	1.540	1.537	-0.22
ALC188	-1.8	-2.1	0.98635	-0.30577	1	0.20	0.25	1.510	1.490	-1.34
BBE401	0.8	2.2	1.04142	-1.78269	0.99999	0.22	0.37	3.123	3.010	-3.77
PAL190	-4.1	-4.9	0.96819	-0.40894	0.99999	0.27	0.46	3.047	3.003	-1.44
CHA467	-4.4	-4.5	0.94918	0.51711	0.99998					
PET427	-4.0	-4.5	0.96563	-0.22994	1					
GRC474	-2.3	-3.1	0.9872	-0.56967	1					
MEV405	-5.5	-6.7	0.95454	-0.40855	0.99999					
CAN407	-2.4	-3.9	0.99292	-0.78069	0.99999					
JOT403	-3.8	-4.9	0.96987	-0.30469	0.99995					
SEK430	-2.9	-4.3	0.98087	-0.37078	0.99997	1.64	**3.46**	3.060	3.000	-2.00
YOS404	-4.5	-5.7	0.96746	-0.53477	0.99999	1.80	**3.31**	3.000	2.963	-1.24
PIN414	-1.9	-2.9	0.99196	-0.52185	0.99999	0.47	0.61	2.973	2.990	0.56
SAN189	-0.9	-2.3	1.00132	-0.30819	0.99994	0.98	1.12	3.130	2.983	-4.92

	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	Shelter temp. average error (C)	Shelter temp. maximum error (C)	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
KIC003								3.160	3.057	-3.38
KNZ184								3.180	3.080	-3.25
GRB411	-5.9	-6.3	0.94442	-0.27184	0.99997					
LAV410	-3.4	-4.0	0.96822	-0.07477	1	1.76	**3.18**	2.980	3.030	1.65
OXF122	-1.7	-2.8	0.99878	-0.90738	0.99999	0.06	0.16	1.560	1.497	-4.23
ANA115	0.5	1.1	1.01102	-0.1761	0.99998					
DCP114	-0.2	0.9	1.00484	-0.17514	0.99991	0.23	0.50	1.520	1.503	-1.11
QAK172	-0.9	-1.2	0.99478	-0.14261	0.99999	0.14	0.20	1.537	1.490	-3.13
DIN431	-1.0	-1.4	0.99376	-0.11177	1					
GTH161	-3.5	-4.8	0.98457	-0.91907	0.99986	0.30	0.37	3.027	2.990	-1.23
DEN417	-1.1	-1.7	0.98063	0.4124	0.99999					
CNT169	-6.4	-8.3	0.93852	-0.03683	0.99986	0.29	0.33	3.040	3.000	-1.33
GLR468	-4.4	-5.9	0.96744	-0.47147	0.99997	0.52	0.58	2.990	3.000	0.33
ROM206	-2.4	-3.8	0.98937	-0.58729	0.99999	0.24	0.36	3.030	2.997	-1.11
ROM406	-3.9	-5.0	0.9656	-0.10314	0.99999	1.79	**3.14**	3.027	3.010	-0.55
THR422	-2.4	-4.1	0.94939	1.15039	0.99994	1.29	1.47	3.070	3.000	-2.33
PND165	-1.1	-1.5	0.98497	0.1668	0.99999	0.80	1.52	3.057	3.003	-1.78
YEL408	-3.7	-5.9	0.98473	-0.90442	0.99995	1.29	1.49	3.007	3.020	0.44
BAS601	-2.6	-3.0	0.97563	-0.03096	0.99999	1.42	**2.27**	3.287	3.217	-2.18
SHE604								3.330	3.170	-5.05
BUF603								3.353	3.323	-0.90
NEC602	-3.9	-5.1	0.9715	-0.47079	1	0.29	0.80	3.244	3.300	1.70
WNC429	-4.7	-6.0	0.96256	-0.47649	0.99996	0.13	0.16	2.993	3.010	0.55
UVL124	0.8	1.3	1.00291	0.2152	0.99998					
HOX148	1.1	1.3	1.00507	0.44431	0.99999					
PRK134	0.3	1.2	0.99199	0.68477	0.99993	0.27	0.73	1.523	1.500	-1.56
VIN140	-1.0	-2.2	0.97984	0.39413	0.99992	0.77	1.24	1.520	1.497	-1.56
SAL133	-0.1	-0.7	0.99968	-0.17228	0.99994					
VOY413	3.4	6.2	0.99793	1.79471	1	0.64	0.93	3.160	3.000	-5.33
STK138	0.6	2.2	0.99668	0.38943	0.99998	0.09	0.11	1.507	1.510	0.22

	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	Shelter temp. average error (C)	Shelter temp. maximum error (C)	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
BVL130	-1.5	-1.8	0.97902	0.42831	0.99999	0.27	0.56	1.500	1.497	-0.22
ALH157	-1.7	-3.1	0.99259	-0.42179	0.99992	0.45	0.82	1.523	1.500	-1.56
WFM105								3.013	3.020	0.22
NIC001								3.030	3.000	-1.00
HWF187	-2.2	-2.5	0.98118	-0.16523	1					
UND002								3.017	3.020	0.11
HOW191	-4.2	-4.4	0.96286	-0.40667	0.99998					
ASH135	-4.7	-5.1	0.95816	-0.31783	1					
CTH110	-3.5	-3.7	0.97207	-0.54651	0.99998					
KEF112	-2.6	-3.2	0.97256	-0.13647	0.99993					
MKG113	0.1	-1.7	1.00862	-0.36949	0.99994					
GRS420	-2.8	-3.6	0.97926	-0.35728	1	0.28	0.47	3.037	3.007	-1.00
PSU106	0.8	1.6	1.01677	-0.47066	0.99998					
ABT147	-1.1	-1.2	0.99294	-0.37282	0.99999					
WST109	-0.8	-1.8	0.99514	-0.25764	0.99994					
LRL117	-3.5	-4.9	0.99066	-1.30958	0.99994	0.48	0.65	1.597	1.500	-6.44
ARE128	-0.8	-1.7	1.00896	-0.80592	0.99993					
PNF126	1.2	1.7	1.00789	0.19347	0.99999					
SHN418	-4.1	-4.6	0.96564	-0.36003	1	0.57	0.79	1.473	1.500	1.78
WSP144	-2.2	-3.4	0.98867	-0.62015	0.99997	0.68	0.94	1.533	1.500	-2.22
BEL116	-3.2	-4.9	0.98851	-0.90721	0.99998					
VPI120	-1.1	-1.5	0.99265	-0.28599	0.99998	0.29	0.45	1.547	1.500	-3.11
PAR107	-1.6	-2.7	1.00098	-0.89739	0.99999	0.21	0.33	1.547	1.500	-3.11
CDR119	-2.9	-4.4	0.98679	-0.73121	0.99994	0.27	0.41	1.540	1.500	-2.67
BWR139	0.1	-0.8	1.01015	-0.50418	0.99999	0.13	0.34	1.440	1.500	4.00
CND125	-2.9	-3.4	0.97118	-0.05317	0.99999	0.04	0.08	1.530	1.500	-2.00
PED108	-3.4	-5.9	0.98554	-0.67255	0.99983	0.26	0.29	1.577	1.503	-4.88
BFT142	0.0	-1.9	1.01401	-0.63216	0.99998	0.31	0.46	1.527	1.503	-1.55

4.4 Wind Speed

The wind speed sensors at eight sites equipped for meteorological measurements were audited. Wind speed data accuracy results at all sites were found to be well within the acceptance limit. The results of the wind speed performance audits are presented in Table 4-3.

4.4.1 Wind Speed Starting Threshold

The condition of the wind speed bearings was evaluated as part of the performance audits. The data acceptance criterion for wind speed bearing torque is not defined in the QAPP. However, ***Appendix 1: CASTNET Field Standard Operating Procedures***, states that the wind speed bearing torque should be ≤ 0.2 g-cm. To establish the wind speed bearing torque criterion for audit purposes the rational described in the QAPP for data quality objectives (DQO) was applied. The QAPP states that field criteria are more stringent than DQO and established to maintain the system within DQO. Typically field criteria are set at approximately one-half the DQO. Therefore, 0.5 g-cm was used for the acceptance limit for audit purposes. This value is within the manufacture's specifications for a properly maintained system. One site was found to be outside the acceptance limit.

4.5 Wind Direction

Two separate tests were performed to evaluate the accuracy of each wind direction sensor:

- A linearity test was performed to evaluate the ability of the sensor to function properly and accurately throughout the range from 1 to 360 degrees. This test evaluates the sensor independently of orientation and can be performed with the sensor mounted on a test fixture.
- An orientation test was used to determine if the sensor was aligned properly when installed to measure wind direction accurately in degrees true. An audit standard compass was used to perform the orientation tests.

Using the average error of the orientation tests for each of the eight sensors tested, one site was outside the acceptance criterion of ± 5 degrees. The results of the wind direction performance audits are presented in Table 4-3.

4.5.1 Wind Direction Starting Threshold

The condition of the wind direction bearings was evaluated as part of the performance audits. The data acceptance criterion for wind direction bearing torque is not defined in the QAPP. However, ***Appendix 1: CASTNET Field Standard Operating Procedures***, states that the wind direction bearing torque should be ≤ 10 g-cm for R. M. Young sensors. The manufacturer states that a properly maintained sensor will be accurate up to a starting threshold of 11 g-cm. To establish the wind direction bearing torque criterion for audit purposes the rational described in the QAPP for data quality objectives (DQO) was applied. The QAPP states that field criteria are more stringent than DQO and established to maintain the system within DQO. Typically field criteria are set to approximately one-half the DQO. For audit purposes 20 g-cm was used for the acceptance limit for R. M. Young sensors. Climatronics sensors typically have a lower starting torque. For audit purposes a threshold of 10 g-cm was selected for Climatronics sensors. All of the wind direction starting thresholds were within acceptance limits. The test results are provided in Table 4-3.

Table 4-3. Performance Audit Results for Wind Sensors

	Wind Direction					Wind Speed				
	Orientation Error		Linearity Error		Starting Torque (g-cm)	Low Range Error		High Range Error		Starting Torque (g-cm)
Site	Ave (deg)	Max (deg)	Ave (deg)	Max (deg)		Ave (m/s)	Max (m/s)	Ave (% diff)	Max (% diff)	
BAS601	1.25	2				0.01	-0.05	0.01	0.01	0.00
BUF603	1.75	4				0.01	-0.05	0.01	-0.02	0.00
BVL130	6.2	**9**	1.2	3	18.5	0.05	-0.2	0.00	0.00	0.45
CHE185	2	3	1	3	20	0.10	-0.3	0.00	0.01	0.60
NEC602	1.5	3				0.00	-0.01	0.01	0.01	0.00
PAL190	2	4	1.5	4	9	0.05	-0.2	0.00	0.00	0.20
PND165	1	2	2	4	7.5	0.05	-0.2	0.00	0.00	0.25
SHE604	2	3				0.01	-0.05	0.01	0.02	0.00

* Note: The wind systems acceptance criteria were applied to the average of the results. The data validation section of the CASTNET QAPP states that if any wind direction or wind speed challenge result is outside the acceptance criterion the variable is flagged.

4.6 Temperature and Two-Meter Temperature

The site temperature measurement systems consist of a temperature sensor mounted at approximately 9 meters above ground-level on a tower. A few sites also utilized a second sensor to measure temperature at approximately two meters from the ground (2-meter temperature).

All sites use shields to house the sensors that are either mechanically aspirated with forced air, or naturally aspirated. In all cases the sensors were removed from the sensor shields, and placed in a uniform temperature bath with a precision NIST-traceable RTD, during the audit.

Results of the tests indicate that of the 54 sensors tested, two were outside the acceptance criterion. It should be noted that both sensors were located at sites recently added to the CASTNET and operated by the BLM. Temperature sensors utilized by the BLM are not the same type as those at other CASTNET sites. The BLM temperature sensors are combined relative humidity and temperature sensors and not standalone RTD or encased thermistor temperature sensors. Due to the design of the RH/Temperature sensor, it cannot be submerged in water baths in order to challenge the sensor at different temperature audit levels. For that reason the combination RH/Temperature sensors were audited by placing the sensor in a watertight chamber (RH salt chamber) and then placing the chamber in an ice-water bath, ambient bath, and hot water bath. Therefore the audit results are not directly comparable to audit results of RTD or encased thermistor sensors.

A change to the temperature measurement method at NPS sponsored sites was observed in 2015. The location of the measurement is being moved from approximately 9 meters to approximately 2 meters above ground. Audit data for 2015 are reported as temperature with comments in each site spot report that indicate which sensors have been moved to the new measurement height. It is important to note that the site DAS label for the measurement is still "temperature". The currently measured temperature data are not comparable to data measured at the previous height although the data record at each site makes no distinction regarding the height of the measurement. It is unknown if the change is documented during the data validation and processing procedures. Beginning in 2016 audit data will indicate the height of the measurement at all sites.

Only four 2-meter temperature sensors were tested, and all were within criterion. The average errors for all sensors are presented in Table 4-4.

4.6.1 Temperature Shield Blower Motors

All of the temperature sensor shield blower motors encountered during the site audits conducted during 2015 were found to be functioning. All 2-meter temperature sensor shield blowers were functioning properly.

4.7 Relative Humidity

The relative humidity systems at the sites were tested with a combination of primary standard salt solutions, and a certified transfer standard relative humidity probe. The results of the average and maximum errors throughout the measurement range of approximately 30% to 95% are presented in Table 4-4.

At the seven sites measuring relative humidity audited in 2015, the measurements were made with relative humidity sensors manufactured by Viasala. As in previous years, operation of humidity sensors with respect to natural or forced-air aspiration can vary between sites. At most EPA sponsored sites humidity sensors are operating in naturally aspirated shields. At most NPS sponsored sites humidity sensors are operating in shields designed to be mechanically aspirated with forced-air blowers.

During audit tests with the primary standard salt solutions, the sensors were removed from the shields and placed in a temperature controlled enclosure. During audit tests with the transfer standard probe, the sensor and transfer were placed in the same ambient conditions. Therefore the audit tests do not account for differences in the operation of the sensors due to the different shield configurations.

The average error of all sensors tested were within the acceptance criterion. The results of the tests are included in Table 4-4.

Table 4-4. Performance Audit Results for Temperature and Relative Humidity

Site	Temperature Ave. Error (deg C)	2 Meter Temperature Ave. Error (deg C)	Relative Humidity Range 0 – 100%	
			Ave. Error	Max. Error
ALC188	0.14			
ALH157	0.12			
BAS601	0.79		6.9	**14.5**
BBE401	0.05			
BFT142	0.16			
BUF603	0.23		2.0	-2.6
BVL130	0.17	0.16	5.3	-7.2
BWR139	0.09			
CAD150	0.03			
CDR119	0.19			
CDZ171	0.27			
CHE185	0.12	0.09		
CKT136	0.38			
CND125	0.16			
CNT169	0.12			

Site	Temperature Ave. Error (deg C)	2 Meter Temperature Ave. Error (deg C)	Relative Humidity Range 0 – 100%	
			Ave. Error	Max. Error
CVL151	0.13			
DCP114	0.08			
GLR468	0.2			
GRS420	0.15			
GTH161	0.32			
KIC003	0.17			
KNZ184	0.3			
LAV410	0.03			
LRL117	0.21			
MAC426	0.27			
MCK131	0.17			
MCK231	0.21			
NEC602	0.26		1.4	-3.2
NIC001	0.18			
OXF122	0.17			
PAL190	0.22	0.22	3.4	-7.4
PAR107	0.05			
PED108	0.1			
PIN414	0.06			
PND165	0.33	0.35	3.1	-5.9
PRK134	0.22			
QAK172	0.11			
ROM206	0.23			
ROM406	0.29			
SAN189	0.08			
SEK430	0.12			

Site	Temperature Ave. Error (deg C)	2 Meter Temperature Ave. Error (deg C)	Relative Humidity	
			Range 0 – 100%	
			Ave. Error	Max. Error
SHE604	1.54		0.7	0.7
SHN418	0.14			
STK138	0.2			
THR422	0.15			
UND002	0.35			
VIN140	0.07			
VOY413	0.2			
VPI120	0.03			
WFM105	0.35			
WNC429	0.04			
WSP144	0.22			
YEL408	0.13			
YOS404	0.08			

4.8 Solar Radiation

The ambient conditions encountered during the audit visits were suitable (high enough light levels) for accurate comparisons of solar radiation measurements. A World Radiation Reference (WRR) traceable Eppley PSP radiometer and translator were used as the audit standard system.

Seven sites were tested. All sites had daytime average results that were within the acceptance criterion. The results of the individual tests for each site are included in Table 4-5. The percent difference of the maximum single-hour average solar radiation value observed during each site audit is also reported in Table 4-5 although this criterion is not part of the CASTNET data quality indicators. Those values greater than ±10% are bold.

4.9 Precipitation

The seven sites audited used a tipping bucket rain gauge for the obtaining precipitation measurement data. The audit challenges consisted of entering multiple amounts of a known volume of water into the tipping bucket funnel at a rate equal to approximately 2 inches of rain per hour. Equivalent amounts of water entered were compared to the amount recorded by the DAS. The results are summarized in Tables 4-5.

Of the three tipping bucket heaters tested, all were found to be functioning properly.

Table 4-5. Performance Audit Results for Solar Radiation and Precipitation

	Site	Solar Radiation Error				Precipitation Ave. Error (% diff)
		Daytime Ave. (% diff)	Std. Max. Value (w/m2)	Site Max. Observed (w/m2)	Max. Value (% diff)	
8/14/2015	BAS601	0.61	858	846	-1.4	7.0
8/19/2015	BUF603	1.32	910	922	1.3	5.2
9/14/2015	BVL130	2.58	810	845	4.1	5.0
4/6/2015	CHE185	6.55	524	562	6.8	1.0
8/20/2015	NEC602	9.34	864	778	**-11.1**	3.6
4/17/2015	PAL190	3.63	985	1029	4.3	3.0
8/10/2015	PND165	1.18	987	999	1.2	3.0

4.10 Data Acquisition Systems (DAS)

All of the NPS sponsored sites visited utilized an ESC logger as the primary and only DAS. All EPA sites visited operated Campbell loggers as their only DAS. The results presented in table 4-6 include the tests performed on the primary logger at each site.

4.10.1 Analog Test

The accuracy of each primary logger was tested on two different channels (if two channels were available to be used) with a NIST-traceable Fluke digital voltmeter. At the EPA sponsored sites the channels above analog channel 8 could not be tested since there were no empty channels available to test. All data loggers were within the acceptance criterion of ± 0.003 volts.

4.10.2 Functionality Tests

Other performance tests used to evaluate the DAS included the verification of the date and time, and operation of the battery backup system used to save the DAS date, time, and configuration during a power outage. All DAS were set to the correct date and within ±5 minutes per the acceptance criterion for time.

Table 4-6. Performance Audit Results for Data Acquisition Systems

	Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)
		Low Channel		High Channel			
		Average	Maximum	Average	Maximum		
2/10/2015	EVE419	0.0002	0.0005	0.0001	0.0002	Y	3.57
2/27/2015	CAD150	0.0004	-0.0010			Y	0.05
2/28/2015	CVL151	0.0003	-0.0005			Y	0.00
3/13/2015	CDZ171	0.0003	-0.0005			Y	0.02
3/15/2015	MCK131	0.0003	-0.0005			Y	0.00
3/15/2015	MCK231	0.0003	-0.0005			Y	0.00
3/17/2015	MAC426	0.0003	0.0005			Y	0.42
3/18/2015	CKT136	0.0005	0.0008			Y	0.13
4/8/2015	ALC188	0.0003	0.0006			Y	0.02
4/13/2015	BBE401	0.0002	0.0003			Y	0.28
4/17/2015	PAL190	0.0000	0.0001			Y	0.00
4/27/2015	SEK430	0.0003	-0.0007			Y	0.18
4/28/2015	YOS404	0.0002	-0.0006	0	0	Y	0.07
4/29/2015	PIN414	0.0004	-0.0010			Y	0.47
4/30/2015	SAN189	0.0003	0.0004			Y	0.00
5/4/2015	KIC003	0.0004	0.0010			Y	0.00
5/4/2015	KNZ184	0.0003	-0.0005			Y	0.00
5/31/2015	OXF122	0.0003	-0.0005			Y	0.02
6/4/2015	DCP114	0.0003	-0.0006			Y	0.02
6/5/2015	QAK172	0.0002	-0.0005			Y	0.00
7/2/2015	GTH161	0.0003	0.0005			Y	0.03
7/24/2015	CNT169	0.0003	-0.0005			Y	0.02
7/28/2015	GLR468	0.0003	0.0005			Y	0.00
8/3/2015	ROM206	0.0000	0.0000			Y	0.00
8/4/2015	ROM406	0.0000	0.0000			Y	0.37

	Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)
		Low Channel		High Channel			
		Average	Maximum	Average	Maximum		
8/4/2015	THR422	0.0003	-0.0007			Y	0.13
8/10/2015	PND165	0.0000	0.0000			Y	0.00
8/13/2015	YEL408	0.0000	0.0000			Y	0.17
8/14/2015	BAS601					Y	3.17
8/18/2015	SHE604					Y	0.50
8/19/2015	BUF603					Y	2.33
8/20/2015	NEC602					Y	2.58
8/21/2015	WNC429	0.0000	0.0000			Y	0.33
9/3/2015	PRK134	0.0003	0.0004			Y	0.00
9/7/2015	VIN140	0.0003	-0.0006			Y	0.02
9/8/2015	VOY413	0.0000	0.0000			Y	1.72
9/11/2015	STK138	0.0003	-0.0005			Y	0.00
9/14/2015	BVL130	0.0000	0.0000			Y	0.00
9/16/2015	ALH157	0.0003	-0.0005			Y	0.00
10/26/2015	GRS420	0.0000	0.0000			Y	0.05
11/1/2015	LRL117	0.0003	-0.0005	0	0	Y	0.02
11/6/2015	SHN418	0.0001	-0.0001			Y	0.57
11/9/2015	WSP144	0.0000	0.0000			Y	0.02
11/19/2015	VPI120	0.0003	0.0005			Y	0.00
11/21/2015	PAR107	0.0003	-0.0005			Y	0.00
11/22/2015	CDR119	0.0004	-0.0007			Y	0.13
11/24/2015	BWR139	0.0001	0.0001			Y	0.02
12/1/2015	CND125	0.0003	-0.0005			Y	0.28
12/3/2015	PED108	0.0003	0.0004			Y	0.00
12/4/2015	BFT142	0.0003	-0.0006			Y	0.00

5.0 Systems Audit Results

The following sections summarize the site systems audit findings and provide information observed regarding the measurement processes at the sites. Conditions that directly affect data accuracy have been reported in the previous sections. Other conditions that affect data quality and improvements to some measurement systems or procedures are suggested in the following sections.

5.1 Siting Criteria

All of the sites that were visited have undergone changes during the period of site operation which include population growth, road construction, and foresting activities. None of those changes were determined to have a significant impact on the siting criteria that did not exist when the site was initially established.

Some sites that are located in state and national parks are not in open areas, and have trees within the 50 meter criterion established in the QAPP. Given the land use and aesthetic concerns, these sites are acceptable and represent an adequate compromise with regard to siting criteria and the goal of long-term monitoring.

5.2 Sample Inlets

With consideration given to the siting criteria compromises described in the previous section, the sites visited this year have analyzer sample trains that are sited properly and in accordance with the CASTNET QAPP. Ozone sample inlets are between 3 and 15 meters. With the exception of one site (WNC429) Teflon tubing of the proper diameter is used for the ozone inlets. The ozone sample train at WNC429 is primarily glass with an exhaust fan downstream of the ozone sample port. The ozone analyzer at WNC429 (South Dakota) is operated by the State.

All ozone sample inlets are currently being evaluated with respect to obstructions above the inlet. The acceptance criterion requires that there should be no obstructions (including trees) within a 22.5 degree angle (object distance must be at least two times the height) above the ozone inlet. Results of the evaluations will be included in future reports. It is anticipated that the new criteria will replace the evaluation of trees within 20 meters of the sample inlet.

With the exception of WNC429, the ozone zero, span, and precision calibration test gases are introduced at the ozone sample inlet, through all filters and the entire sample train. All sample trains are comprised of only Teflon fittings and materials. Sample inlet particulate filters of 5 micron are present at most sites.

The dry deposition filter packs are designed to sample from 10 meters. Most of the filter pack sample lines are also Teflon. Inline filters are present in the sample trains.

5.3 Infrastructure

Sites continue to be improved by repairing the site shelters which had deteriorated throughout the years of operation. The installation and upgrade of the data loggers and degrading signal cables, was especially helpful. A few of the site shelters are still in need of repair, but overall the condition of the sites has improved again during the past year.

5.4 Site Operators

Generally the site operators are very conscientious and eager to complete the site activities correctly. They are willing to, and have performed sensor replacements and repairs at the sites with support provided by the AMEC and ARS field operations centers. In some cases, where replacements or repairs were made, documentation of the activities was not complete, and did not include serial numbers of the removed and installed equipment.

Many of the CASTNET site operators also perform site operator duties for the National Atmospheric Deposition Program (NADP). Many of the NPS site operators also perform other air, or environmental quality functions within their park. All are a valuable resource for the program. Some of the site operators mentioned that the CASTNET features in the NPS "Monitor" are informative, helpful, and appreciated.

Still many of the site operators have not been formally trained to perform the CASTNET duties by either AMEC or ARS. They had been given instructions by the previous site operators and over the phone instructions from the field operation centers at AMEC and ARS.

5.5 Documentation

There were some documentation problems with the Site Status Report Forms (SSRF) completed by the site operators each week during the regular site visits. Common errors included improper reporting of "initial flow", "final flow", and "leak check" values.

The NPS site operator procedures are well developed and readily accessible at all of the NPS sites visited. There is an electronic interface, "DataView 2", available to view, analyze, and print site data. There are electronic "checklists" for the site operator to complete during the site visits; however, all of the CASTNET filter pack procedures are not included in the "checklists". Flow rates and leak check results are not recorded electronically.

An electronic logbook is included in the interface software. This system permits easy access to site documentation data. Complete calibration reports have been added to the system and accessible through the site computer, however the reports available on-site are not up to date.

5.6 Site Sensor and FSAD Identification

Continued improvement has also been made in the area of documentation of sensors and systems used at the sites. It is important to maintain proper sensor identification for the purposes of site inventory and to properly identify operational sensors for data validation procedures. Many sensors have had new numbers affixed for proper identification.

Where possible the identification numbers assigned (serial numbers and barcodes) are used within the field site audit database for all the sensors encountered during the site audits. The records are used for both the performance and systems audits. If a sensor is not assigned a serial number by the manufacturer, that field is entered as “none”. If it is unknown whether an additional client ID number is assigned to a sensor, and a number is not found, the client ID is also entered as “none”. If it is typical for a manufacturer and/or client ID number to be assigned to a sensor, and that number is not present, the field is entered as “missing”. If either the serial number or the client ID numbers cannot be read, the field is entered as “illegible”. An auto-number field is assigned to each sensor in the database in order to make the records unique.

6.0 Summary and Recommendations

The CASTNET Site Audit Program has been successful in evaluating the field operations of the sites. The results of performance and systems audits are recorded and archived in a relational database, the Field Site Audit Database (FSAD). CASTNET site operations are generally acceptable and continue to improve. Some differences between actual site operations and operations described in the QAPP have been identified and described. Procedural differences between EPA and NPS sponsored sites have also been described.

As discussed previously the shelters have received some much needed attention. It was also observed that improvements were made to the shelter temperature control systems. As a requirement in 40 CFR Part 58 for ozone monitoring, shelter temperature is an important variable. Additional improvement could be made to accurately measure and report shelter temperature.

The previous paragraphs and sections included some recommendations for improving the field operations systems. One recommendation for improving the audit program is presented in the following section; this recommendation was also included in the previous annual report.

6.1 In Situ Comparisons

An improvement to the audit procedures designed to evaluate the differences in measurement technique would be to develop an "In Situ" audit measurement system. This would require a suite of sensors that would be collocated with the site sensors. Ideally the audit sensors would address the inconsistent sensor installations observed throughout the network. By deploying a suite of certified NIST traceable sensors installed and operating as recommended by the manufacturer and to EPA guidelines, subtle differences in the operation of the existing CASTNET measurement systems could be evaluated. The "In Situ" sensors would be operated at each site for a 24 hour period and the measurements would be compared to the CASTNET measurements.

7.0 References

Office of Air Quality and Planning Standards AMTIC website, SOP and guidance documents: www.epa.gov/ttn/amtic/

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Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV - Meteorological Measurements – EPA.

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Sensitivity of the National Oceanic and Atmospheric Administration multilayer model to instrument error and parameterization uncertainty: Journal of Geophysical Research, Vol. 105. No. D5, March 16, 2000.

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Bowker, G.E., Schwede, D.B.; Lear, G.G.; Warren-Hicks, W.J., and Finkelstein, P.L., 2011. Quality assurance decisions with air models: a case study of imputation of missing input data using EPA's multi-layer model. Water, Air, and Soil Pollution 222, 391e402.

APPENDIX 1

Audit Standards Certifications

	Date	1/3/2014
m_1	1/3/2014	1.01247
m_2	1/2/2014	1.00736
m_3	1/1/2014	1.00869
m_4	12/31/2013	1.00353
m_5	12/30/2013	1.00200
m_6	12/17/2012	1.00320
I_1	1/3/2014	-1.24114
I_2	1/2/2014	0.04271
I_3	1/1/2014	-0.15798
I_4	12/31/2013	-0.21509
I_5	12/30/2013	-0.60650
I_6	12/17/2012	0.03150
Average m	1/3/2014	1.00621
Avarage I	1/3/2014	-0.35775
s_m (%)	1/3/2014	0.40
s_I (ppb)	1/3/2014	0.5
Test s_m	1/3/2014	PASS
Test s_I	1/3/2014	PASS

	Date	1/4/2014
m_1	1/4/2014	1.00619
m_2	1/3/2014	1.01247
m_3	1/2/2014	1.00736
m_4	1/1/2014	1.00869
m_5	12/31/2013	1.00353
m_6	12/30/2013	1.00200
I_1	1/4/2014	-0.04260
I_2	1/3/2014	-1.24114
I_3	1/2/2014	0.04271
I_4	1/1/2014	-0.15798
I_5	12/31/2013	-0.21509
I_6	12/30/2013	-0.60650
Average m	1/4/2014	1.00671
Avarage I	1/4/2014	-0.37010
s_m (%)	1/4/2014	0.37
s_I (ppb)	1/4/2014	0.5
Test s_m	1/4/2014	PASS
Test s_I	1/4/2014	PASS

	Date	1/8/2014
m_1	1/8/2014	1.00420
m_2	1/4/2014	1.00619
m_3	1/3/2014	1.01247
m_4	1/2/2014	1.00736
m_5	1/1/2014	1.00869
m_6	12/31/2013	1.00353
I_1	1/8/2014	0.35220
I_2	1/4/2014	-0.04260
I_3	1/3/2014	-1.24114
I_4	1/2/2014	0.04271
I_5	1/1/2014	-0.15798
I_6	12/31/2013	-0.21509
Average m	1/8/2014	1.00707
Avarage I	1/8/2014	-0.21032
s_m (%)	1/8/2014	0.32
s_I (ppb)	1/8/2014	0.5
Test s_m	1/8/2014	PASS
Test s_I	1/8/2014	PASS

	Date	1/7/2015
m_1	1/7/2015	1.01820
m_2	1/8/2014	1.00420
m_3	1/4/2014	1.00619
m_4	1/3/2014	1.01247
m_5	1/2/2014	1.00736
m_6	1/1/2014	1.00869
I_1	1/7/2015	-0.41020
I_2	1/8/2014	0.35220
I_3	1/4/2014	-0.04260
I_4	1/3/2014	-1.24114
I_5	1/2/2014	0.04271
I_6	1/1/2014	-0.15798
Average m	1/7/2015	1.00952
Avarage I	1/7/2015	-0.24284
s_m (%)	1/7/2015	0.50
s_I (ppb)	1/7/2015	0.5
Test s_m	1/7/2015	PASS
Test s_I	1/7/2015	PASS

	Date	9/21/2015
m_1	9/21/2015	1.01937
m_2	1/7/2015	1.01820
m_3	1/8/2014	1.00420
m_4	1/4/2014	1.00619
m_5	1/3/2014	1.01247
m_6	1/2/2014	1.00736
I_1	9/21/2015	0.02326
I_2	1/7/2015	-0.41020
I_3	1/8/2014	0.35220
I_4	1/4/2014	-0.04260
I_5	1/3/2014	-1.24114
I_6	1/2/2014	0.04271
Average m	9/21/2015	1.01130
Avarage I	9/21/2015	-0.21263
s_m (%)	9/21/2015	0.63
s_I (ppb)	9/21/2015	0.6
Test s_m	9/21/2015	PASS
Test s_I	9/21/2015	PASS

$$\left.\sum_{i=1}^{6} m_i\right)^2 \Bigg]$$

$$\left.\sum_{i=1}^{6} I_i\right)^2 \Bigg]$$

$$S_m = \frac{100}{\bar{m}}\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i\right)^2\right]}$$

$$S_I = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i\right)^2\right]}$$

$$S_m = \frac{100}{\bar{m}}\sqrt{\ldots}$$

$$S_I = \sqrt{\frac{1}{5}\ldots}$$

EEMS # **01110**
New 6-day after replacing detector B
At EEMS
BKG = 0.0
COEF = 1.035

EEMS # **01110**
New 6-day after replacing detector B
At EEMS
BKG = 0.0
COEF = 1.035

EEMS # **01110**
At EPA Region 4

BKG = 0.0
COEF = 1.035

EEMS # **01110**
At EPA Region 4
1/7/2015
BKG = 0.0
COEF = 1.035

EEMS # **01110**
At EPA Region 7
9/21/2015
BKG = 0.0
COEF = 1.035

EEMS # S/N =	Date 01111 0517112175	12/29/2014
m_1	12/29/2014	0.99851
m_2	12/28/2014	1.00536
m_3	1/8/2014	1.00920
m_4	9/30/2013	1.00525
m_5	1/2/2013	1.00488
m_6	12/31/2012	1.00502
I_1	12/29/2014	0.34334
I_2	12/28/2014	0.22548
I_3	1/8/2014	-0.14250
I_4	9/30/2013	0.25684
I_5	1/2/2013	0.21264
I_6	12/31/2012	0.25051
Average m	12/29/2014	1.00470
Avarage I	12/29/2014	0.19105
$s_{m\,(\%)}$	12/29/2014	0.34
$s_{I\,(ppb)}$	12/29/2014	0.2
Test s_m	12/29/2014	PASS
Test s_I	12/29/2014	PASS

EEMS # S/N =	Date 01111 0517112175	12/30/2014
m_1	12/30/2014	0.99997
m_2	12/29/2014	0.99851
m_3	12/28/2014	1.00536
m_4	1/8/2014	1.00920
m_5	9/30/2013	1.00525
m_6	1/2/2013	1.00488
I_1	12/30/2014	0.34935
I_2	12/29/2014	0.34334
I_3	12/28/2014	0.22548
I_4	1/8/2014	-0.14250
I_5	9/30/2013	0.25684
I_6	1/2/2013	0.21264
Average m	12/30/2014	1.00386
Avarage I	12/30/2014	0.20753
$s_{m\,(\%)}$	12/30/2014	0.39
$s_{I\,(ppb)}$	12/30/2014	0.2
Test s_m	12/30/2014	PASS
Test s_I	12/30/2014	PASS

EEMS # S/N =	Date 01111 0517112175	12/31/2014
m_1	12/31/2014	0.99332
m_2	12/30/2014	0.99997
m_3	12/29/2014	0.99851
m_4	12/28/2014	1.00536
m_5	1/8/2014	1.00920
m_6	9/30/2013	1.00525
I_1	12/31/2014	0.52061
I_2	12/30/2014	0.34935
I_3	12/29/2014	0.34334
I_4	12/28/2014	0.22548
I_5	1/8/2014	-0.14250
I_6	9/30/2013	0.25684
Average m	12/31/2014	1.00193
Avarage I	12/31/2014	0.25885
$s_{m\,(\%)}$	12/31/2014	0.57
$s_{I\,(ppb)}$	12/31/2014	0.2
Test s_m	12/31/2014	PASS
Test s_I	12/31/2014	PASS

EEMS # S/N =	Date 01111 0517112175	1/2/2015
m_1	1/2/2015	0.99482
m_2	12/31/2014	0.99332
m_3	12/30/2014	0.99997
m_4	12/29/2014	0.99851
m_5	12/28/2014	1.00536
m_6	1/8/2014	1.00920
I_1	1/2/2015	0.16499
I_2	12/31/2014	0.52061
I_3	12/30/2014	0.34935
I_4	12/29/2014	0.34334
I_5	12/28/2014	0.22548
I_6	1/8/2014	-0.14250
Average m	1/2/2015	1.00019
Avarage I	1/2/2015	0.24355
$s_{m\,(\%)}$	1/2/2015	0.61
$s_{I\,(ppb)}$	1/2/2015	0.2
Test s_m	1/2/2015	PASS
Test s_I	1/2/2015	PASS

EEMS # S/N =	Date 01111 0517112175	1/3/2015
m_1	1/3/2015	0.99307
m_2	1/2/2015	0.99482
m_3	12/31/2014	0.99332
m_4	12/30/2014	0.99997
m_5	12/29/2014	0.99851
m_6	12/28/2014	1.00536
I_1	1/3/2015	0.13058
I_2	1/2/2015	0.16499
I_3	12/31/2014	0.52061
I_4	12/30/2014	0.34935
I_5	12/29/2014	0.34334
I_6	12/28/2014	0.22548
Average m	1/3/2015	0.99751
Avarage I	1/3/2015	0.28906
$s_{m\,(\%)}$	1/3/2015	0.48
$s_{I\,(ppb)}$	1/3/2015	0.1
Test s_m	1/3/2015	PASS
Test s_I	1/3/2015	PASS

EEMS # S/N =	Date 01111 0517112175	1/7/2015
m_1	1/7/2015	1.01540
m_2	1/3/2015	0.99307
m_3	1/2/2015	0.99482
m_4	12/31/2014	0.99332
m_5	12/30/2014	0.99997
m_6	12/29/2014	0.99851
I_1	1/7/2015	-0.09100
I_2	1/3/2015	0.13058
I_3	1/2/2015	0.16499
I_4	12/31/2014	0.52061
I_5	12/30/2014	0.34935
I_6	12/29/2014	0.34334
Average m	1/7/2015	0.99918
Avarage I	1/7/2015	0.23631
$s_{m\,(\%)}$	1/7/2015	0.84
$s_{I\,(ppb)}$	1/7/2015	0.2
Test s_m	1/7/2015	PASS
Test s_I	1/7/2015	PASS

$$\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2-\frac{1}{6}\left(\sum_{i=1}^{6}m_i\right)^2\right]$$

$$\left[\sum_{i=1}^{6}(I_i)^2-\frac{1}{6}\left(\sum_{i=1}^{6}I_i\right)^2\right]$$

$$S_m=\frac{100}{\overline{m}}\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2-\frac{1}{6}\left(\sum_{i=1}^{6}m_i\right)^2\right]}$$

$$S_I=\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(I_i)^2-\frac{1}{6}\left(\sum_{i=1}^{6}I_i\right)^2\right]}$$

$$S_m=\frac{100}{\overline{m}}\sqrt{\frac{1}{5}}$$

$$S_I=\sqrt{\frac{1}{5}}$$

At EEMS new BKG and COEF
12/29/2014
BKG = -0.5
COEF = 1.035

At EEMS new BKG and COEF
12/30/2014
BKG = -0.5
COEF = 1.035

At EEMS new BKG and COEF
12/31/2014
BKG = -0.5
COEF = 1.035

At EEMS new BKG and COEF
1/2/2015
BKG = -0.5
COEF = 1.035

At EEMS new BKG and COEF
1/3/2015
BKG = -0.5
COEF = 1.035

At EEMS new BKG and COEF
1/7/2015
BKG = -0.5
COEF = 1.035

Enter date in yellow highlighted cell next to "Date".

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

		Date 3/5/2015
m_1	3/5/2015	0.99532
m_2	3/4/2015	0.99277
m_3	3/3/2015	0.99785
m_4	1/7/2015	1.02480
m_5	1/8/2014	1.01870
m_6	1/4/2014	1.00565
I_1	3/5/2015	-0.49499
I_2	3/4/2015	-0.44505
I_3	3/3/2015	-0.29464
I_4	1/7/2015	0.57470
I_5	1/8/2014	0.40360
I_6	1/4/2014	0.39663
Average m	3/5/2015	1.00585
Avarage I	3/5/2015	0.02337
s_m (%)	3/5/2015	1.31
s_I (ppb)	3/5/2015	0.5
Test s_m	3/5/2015	PASS
Test s_I	3/5/2015	PASS

EEMS # **01112**

At EEMS

offset = -0.2
span = 1.017

Enter date in yellow highlighted cell next to "Date".

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

		Date 3/7/2015
m_1	3/7/2015	0.99124
m_2	3/5/2015	0.99532
m_3	3/4/2015	0.99277
m_4	3/3/2015	0.99785
m_5	1/7/2015	1.02480
m_6	1/8/2014	1.01870
I_1	3/7/2015	-0.46416
I_2	3/5/2015	-0.49499
I_3	3/4/2015	-0.44505
I_4	3/3/2015	-0.29464
I_5	1/7/2015	0.57470
I_6	1/8/2014	0.40360
Average m	3/7/2015	1.00345
Avarage I	3/7/2015	-0.12009
s_m (%)	3/7/2015	1.44
s_I (ppb)	3/7/2015	0.5
Test s_m	3/7/2015	PASS
Test s_I	3/7/2015	PASS

EEMS # **01112**

At EEMS

offset = -0.2
span = 1.017

Enter date in yellow highlighted cell next to "Date".

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

		Date 3/8/2015
m_1	3/8/2015	0.99208
m_2	3/7/2015	0.99124
m_3	3/5/2015	0.99532
m_4	3/4/2015	0.99277
m_5	3/3/2015	0.99785
m_6	1/7/2015	1.02480
I_1	3/8/2015	-0.33284
I_2	3/7/2015	-0.46416
I_3	3/5/2015	-0.49499
I_4	3/4/2015	-0.44505
I_5	3/3/2015	-0.29464
I_6	1/7/2015	0.57470
Average m	3/8/2015	0.99901
Avarage I	3/8/2015	-0.24283
s_m (%)	3/8/2015	1.29
s_I (ppb)	3/8/2015	0.4
Test s_m	3/8/2015	PASS
Test s_I	3/8/2015	PASS

$$S_m = \frac{100}{\bar{m}}\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i\right)^2\right]}$$

$$S_I = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i\right)^2\right]}$$

EEMS # **01112**

At EEMS

offset = -0.2
span = 1.017

Enter date in yellow highlighted cell next to "Date".

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

		Date 3/9/2015
m_1	3/9/2015	0.99502
m_2	3/8/2015	0.99208
m_3	3/7/2015	0.99124
m_4	3/5/2015	0.99532
m_5	3/4/2015	0.99277
m_6	3/3/2015	0.99785
I_1	3/9/2015	-0.53651
I_2	3/8/2015	-0.33284
I_3	3/7/2015	-0.46416
I_4	3/5/2015	-0.49499
I_5	3/4/2015	-0.44505
I_6	3/3/2015	-0.29464
Average m	3/9/2015	0.99405
Avarage I	3/9/2015	-0.42803
s_m (%)	3/9/2015	0.25
s_I (ppb)	3/9/2015	0.1
Test s_m	3/9/2015	PASS
Test s_I	3/9/2015	PASS

EEMS # **01112**

At EEMS

offset = -0.2
span = 1.017

Enter date in yellow highlighted cell next to "Date".

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

		Date 6/25/2015
m_1	6/25/2015	0.99659
m_2	3/9/2015	0.99502
m_3	3/8/2015	0.99208
m_4	3/7/2015	0.99124
m_5	3/5/2015	0.99532
m_6	3/4/2015	0.99277
I_1	6/25/2015	-0.18324
I_2	3/9/2015	-0.53651
I_3	3/8/2015	-0.33284
I_4	3/7/2015	-0.46416
I_5	3/5/2015	-0.49499
I_6	3/4/2015	-0.44505
Average m	6/25/2015	0.99384
Avarage I	6/25/2015	-0.40946
s_m (%)	6/25/2015	0.21
s_I (ppb)	6/25/2015	0.1
Test s_m	6/25/2015	PASS
Test s_I	6/25/2015	PASS

EEMS # **01112**

At EPA R-7

offset = -0.2
span = 1.017

EEMS # **01113**
S/N = **0517112167**

m_1	1/3/2015	0.99747
m_2	1/2/2015	0.99542
m_3	12/31/2014	0.99671
m_4	12/30/2014	0.99501
m_5	12/29/2014	0.99984
m_6	12/28/2014	0.999206
I_1	1/3/2015	-0.18872
I_2	1/2/2015	-0.06509
I_3	12/31/2014	-0.05931
I_4	12/30/2014	0.15486
I_5	12/29/2014	0.04619
I_6	12/28/2014	0.333331
Average m	1/3/2015	0.99728
Avarage I	1/3/2015	0.03688
s_m (%)	1/3/2015	0.20
s_I (ppb)	1/3/2015	0.2
Test s_m	1/3/2015	PASS
Test s_I	1/3/2015	PASS

S/N = 0517112167
Enter new slope and intercept in yellow highlighted cells
Date **1/7/2015**

m_1	1/7/2015	1.02050
m_2	12/28/2014	0.99921
m_3	12/29/2014	0.99984
m_4	12/30/2014	0.99501
m_5	12/31/2014	0.99671
m_6	1/2/2015	0.99542
I_1	1/7/2015	-0.34620
I_2	12/28/2014	0.33333
I_3	12/29/2014	0.04619
I_4	12/30/2014	0.15486
I_5	12/31/2014	-0.05931
I_6	1/2/2015	-0.06509
Average m	1/7/2015	1.00112
Avarage I	1/7/2015	0.01063
s_m (%)	1/7/2015	0.97
s_I (ppb)	1/7/2015	0.2
Test s_m	1/7/2015	PASS
Test s_I	1/7/2015	PASS

S/N = 0517112167
Enter new slope and intercept in yellow highlighted cells
Date **4/29/2015**

m_1	4/29/2015	1.02260
m_2	1/7/2015	1.02050
m_3	12/28/2014	0.99921
m_4	12/29/2014	0.99984
m_5	12/30/2014	0.99501
m_6	12/31/2014	0.99671
I_1	4/29/2015	-0.20400
I_2	1/7/2015	-0.34620
I_3	12/28/2014	0.33333
I_4	12/29/2014	0.04619
I_5	12/30/2014	0.15486
I_6	12/31/2014	-0.05931
Average m	4/29/2015	1.00565
Avarage I	4/29/2015	-0.01252
s_m (%)	4/29/2015	1.24
s_I (ppb)	4/29/2015	0.2
Test s_m	4/29/2015	PASS
Test s_I	4/29/2015	PASS

S/N = 0517112167
Enter new slope and intercept in yellow highlighted cells
Date **9/21/2015**

m_1	9/21/2015	1.02307
m_2	4/29/2015	1.02260
m_3	1/7/2015	1.02050
m_4	12/28/2014	0.99921
m_5	12/29/2014	0.99984
m_6	12/30/2014	0.99501
I_1	9/21/2015	-0.26399
I_2	4/29/2015	-0.20400
I_3	1/7/2015	-0.34620
I_4	12/28/2014	0.33333
I_5	12/29/2014	0.04619
I_6	12/30/2014	0.15486
Average m	9/21/2015	1.01004
Avarage I	9/21/2015	-0.04664
s_m (%)	9/21/2015	1.32
s_I (ppb)	9/21/2015	0.3
Test s_m	9/21/2015	PASS
Test s_I	9/21/2015	PASS

S/N = 0517112167
Enter new slope and intercept in yellow highlighted cells
Date

m_1	1/0/1900	
m_2	9/21/2015	1.02307
m_3	4/29/2015	1.02260
m_4	1/7/2015	1.02050
m_5	12/28/2014	0.99921
m_6	12/29/2014	0.99984
I_1	1/0/1900	
I_2	9/21/2015	-0.26399
I_3	4/29/2015	-0.20400
I_4	1/7/2015	-0.34620
I_5	12/28/2014	0.33333
I_6	12/29/2014	0.04619
Average m	1/0/1900	1.01304
Avarage I	1/0/1900	-0.08693
s_m (%)	1/0/1900	40.84
s_I (ppb)	1/0/1900	0.3
Test s_m	1/0/1900	FAIL
Test s_I	1/0/1900	PASS

$$S_m = \frac{100}{\bar{m}}\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i\right)^2\right]}$$

$$S_I = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i\right)^2\right]}$$

$$S_m = \frac{100}{\bar{m}}\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\left(\right.\right.}$$

$$S_I = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\left(\right.\right.}$$

EEMS # **01113**
First 6-day run
At EEMS
offset = **-0.1**
span = **1.035**

EEMS # **01113**
First Verification
At EPA Region 4
offset = **-0.1**
span = **1.035**

EEMS # **01113**
Verification
At EPA RTP
offset = **-0.1**
span = **1.035**

EEMS # **01113**
Verification
At EPA R7
offset = **-0.1**
span = **1.035**

EEMS # **01113**

	Date	1/3/2014
m_1	1/3/2014	1.01247
m_2	1/2/2014	1.00736
m_3	1/1/2014	1.00869
m_4	12/31/2013	1.00353
m_5	12/30/2013	1.00200
m_6	12/17/2012	1.00320
I_1	1/3/2014	-1.24114
I_2	1/2/2014	0.04271
I_3	1/1/2014	-0.15798
I_4	12/31/2013	-0.21509
I_5	12/30/2013	-0.60650
I_6	12/17/2012	0.03150
Average m	1/3/2014	1.00621
Avarage I	1/3/2014	-0.35775
s_m (%)	1/3/2014	0.40
s_I (ppb)	1/3/2014	0.5
Test s_m	1/3/2014	PASS
Test s_I	1/3/2014	PASS

EEMS # 01110
New 6-day after replacing detector B
At EEMS
BKG = 0.0
COEF = 1.035

	Date	1/4/2014
m_1	1/4/2014	1.00619
m_2	1/3/2014	1.01247
m_3	1/2/2014	1.00736
m_4	1/1/2014	1.00869
m_5	12/31/2013	1.00353
m_6	12/30/2013	1.00200
I_1	1/4/2014	-0.04260
I_2	1/3/2014	-1.24114
I_3	1/2/2014	0.04271
I_4	1/1/2014	-0.15798
I_5	12/31/2013	-0.21509
I_6	12/30/2013	-0.60650
Average m	1/4/2014	1.00671
Avarage I	1/4/2014	-0.37010
s_m (%)	1/4/2014	0.37
s_I (ppb)	1/4/2014	0.5
Test s_m	1/4/2014	PASS
Test s_I	1/4/2014	PASS

EEMS # 01110
New 6-day after replacing detector B
At EEMS
BKG = 0.0
COEF = 1.035

	Date	1/8/2014
m_1	1/8/2014	1.00420
m_2	1/4/2014	1.00619
m_3	1/3/2014	1.01247
m_4	1/2/2014	1.00736
m_5	1/1/2014	1.00869
m_6	12/31/2013	1.00353
I_1	1/8/2014	0.35220
I_2	1/4/2014	-0.04260
I_3	1/3/2014	-1.24114
I_4	1/2/2014	0.04271
I_5	1/1/2014	-0.15798
I_6	12/31/2013	-0.21509
Average m	1/8/2014	1.00707
Avarage I	1/8/2014	-0.21032
s_m (%)	1/8/2014	0.32
s_I (ppb)	1/8/2014	0.5
Test s_m	1/8/2014	PASS
Test s_I	1/8/2014	PASS

EEMS # 01110
At EPA Region 4
BKG = 0.0
COEF = 1.035

	Date	1/7/2015
m_1	1/7/2015	1.01820
m_2	1/8/2014	1.00420
m_3	1/4/2014	1.00619
m_4	1/3/2014	1.01247
m_5	1/2/2014	1.00736
m_6	1/1/2014	1.00869
I_1	1/7/2015	-0.41020
I_2	1/8/2014	0.35220
I_3	1/4/2014	-0.04260
I_4	1/3/2014	-1.24114
I_5	1/2/2014	0.04271
I_6	1/1/2014	-0.15798
Average m	1/7/2015	1.00952
Avarage I	1/7/2015	-0.24284
s_m (%)	1/7/2015	0.50
s_I (ppb)	1/7/2015	0.5
Test s_m	1/7/2015	PASS
Test s_I	1/7/2015	PASS

EEMS # 01110
At EPA Region 4
1/7/2015
BKG = 0.0
COEF = 1.035

	Date	9/21/2015
m_1	9/21/2015	1.01937
m_2	1/7/2015	1.01820
m_3	1/8/2014	1.00420
m_4	1/4/2014	1.00619
m_5	1/3/2014	1.01247
m_6	1/2/2014	1.00736
I_1	9/21/2015	0.02326
I_2	1/7/2015	-0.41020
I_3	1/8/2014	0.35220
I_4	1/4/2014	-0.04260
I_5	1/3/2014	-1.24114
I_6	1/2/2014	0.04271
Average m	9/21/2015	1.01130
Avarage I	9/21/2015	-0.21263
s_m (%)	9/21/2015	0.63
s_I (ppb)	9/21/2015	0.6
Test s_m	9/21/2015	PASS
Test s_I	9/21/2015	PASS

EEMS # 01110
At EPA Region 7
9/21/2015
BKG = 0.0
COEF = 1.035

$$\left(\sum_{i=1}^{6} m_i\right)^2 \Bigg]$$

$$\left(\sum_{i=1}^{6} I_i\right)^2 \Bigg]$$

$$S_m = \frac{100}{\bar{m}}\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i\right)^2\right]}$$

$$S_I = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i\right)^2\right]}$$

$$S_m = \frac{100}{\bar{m}}\sqrt{\ }$$

$$S_I = \sqrt{\frac{1}{5}}$$

Ozone Transfer Standard Verification Summary Report

U. S. Environmental Protection Agency
Region 4 Science and Ecosystem Support Division
Enforcement and Investigations Branch
Superfund and Air Section
980 College Station Rd.
Athens, GA 30605

	EPA Standard	GUEST Instrument
Agency:	EPA Region 4	EEMS
Contact:	Mike Crowe	Eric Hebert
Make:	NIST	Thermo
Model:	SRP-10	49CPS
S/N:	10	49CPS-70008-364
Guest Test Status:		**PASS**
Guest Known Offset:		0

EEMS # 01110

SESD Project #: 15-0158
Test #: # 1 "as found"

Level 2	**Slope**	**Intercept**	**R^2**	**High O_3**	**Lower O_3**
Averages:	1.0182	-0.4102	0.9999982	487	0
Upper Tolerance:	1.0300	3.0000			
LowerTolerance:	0.9700	-3.0000			

Date Start	Time Start	Date End	Time End	File	Slope	Intercept	R^2	Upper Range (ppb O_3)	Lower Range (ppb O_3)
01/07/15	4:08 PM	01/07/15	5:57 PM	c0107001.xls	1.0131	-0.4703	0.9999977	482	0.03
01/07/15	5:57 PM	01/07/15	7:48 PM	c0107002.xls	1.0167	-0.4430	0.9999990	483	-0.11
01/07/15	7:48 PM	01/07/15	9:44 PM	c0107003.xls	1.0186	-0.4633	0.9999991	486	0.10
01/07/15	9:44 PM	01/07/15	11:34 PM	c0107004.xls	1.0189	-0.4071	0.9999997	488	-0.04
01/07/15	11:34 PM	01/08/15	1:30 AM	c0107005.xls	1.0196	-0.4802	0.9999980	489	0.10
01/08/15	1:30 AM	01/08/15	3:17 AM	c0107006.xls	1.0204	-0.3861	0.9999980	489	-0.29
01/08/15	3:17 AM	01/08/15	5:14 AM	c0107007.xls	1.0204	-0.2214	0.9999961	489	-0.40

Comments:

Instrument tested as found.
Ozone calibration factors at time of test: O3 BKG: 0.0 ppb O3 COEF: 1.035

Instrument within tolerance

Verification Expires on: **January 8, 2016**

Mike Crowe [signature] Date 1-8-15

Ozone Transfer Standard Verification Summary Report

U. S. Environmental Protection Agency
Region 4 Science and Ecosystem Support Division
Enforcement and Investigations Branch
Superfund and Air Section
980 College Station Rd.
Athens, GA 30605

	EPA Standard	GUEST Instrument
Agency:	EPA R4 SESD	EEMS
Contact:	Mike Crowe	Eric Hebert
Make:	NIST	Thermo
Model:	SRP	49CPS
S/N:	10	517112175
Guest Test Status:		**PASS**
Guest Known Offset:		0

EEMS# 01111

SESD Project #: 15-0157
Test #: # 1 "as found"

Level 2	**Slope**	**Intercept**	**R^2**	**High O_3**	**Lower O_3**
Averages:	1.0154	-0.0910	0.9999992	496	0
Upper Tolerance:	1.0300	3.0000			
LowerTolerance:	0.9700	-3.0000			

Date Start	**Time Start**	**Date End**	**Time End**	**File**	**Slope**	**Intercept**	**R^2**	**Upper Range (ppb O_3)**	**Lower Range (ppb O_3)**
01/07/15	10:50 AM	01/07/15	11:48 AM	c0107001.xls	1.0139	-0.1230	0.9999995	497	-0.02
01/07/15	11:49 AM	01/07/15	12:52 PM	c0107002.xls	1.0161	-0.0751	0.9999995	496	-0.18
01/07/15	12:52 PM	01/07/15	1:49 PM	c0107003.xls	1.0164	-0.0749	0.9999986	496	-0.34

Comments:

Instrument tested as found.
Ozone calibration factors at time of test: O3 BKG: -0.5 ppb O3 COEF: 1.035

No Alarms.

Instrument within tolerance.

Verification Expires on: **January 7, 2016**

Mike Crowe [signature] Date 1-8-15

SESDFORM-046-R0

Ozone Transfer Standard Verification Summary Report

U. S. Environmental Protection Agency
Region 4 Science and Ecosystem Support Division
Enforcement and Investigations Branch
Superfund and Air Section
980 College Station Rd.
Athens, GA 30605

	EPA Standard	GUEST Instrument
Agency:	EPA Region 4	EEMS
Contact:	Mike Crowe	Eric Hebert
Make:	NIST	Thermo
Model:	SRP-10	49CPS
S/N:	10	49CPS-0419606966
Guest Test Status:		**PASS**
Guest Known Offset:		0

EEMS # 01112

SESD Project #: 15-0159
Test #: # 1 "as found"

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	1.0248	0.5747	0.9999923	487	0
Upper Tolerance:	1.0300	3.0000			
LowerTolerance:	0.9700	-3.0000			

Date Start	Time Start	Date End	Time End	File	Slope	Intercept	R^2	Upper Range (ppb O_3)	Lower Range (ppb O_3)
01/07/15	4:08 PM	01/07/15	5:57 PM	c0107001.xls	1.0272	0.3538	0.9999978	482	0.03
01/07/15	5:57 PM	01/07/15	7:48 PM	c0107002.xls	1.0279	0.3801	0.9999987	483	-0.11
01/07/15	7:48 PM	01/07/15	9:44 PM	c0107003.xls	1.0274	0.3748	0.9999988	486	0.10
01/07/15	9:44 PM	01/07/15	11:34 PM	c0107004.xls	1.0241	0.5498	0.9999944	488	-0.04
01/07/15	11:34 PM	01/08/15	1:30 AM	c0107005.xls	1.0235	0.6388	0.9999907	489	0.10
01/08/15	1:30 AM	01/08/15	3:17 AM	c0107006.xls	1.0218	0.7911	0.9999857	489	-0.29
01/08/15	3:17 AM	01/08/15	5:14 AM	c0107007.xls	1.0214	0.9343	0.9999802	489	-0.40

Comments:

Instrument tested as found.
Ozone calibration factors at time of test: O3 BKG: -0.5 ppb O3 COEF: 1.045

Instrument within tolerance

Verification Expires on: **January 8, 2016**

Mike Crowe [signature] Date 1-8-15

Ozone Transfer Standard Verification Summary Report

U. S. Environmental Protection Agency
Region 4 Science and Ecosystem Support Division
Enforcement and Investigations Branch
Superfund and Air Section
980 College Station Rd.
Athens, GA 30605

	EPA Standard	GUEST Instrument
Agency:	EPA Region 4	EEMS
Contact:	Mike Crowe	Eric Hebert
Make:	NIST	Thermo
Model:	SRP	49CPS
S/N:	10	517112167
Guest Test Status:		PASS
Guest Known Offset:		0

EEMS# 01113

SESD Project #: 15-0156
Test #: # 1 "as found"

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	1.0205	-0.3462	0.9999994	496	0
Upper Tolerance:	1.0300	3.0000			
LowerTolerance:	0.9700	-3.0000			

Date Start	Time Start	Date End	Time End	File	Slope	Intercept	R^2	Upper Range (ppb O_3)	Lower Range (ppb O_3)
01/07/15	10:50 AM	01/07/15	11:48 AM	c0107001.xls	1.0188	-0.3391	0.9999996	497	-0.02
01/07/15	11:49 AM	01/07/15	12:52 PM	c0107002.xls	1.0216	-0.3573	0.9999997	496	-0.18
01/07/15	12:52 PM	01/07/15	1:49 PM	c0107003.xls	1.0212	-0.3421	0.9999990	496	-0.34

Comments:

Instrument tested as found.
Ozone calibration factors at time of test: O3 BKG: -0.1 ppb O3 COEF: 1.035
No Alarms.

Instrument within tolerance.

Verification Expires on: **January 7, 2016**

Mike Crowe [signature] Date 1-8-15

SESDFORM-046-R0

REPORT OF RE-VERIFICATION

U. S. Environmental Protection Agency
Office of Research and Development
Air Pollution Prevention and Control Division
Technical Services Branch
109 T.W. Alexander Drive
RTP, NC 27711

U.S. EPA
Scott Moore
4930 Old Page Rd.
RTP, NC 27709
(919) 541-5104
moore.scott@epa.gov

Primary Standard

Agency:	**EPA RTP**
Contact:	**Scott Moore**
Make:	**NIST**
Model:	**SRP**
S/N:	**01**
NIST Ver.	**May 08, 2015**
Level	**2**

Guest Information

Agency:	EE & MS
Contact:	Eric Hebert
Make:	Thermo
Model:	49c
S/N:	686
Offset:	517112167
Status:	**PASS**

EEMS
01113

	Slope	Intercept	R^2
→ Averages:	1.0226	-0.2040	0.99999826
Upper Limit:	1.0300	3.0000	NA
Lower Limit	0.9700	-3.0000	NA

Date Start	Time Start	Date End	Time End	File	Slope	Intercept	R^2
04/29/15	**18:54**	**04/29/15**	**21:45**	**c0429001.xls**	**1.0199**	**-0.2951**	**0.99999564**
04/29/15	**21:45**	**04/30/15**	**0:46**	**c0429002.xls**	**1.0226**	**-0.2165**	**0.99999934**
04/30/15	**21:21**	**05/01/15**	**0:00**	**C0430002.xls**	**1.0254**	**-0.1003**	**0.99999980**

Comments: Ozone concentrations were run, on an average at 520, 471, 428, 388, 351, 316, 285, 244, 199, 157, 122, 93, 55 and 22 ppb . Next Re-Verification will be due by 5/1/16.

Scott A. Moore Scott A. Moore DATE: May 1, 2015

Standard Reference Photometer
Calibration Report

Calibrating Institute:	EPA Region 7	**Date:**	25-Jun-15
Operator:	J. Regehr / T. Bui	**Start Time:**	14:31
Instrument:	SRP-13 Cell Length=89.84	**End Time:**	15:42
Comment:	Certification of EEMS TEI49cPS SRP Generating Slope	**Filename:**	c0625004.xls

Calibrated Instrument:	EEMS	**Calibration Results**	**Value**	**Standard Uncertainty**
Owner:	EEMS			
Contact:	Eric Hebert	**Slope**	0.99403	0.00031
Make:	TEI	**Intercept**	-0.24830	0.07372
Model:	49c-PS	**Covariance**		-3.0030E-08
Serial Number:	419606966	**Res Std Dev**	0.12237	

Calibration Parameters: Raw Saved;Dark Count On (5)
Air Flow Rate: 7.0 l/min
Lamp Intensity Range: 0.0 to 45.0 %
Number Conc. Points: 7 **Points/Concentration:** 10
Conditioning: 45.0 % for 5 minutes

Calibration	**SRP-13**		**EEMS**		**EEMS**	
Data Points	**Result**	**Std. Dev**	**Result**	**Std. Dev**	**Predicted**	**Residual**
Dark Count 1	12					
Dark Count 2	11					
1	460.1	0.5	457.0	0.4	457.12	-0.13
2	349.4	0.2	347.2	0.2	347.11	0.06
3	231.0	0.2	229.6	0.2	229.41	0.23
4	102.9	0.4	101.9	0.1	102.08	-0.13
5	48.9	0.3	48.3	0.1	48.33	-0.03
6	24.2	0.3	23.8	0.1	23.80	0.02
7	0.0	0.2	-0.3	0.1	-0.25	-0.02

Standard Reference Photometer
Calibration Report

Calibrating Institute:	EPA Region 7	**Date:**	25-Jun-15
Operator:	J. Regehr / T. Bui	**Start Time:**	15:42
Instrument:	SRP-13 Cell Length=89.84	**End Time:**	16:49
Comment:	Certification of EEMS TEI49cPS SRP Generating Slope	**Filename:**	c0625005.xls

		Calibration Results	**Value**	**Standard Uncertainty**
Calibrated Instrument:	EEMS			
Owner:	EEMS			
Contact:	Eric Hebert	**Slope**	0.99584	0.00025
Make:	TEI	**Intercept**	-0.27154	0.06115
Model:	49c-PS	**Covariance**		-1.8977E-08
Serial Number:	419606966	**Res Std Dev**	0.10157	

Calibration Parameters:	Raw Saved;Dark Count On (5)		
Air Flow Rate:	7.0 l/min		
Lamp Intensity Range:	0.0 to 45.0 %		
Number Conc. Points:	7	**Points/Concentration:**	10
Conditioning:	45.0 % for 5 minutes		

Calibration	**SRP-13**		**EEMS**		**EEMS**	
Data Points	**Result**	**Std. Dev**	**Result**	**Std. Dev**	**Predicted**	**Residual**
Dark Count 1	12					
Dark Count 2	9					
1	462.5	0.4	460.3	0.3	460.33	-0.06
2	349.8	0.3	348.3	0.3	348.10	0.17
3	230.9	0.3	229.5	0.2	229.65	-0.13
4	102.2	0.3	101.5	0.1	101.55	-0.06
5	49.8	0.3	49.4	0.1	49.35	0.05
6	24.2	0.3	23.9	0.1	23.79	0.06
7	0.1	0.1	-0.2	0.1	-0.16	-0.04

Standard Reference Photometer
Calibration Report

Calibrating Institute:	EPA Region 7	**Date:**	25-Jun-15
Operator:	J. Regehr / T. Bui	**Start Time:**	16:49
Instrument:	SRP-13 Cell Length=89.84	**End Time:**	17:54
Comment:	Certification of EEMS TEI49cPS SRP Generating Slope	**Filename:**	c0625006.xls

		Calibration Results	**Value**	**Standard Uncertainty**
Calibrated Instrument:	EEMS			
Owner:	EEMS			
Contact:	Eric Hebert	**Slope**	0.99726	0.00023
Make:	TEI	**Intercept**	-0.22502	0.05447
Model:	49c-PS	**Covariance**		-1.6575E-08
Serial Number:	419606966	**Res Std Dev**	0.09045	

Calibration Parameters: Raw Saved;Dark Count On (5)

Air Flow Rate: 7.0 l/min

Lamp Intensity Range: 0.0 to 45.0 %

Number Conc. Points: 7 **Points/Concentration:** 10

Conditioning: 45.0 % for 5 minutes

Calibration	**SRP-13**		**EEMS**		**EEMS**	
Data Points	**Result**	**Std. Dev**	**Result**	**Std. Dev**	**Predicted**	**Residual**
Dark Count 1	11					
Dark Count 2	7					
1	462.4	0.4	460.9	0.3	460.94	-0.01
2	349.9	0.3	348.8	0.2	348.67	0.09
3	231.1	0.2	230.2	0.2	230.26	-0.07
4	102.3	0.4	101.6	0.1	101.77	-0.15
5	50.1	0.3	49.8	0.2	49.69	0.07
6	24.1	0.4	23.9	0.1	23.85	0.09
7	0.1	0.2	-0.2	0.1	-0.17	-0.02

Standard Reference Photometer
Calibration Report

Calibrating Institute:	EPA Region 7	**Date:**	25-Jun-15
Operator:	J. Regehr / T. Bui	**Start Time:**	17:54
Instrument:	SRP-13 Cell Length=89.84	**End Time:**	19:00
Comment:	Certification of EEMS TEI49cPS SRP Generating Slope	**Filename:**	c0625007.xls

		Calibration Results	**Value**	**Standard Uncertainty**
Calibrated Instrument:	EEMS			
Owner:	EEMS			
Contact:	Eric Hebert	**Slope**	0.99728	0.00014
Make:	TEI	**Intercept**	-0.04014	0.03263
Model:	49c-PS	**Covariance**		-5.0075E-09
Serial Number:	419606966	**Res Std Dev**	0.05420	

Calibration Parameters: Raw Saved;Dark Count On (5)
Air Flow Rate: 7.0 l/min
Lamp Intensity Range: 0.0 to 45.0 %
Number Conc. Points: 7 **Points/Concentration:** 10
Conditioning: 45.0 % for 5 minutes

Calibration	SRP-13		EEMS		EEMS	
Data Points	Result	Std. Dev	Result	Std. Dev	Predicted	Residual
Dark Count 1	10					
Dark Count 2	6					
1	462.6	0.3	461.3	0.2	461.30	0.00
2	349.8	0.3	348.8	0.3	348.80	-0.05
3	230.6	0.2	230.1	0.2	229.96	0.09
4	102.1	0.3	101.7	0.1	101.78	-0.04
5	50.2	0.2	50.0	0.1	50.06	-0.01
6	24.3	0.1	24.1	0.1	24.17	-0.05
7	-0.1	0.4	-0.1	0.2	-0.18	0.05

Standard Reference Photometer
Calibration Report

Calibrating Institute:	EPA Region 7	**Date:**	25-Jun-15
Operator:	J. Regehr / T. Bui	**Start Time:**	19:00
Instrument:	SRP-13 Cell Length=89.84	**End Time:**	20:06
Comment:	Certification of EEMS TEI49cPS SRP Generating Slope	**Filename:**	c0625008.xls

		Calibration Results	Value	Standard Uncertainty
Calibrated Instrument:	EEMS			
Owner:	EEMS			
Contact:	Eric Hebert	**Slope**	0.99853	0.00033
Make:	TEI	**Intercept**	-0.13118	0.07934
Model:	49c-PS	**Covariance**		-4.8749E-08
Serial Number:	419606966	**Res Std Dev**	0.13176	

Calibration Parameters: Raw Saved;Dark Count On (5)

Air Flow Rate: 7.0 l/min

Lamp Intensity Range: 0.0 to 45.0 %

Number Conc. Points: 7 **Points/Concentration:** 10

Conditioning: 45.0 % for 5 minutes

Calibration	SRP-13		EEMS		EEMS	
Data Points	**Result**	**Std. Dev**	**Result**	**Std. Dev**	**Predicted**	**Residual**
Dark Count 1	9					
Dark Count 2	2					
1	461.8	0.7	461.1	0.6	460.99	0.13
2	349.2	0.3	348.5	0.2	348.56	-0.09
3	230.3	0.5	229.8	0.3	229.85	-0.06
4	102.0	0.4	101.5	0.1	101.67	-0.17
5	50.1	0.3	50.0	0.1	49.85	0.14
6	24.4	0.7	24.1	0.1	24.23	-0.09
7	-0.1	0.2	-0.1	0.1	-0.23	0.14

Standard Reference Photometer
Calibration Report

Calibrating Institute:	EPA Region 7	**Date:**	21-Sep-15
Operator:	J. Regehr / T. Bui	**Start Time:**	10:52
Instrument:	SRP-13 Cell Length=89.84	**End Time:**	12:03
Comment:	Certification of EEMS TEI49cPS 70008364 SRP Genera	**Filename:**	c0921004.xls

		Calibration Results	**Value**	**Standard Uncertainty**
Calibrated Instrument:	EEMS			
Owner:	EEMS			
Contact:	Eric Hebert	**Slope**	1.01700	0.00033
Make:	TEI	**Intercept**	-0.06939	0.07872
Model:	49c-PS	**Covariance**		-3.7649E-08
Serial Number:	70008-364	**Res Std Dev**	0.13077	

Calibration Parameters: Raw Saved;Dark Count On (5)
Air Flow Rate: 7.0 l/min
Lamp Intensity Range: 0.0 to 45.0 %
Number Conc. Points: 7 **Points/Concentration:** 10
Conditioning: 45.0 % for 5 minutes

Calibration	**SRP-13**		**EEMS**		**EEMS**	
Data Points	**Result**	**Std. Dev**	**Result**	**Std. Dev**	**Predicted**	**Residual**
Dark Count 1	11					
Dark Count 2	10					
1	459.0	0.3	466.6	0.2	466.71	-0.13
2	347.7	0.3	353.7	0.2	353.55	0.19
3	228.7	0.4	232.5	0.1	232.48	-0.02
4	101.0	0.4	102.7	0.1	102.61	0.05
5	49.9	0.2	50.7	0.1	50.68	0.00
6	24.1	0.4	24.3	0.1	24.48	-0.19
7	0.0	0.4	0.0	0.1	-0.12	0.11

(Val 2)
EEMS # 0111O

9/21/15
AVG.
SLOPE = 1.01937
INT = 0.02326

Avg 6 day
m = 1.01130
b = -0.21263

Standard Reference Photometer
Calibration Report

Calibrating Institute:	EPA Region 7	**Date:**	21-Sep-15
Operator:	J. Regehr / T. Bui	**Start Time:**	14:44
Instrument:	SRP-13 Cell Length=89.84	**End Time:**	15:57
Comment:	Certification of EEMS TEI49cPS 0517112167 SRP Gen	**Filename:**	c0921007.xls

		Calibration Results	**Value**	**Standard Uncertainty**
Calibrated Instrument:	EEMS			
Owner:	EEMS			
Contact:	Eric Hebert	**Slope**	1.02246	0.00041
Make:	TEI	**Intercept**	-0.48395	0.09650
Model:	49c-PS	**Covariance**		-5.8496E-08
Serial Number:	517112167	**Res Std Dev**	0.16017	

Calibration Parameters: Raw Saved;Dark Count On (5)
Air Flow Rate: 7.0 l/min
Lamp Intensity Range: 0.0 to 45.0 %
Number Conc. Points: 7 **Points/Concentration:** 10
Conditioning: 45.0 % for 5 minutes

Calibration	SRP-13		EEMS		EEMS	
Data Points	**Result**	**Std. Dev**	**Result**	**Std. Dev**	**Predicted**	**Residual**
Dark Count 1	11					
Dark Count 2	11					
1	456.7	0.2	466.3	0.3	466.45	-0.16
2	345.5	0.3	352.8	0.2	352.76	0.03
3	227.6	0.4	232.6	0.2	232.27	0.29
4	100.8	0.6	102.5	0.2	102.59	-0.04
5	49.8	0.4	50.6	0.1	50.48	0.10
6	24.3	0.2	24.2	0.1	24.38	-0.18
7	0.1	0.4	-0.4	0.1	-0.35	-0.04

9/21/15

AVG SLOPE = 1.02307
INT = -0.26399

EEMS # 01113

Avg New 6 day m = 1.01004
b = -0.04664

CERTIFICATE OF CALIBRATION AND TESTING

R. M. Young Company certifies that the equipment listed below was inspected and calibrated prior to shipment in accordance with established manufacturing and testing procedures. Standards established by R.M. Young Company for calibrating the measuring and test equipment used in controlling product quality are traceable to the National Institute of Standards and Technology.

MODEL: **18802 / 18811** SERIAL NUMBER: CA04013
(18802 Comprised of Models 18820A Control Unit & 18830A Motor Assembly)
(18811 Comprised of Models 18820A Control Unit & 18831A Motor Assembly)

EEMS # 01253

Nominal Motor RPM	27106D Output Frequency (Hz) - (1)	Calculated Rpm (1)	Indicated Rpm (2)
18802	-	☒ CW / CCW rotation verified	
300	50	300	300
2700	450	2700	2700
5100	850	5100	5100
7500	1250	7500	7500
10,200	1700	10200	10200
12,600	2100	12600	12600
15,000	2500	15000	15000
18811	-	☒ CW / CCW rotation verified	
30.0	5	30.0	30.0
150.0	25	150.0	150.0
300.0	50	300.0	300.0
450.0	75	450.0	450.0
600.0	100	600.0	600.0
750.0	125	750.0	750.0
990.0	165	990.0	990.0

(1) Measured frequency output of RM Young Model 27106D standard anemometer attached to motor shaft - 27106D produces 10 pulses per revolution of the anemometer shaft.
(2) Indicated on the Control Unit LCD display.
* Indicates out of tolerance

☐ New Unit(s)	☒ Service / Repair Unit ☒ No Calibration Adjustments Required	☐ As Found ☐ As Left

Traceable frequency meter used in calibration Model: 34405A SN: 53020093

Date of inspection 12-22-14
Inspection Interval One Year

Tested By RP

CERTIFICATE OF CALIBRATION AND TESTING

R. M. Young Company certifies that the equipment listed below was inspected and calibrated prior to shipment in accordance with established manufacturing and testing procedures. Standards established by R.M. Young Company for calibrating the measuring and test equipment used in controlling product quality are traceable to the National Institute of Standards and Technology.

MODEL: **18802 / 18811** SERIAL NUMBER: CA02777
(18802 Comprised of Models 18820A Control Unit & 18830A Motor Assembly)
(18811 Comprised of Models 18820A Control Unit & 18831A Motor Assembly)
EEMS # 01260

Nominal Motor RPM	27106D Output Frequency (Hz) - (1)	Calculated Rpm (1)	Indicated Rpm (2)
18802	-	☒ CW / CCW rotation verified	
300	50	300	300
2700	450	2700	2700
5100	850	5100	5100
7500	1250	7500	7500
10,200	1700	10200	10200
12,600	2160	12600	12600
15,000	2500	15000	15000
18811	-	☒ CW / CCW rotation verified	
30.0	5	30.0	30.0
150.0	25	150.0	150.0
300.0	50	300.0	300.0
450.0	75	450.0	450.0
600.0	100	600.0	600.0
750.0	125	750.0	750.0
990.0	165	990.0	990.0

(1) Measured frequency output of RM Young Model 27106D standard anemometer attached to motor shaft - 27106D produces 10 pulses per revolution of the anemometer shaft.
(2) Indicated on the Control Unit LCD display.
* Indicates out of tolerance

☐ New Unit(s)	☑ Service / Repair Unit ☑ No Calibration Adjustments Required	☐ As Found ☐ As Left

Traceable frequency meter used in calibration Model: 34405A SN: 53020093

Date of inspection 12-22-14
Inspection Interval One Year

Tested By RP

Date

1/30/2015 - - Calibration and verification of three RTD meters with most recent certification of EEMS RTD

TMI Data -- 1/28/2015

	TMI STD	EEMS RTD 01230 / 01231	diff	corrected
cert date=	12/22/2014			
	0.028	-0.01	0.038	0.022
	9.985	9.95	0.035	9.987
	19.949	19.91	0.039	19.952
	29.918	29.88	0.038	29.926
	39.870	39.82	0.050	39.871
	49.854	49.79	0.064	49.846

RTD 01230/01231

2015 correction: slope= 0.99950102

intercept= -0.0315584

0.9999999

Eric Hebert 1/30/2015

At EEMS RTD 01230 / 01231 raw	Date 1/30/2015 corrected	RTD 01226 EEMS van2 raw	corrected	RTD 01227 EEMS SEG raw	corrected	RTD 01228 EEMS EOH raw	corrected
0.04	0.07	0.01	0.09	0.02	0.08	-0.14	0.08
9.22	9.26	9.18	9.25	9.20	9.23	9.07	9.24
19.34	19.38	19.32	19.38	19.39	19.39	19.28	19.39
25.53	25.57	25.51	25.56	25.60	25.58	25.50	25.58
30.54	30.59	30.52	30.57	30.63	30.59	30.54	30.59
39.97	40.00	39.97	40.01	40.08	40.01	40.01	40.00
51.71	51.74	51.73	51.76	51.85	51.74	51.81	51.74
	slope =	**1.001053**		**1.003428**		**1.005636**	
	intercept =	**-0.07989**		**-0.064093**		**-0.21981**	
	correlation =	**1.0000**		**1.0000**		**1.0000**	

Date

1/30/2015 - - Calibration and verification of three thermocouples and fluke meters with most recent certification of EEMS RTD

TMI Data -- 1/28/2015

	TMI STD	EEMS RTD 01230 / 01231	diff	corrected
cert date=	12/22/2014			
	0.028	-0.01	0.038	0.022
	9.985	9.95	0.035	9.987
	19.949	19.91	0.039	19.952
	29.918	29.88	0.038	29.926
	39.870	39.82	0.050	39.871
	49.854	49.79	0.064	49.846

		RTD 01230/01231
2015 correction:	slope=	0.99950102
	intercept=	-0.0315584
	0.9999999	

Eric Hebert 1/30/2015

At EEMS RTD 01230 / 01231 raw	**Date 1/30/2015** corrected		fluke = 01311 EEMS SEG thermo = 01236 raw	corrected	fluke = 01312 EEMS AER thermo = 01237 raw	corrected	fluke = 01310 EEMS EOH thermo = 01238 raw	corrected
0.05	0.08		0.2	0.14	0.2	0.15	0.2	0.18
9.41	9.45		9.5	9.42	9.6	9.51	9.5	9.44
19.05	19.09		19.2	19.10	19.2	19.07	19.2	19.09
24.48	24.52		24.6	24.48	24.6	24.45	24.6	24.46
30.26	30.31		30.4	30.27	30.4	30.22	30.4	30.23
39.49	39.52		39.7	39.55	39.7	39.48	39.7	39.49
47.31	47.34		47.5	47.33	47.6	44.30	47.6	47.35
71.99	72.06		72.3	72.08	72.5	72.14	72.5	72.12
Thermocouple offset =			-0.1		-0.3		0.6	
POST CALIBRATION CHECK								
25.36	25.40		25.6	25.48	25.7	25.54	25.5	25.36
		slope =	**1.002238**		**1.0044366**		**1.00501**	
		intercept =	**0.06093**		**0.0443271**		**0.01441**	
		correlation =	**1.0000**		**1.0000**		**1.0000**	

MesaLabs

EEMS #
01416

NVLAP Lab Code 200661-0

Calibration Certificate

Certificate No.	5052575	**Sold to:**	Environmental Engineering & Measurement Services, Inc - Gainesville
Product	Definer 220 High Flow		1128 NW 39th Drive
Serial No.	122974		Gainesville, FL 32605
Cal. Date	7-Jan-2015		USA

All calibrations are performed at Mesa Laboratories, Inc., 10 Park Place, Butler, NJ, 07405, an ISO 17025:2005 accredited laboratory through NVLAP of NIST. This report shall not be reproduced except in full without the written approval of the laboratory. Results only relate to the items calibrated. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

As Received Calibration Data

Technician Lilianna Malinowska

Lab. Pressure 760 mmHg
Lab. Temperature 22.4 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Received
504.09 sccm	501.19 sccm	0.58 % %	1.00%	In Tolerance
5011.5 sccm	5000.55 sccm	0.22 % %	1.00%	In Tolerance
30070 sccm	30020.5 sccm	0.16 % %	1.00%	In Tolerance
22.1 °C	22.4 °C	-0.3 °C	±0.8°C	In Tolerance
759 mmHg	760 mmHg	-1.0 mmHg	±3.5mmHg	In Tolerance

Mesa Laboratoires Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	101897	18-Nov-2014	18-Nov-2015
Precision Thermometer	305460	9-Sep-2014	9-Sep-2015
Precision Barometer	2981392	24-Jun-2014	24-Jun-2015

EEMS #
01416
m= 0.998682
b= 0.007551
1/7/2015

MesaLabs

NVLAP Lab Code 200661-0

As Shipped Calibration Data

Certificate No. 5052575
Technician Lilianna Malinowska

Lab. Pressure 750 mmHg
Lab. Temperature 23.1 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
502.12 sccm	500.66 sccm	0.29 %%	1.00%	In Tolerance
5007.8 sccm	5000.45 sccm	0.15 %%	1.00%	In Tolerance
30372 sccm	30405.5 sccm	-0.11 %%	1.00%	In Tolerance
23.1 °C	23.1 °C	-	±0.8°C	In Tolerance
750 mmHg	750 mmHg	-	±3.5mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	101897	18-Nov-2014	18-Nov-2015
Precision Thermometer	305460	9-Sep-2014	9-Sep-2015
Precision Barometer	2981392	24-Jun-2014	24-Jun-2015

Calibration Notes

The expanded uncertainty of flow, temperature, and pressure measurements all have a coverage factor of k = 2 for a confidence interval of approximately 95%.

Flow testing is in accordance with our test number PR18-13 with an expanded uncertainty of 0.18% using high-purity nitrogen or filtered laboratory air. Flow readings in sccm are performed at STP of 21.1°C and 760 mmHg.

Pressure testing is in accordance with our test number PR18-11 with an expanded uncertainty of 0.16 mmHg.

Temperature testing is in accordance with our test number PR18-12 with an expanded uncertainty of 0.04 °C.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Technician Notes:

DWWil

David W. Wilson, Chief Metrologist

MesaLabs

NVLAP

NVLAP Lab Code 200661-0

Calibration Certificate

Certificate No.	5052573	**Sold to:**	Environmental Engineering & Measurement Services, Inc - Gainesville
Product	Definer 220 High Flow		1128 NW 39th Drive
Serial No.	131818		Gainesville, FL 32605
Cal. Date	7-Jan-2015		USA

EEMS # 01417

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As Received Calibration Data

Technician

Lab. Pressure mmHg
Lab. Temperature °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Received
sccm	sccm	%	1.00%	
sccm	sccm	%	1.00%	
sccm	sccm	%	1.00%	
22.1 °C	22.4 °C	-0.3 °C	±0.8°C	In Tolerance
759 mmHg	760 mmHg	-1.0 mmHg	±3.5mmHg	In Tolerance

Mesa Laboratoires Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
Precision Thermometer	305460	9-Sep-2014	9-Sep-2015
Precision Barometer	2981392	24-Jun-2014	24-Jun-2015

MesaLabs

m= 1.003157
b= -0.0054

EEMS#
01417

1/7/2015

NVLAP
NVLAP Lab Code 200661-0

As Shipped Calibration Data

Certificate No. 5052573
Technician Lilianna Malinowska

Lab. Pressure 750 mmHg
Lab. Temperature 23.1 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
502.02 sccm	500.66 sccm	0.27 %%	1.00%	In Tolerance
5008.8 sccm	5000.45 sccm	0.17 %%	1.00%	In Tolerance
30497 sccm	30405.5 sccm	0.30 %%	1.00%	In Tolerance
23.1 °C	23.1 °C	-	±0.8°C	In Tolerance
750 mmHg	750 mmHg	-	±3.5mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	101897	18-Nov-2014	18-Nov-2015
Precision Thermometer	305460	9-Sep-2014	9-Sep-2015
Precision Barometer	2981392	24-Jun-2014	24-Jun-2015

Calibration Notes

The expanded uncertainty of flow, temperature, and pressure measurements all have a coverage factor of k = 2 for a confidence interval of approximately 95%.

Flow testing is in accordance with our test number PR18-13 with an expanded uncertainty of 0.18% using high-purity nitrogen or filtered laboratory air. Flow readings in sccm are performed at STP of 21.1°C and 760 mmHg.

Pressure testing is in accordance with our test number PR18-11 with an expanded uncertainty of 0.16 mmHg.

Temperature testing is in accordance with our test number PR18-12 with an expanded uncertainty of 0.04 °C.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Technician Notes: As Received Data was not taken due to Device Under Test malfunction.

DWWil

David W. Wilson, Chief Metrologist

MesaLabs

NVLAP Lab Code 200661-0

Calibration Certificate

Certificate No.	5052574	**Sold to:**	Environmental Engineering & Measurement Services, Inc - Gainesville
Product	Definer 220 Low Flow		1128 NW 39th Drive
Serial No.	120910		Gainesville, FL 32605
Cal. Date	7-Jan-2015		USA

EEMS # 01415

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As Received Calibration Data

Technician Lilianna Malinowska

Lab. Pressure 759 mmHg
Lab. Temperature 22.3 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Received
30.337 sccm	30.018 sccm	1.06 % %	1.00%	Out of Tolerance
100.88 sccm	100.29 sccm	0.59 % %	1.00%	In Tolerance
506.44 sccm	500.8 sccm	1.13 % %	1.00%	Out of Tolerance
21.1 °C	22.3 °C	-1.2 °C	±0.8°C	Out of Tolerance
759 mmHg	759 mmHg	0.0 mmHg	±3.5mmHg	In Tolerance

Mesa Laboratoires Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-10	105329	17-Oct-2014	17-Oct-2015
Precision Thermometer	305460	9-Sep-2014	9-Sep-2015
Precision Barometer	2981392	24-Jun-2014	24-Jun-2015

MesaLabs

NVLAP Lab Code 200661-0

EEMS#
01415

As Shipped Calibration Data

Certificate No. 5052574
Technician Lilianna Malinowska

Lab. Pressure 750 mmHg
Lab. Temperature 22.6 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
30.411 sccm	30.386 sccm	0.08 %%	1.00%	In Tolerance
101.87 sccm	101.03 sccm	0.83 %%	1.00%	In Tolerance
501.58 sccm	500.525 sccm	0.21 %%	1.00%	In Tolerance
22.6 °C	22.6 °C	-	±0.8°C	In Tolerance
750 mmHg	750 mmHg	-	±3.5mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-10	105329	17-Oct-2014	17-Oct-2015
Precision Thermometer	305460	9-Sep-2014	9-Sep-2015
Precision Barometer	2981392	24-Jun-2014	24-Jun-2015

Calibration Notes

The expanded uncertainty of flow, temperature, and pressure measurements all have a coverage factor of k = 2 for a confidence interval of approximately 95%.

Flow testing is in accordance with our test number PR18-13 with an expanded uncertainty of 0.18% using high-purity nitrogen or filtered laboratory air. Flow readings in sccm are performed at STP of 21.1°C and 760 mmHg.

Pressure testing is in accordance with our test number PR18-11 with an expanded uncertainty of 0.16 mmHg.

Temperature testing is in accordance with our test number PR18-12 with an expanded uncertainty of 0.04 °C.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Technician Notes:

DWWil

David W. Wilson, Chief Metrologist

EPLAB

THE EPPLEY LABORATORY, INC.

12 Sheffield Avenue, PO Box 419, Newport, Rhode Island USA 02840
Phone: 401.847.1020 Fax: 401.847.1031 Email: info@eppleylab.com

Calibration Certificate

Instrument: Precision Spectral Pyranometer, Model PSP, Serial Number 34341F3

Procedure: This pyranometer was compared in Eppley's Integrating Hemisphere according to procedures described in ***ISO 9847 Section 5.3.1*** and Technical Procedure, TP01 of The Eppley Laboratory, Inc.'s Quality Assurance Manual on Calibrations.

Transfer Standard: Eppley Precision Spectral Pyranometer, Model PSP, Serial Number 21231F3

Results:
Sensitivity: **$S = 9.33\ \mu V / Wm^{-2}$**
Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, k=2)
Resistance: 700 Ω at 23°C

Date of Test: January 16, 2015

EEMS # 01245 and 01246

Traceability: This calibration is traceable to the World Radiation Reference (WRR) through comparisons with Eppley's AHF standard self-calibrating cavity pyrheliometers which participated in the Eleventh International Pyrheliometric Comparisons (IPC XI) at Davos, Switzerland in September-October 2010. Unless otherwise stated in the remarks section below or on the Sales Order, the results of this calibration are "AS FOUND / AS LEFT".

Due Date: Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy.

Customer: EEMS
Gainesville, FL

Signatures: M. VIEIRA / Debra L. [signature] In Charge of Test: Thomas D Kirk Reviewed by:

Eppley SO: 64314

Date of Certificate: January 22, 2015

Remarks: With Amplifier # 10765 – Gain = 76.56 So That 1 Volt out = 1400 wm^{-2}

End of Report

PACKING LIST

The Eppley Laboratory, Inc.
12 Sheffield Ave.,P.O. Box 419
Newport, RI 02840-0419
Phone # 401-847-1020 Fed. ID No. 05-0136490

S.O. No. **64314**
1/16/2015

Name / Address	Ship To
EEMS Att: Erik Hebert 1128 NW 39th Drive Gainesville, FL 32605	EEMS Att: Eric Hebert 1128 NW 39th Drive Gainesville, FL 32605

P.O...	Verbal	Ship Date	1/30/2015	Ship Via	UPS Ground

	Or[redacted]
Recalibration of Model PSP# 34341F3	[redacted]
Reset Amplifier	
EEMS # 01245 and 01246	
1/16/2015	
SET GAIN SO $1V = 1400\ Wm^{-2}$	
$1400 \times S = V_{FULL}$	
$S =$ 9.33	
$V_{FULL} =$ 13062	
$\mu V =$ 0.013062	
$GAIN = \frac{1V}{V_{FULL}} =$ 76.56	
Made in USA	

[redacted]

Terms Credit Card

FOB Newport, RI USA

Certificate Number
A1801594
Issue Date: 01/21/15

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 40062084/75299

Description: HYGRO CLIP
Manufacturer: ROTRONIC
Model Number: HYGROCLIP
Serial Number: 40062084/75299
Technician: STEVE TORRES
On-Site Calibration: ☐
Comments:

EEMS # 01220

Calibration Date: 1/21/2015
Calibration Due: ~~1/21/2016~~
Procedure: TMI-M-HYGROTHERMOGRAPHS Rev: 2/22/2011
Temperature: 72 °F
Humidity: 42 % RH
As Found Condition: IN TOLERANCE
Calibration Results: IN TOLERANCE

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

TMI's Quality System is accredited to ISO/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC 17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1.

Results contained in this document relate only to the item calibrated. Calibration due dates appearing on the certificate or label are determined by the client for administrative purposes and do not imply continued conformance to specifications.

FRANK BAHMANN, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
9304027	THUNDER SCIENTIFIC	2500	4/12/2014	4/12/2015

TMI Technical Maintenance, Inc.
12530 TELECOM DRIVE, TEMPLE TERRACE, FL 33637
Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

ANSI/NCSL Z540-1-1994

Technical Maintenance, Inc. **INSTRUMENT DATA SHEET** Rotronic HygroPalm

Asset Numbers: 01220 & 40062084/75299 Customer: EE & MS

Date Tested: 1/21/2015

EEMS# 01220

Parameter Tested	Nominal Value	Tolerance	Lower Limit	Upper Limit	As Found	Pass/Fail	As Left
Temperature Accuracy							
	19.29	±0.2 °C	19.09	19.49	19.1	PASS	AS FOUND
	22.4	±0.2 °C	22.2	22.6	22.3	PASS	AS FOUND
	24.8	±0.2 °C	24.6	25.0	24.7	PASS	AS FOUND
Humidity Accuracy							
	20	±1.5%	18.5	21.5	20.1	PASS	AS FOUND
	50	±1.5%	48.5	51.5	50.5	PASS	AS FOUND
	75	±1.5%	73.5	76.5	75.5	PASS	AS FOUND

Slope = 1.007473

Inter = 0.005495

Certificate Number
A1801590
Issue Date: 01/21/15

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 01225

Description: THERMO HYGROMETER
Manufacturer: ROTRONIC
Model Number: HYGROPALM
Serial Number: 40861 002/124431
Technician: STEVE TORRES
On-Site Calibration: ☐
Comments:

EEMS #
01225

Calibration Date: 1/21/2015
Calibration Due: 1/21/2016
Procedure: TMI-M-HYGROTHERMOGRAPHS Rev: 2/22/2011
Temperature: 72 °F
Humidity: 42 % RH
As Found Condition: IN TOLERANCE
Calibration Results: IN TOLERANCE

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

TMI's Quality System is accredited to ISO/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC 17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1.

Results contained in this document relate only to the item calibrated. Calibration due dates appearing on the certificate or label are determined by the client for administrative purposes and do not imply continued conformance to specifications.

FRANK BAHMANN, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
9304027	THUNDER SCIENTIFIC	2500	4/12/2014	4/12/2015

TMI
Technical Maintenance, Inc.
12530 TELECOM DRIVE, TEMPLE TERRACE, FL 33637
Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

ANSI/NCSL Z540-1-1994

Technical Maintenance, Inc.

Rotronic
Model: HYGROPALM
Humidity and Temperature Indicator

INSTRUMENT DATA SHEET

Asset Number: 01225
Date Tested: 1/21/15

Customer: EE & MS

EEMS # 01225

Parameter Tested	Nominal Value	Tolerance	Lower Limit	Upper Limit	As Found	Pass/Fail	As Left	Pass/Fail
Temperature Accuracy	60.86 °F	± 0.4 °F	60.46 °F	61.26 °F	61.2 °F	Pass	As Found	Pass
	69.74 °F	± 0.4 °F	69.34 °F	70.14 °F	69.9 °F	Pass	As Found	Pass
	78.82 °F	± 0.4 °F	78.42 °F	79.22 °F	79.1 °F	Pass	As Found	Pass
Humidity Accuracy	33.00 %	± .5%+1.5% of rdg	32.00 %	34.00 %	32.4 %	Pass	As Found	Pass
	50.00 %	± .5%+1.5% of rdg	48.75 %	51.25 %	48.9 %	Pass	As Found	Pass
	70.00 %	± .5%+1.5% of rdg	68.45 %	71.55 %	68.8 %	Pass	As Found	Pass

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 01310
EEMS #

Description: DIGITAL MULTIMETER
Manufacturer: FLUKE
Model Number: 187
Serial Number: 86590148
Technician: JOSH LOPEZ
On-Site Calibration: ☐
Comments:

Calibration Date: 1/22/2015
Calibration Due: ~~1/22/2016~~
Procedure: METCAL FLUKE 187
Rev: 8/30/2012
Temperature: 68 °F
Humidity: 42 % RH
As Found Condition: IN TOLERANCE
Calibration Results: IN TOLERANCE

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

TMI's Quality System is accredited to ISO/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC 17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1.

Results contained in this document relate only to the item calibrated. Calibration due dates appearing on the certificate or label are determined by the client for administrative purposes and do not imply continued conformance to specifications.

FRANK BAHMANN, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
7040208	FLUKE	5520A	4/9/2014	4/9/2015

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 01311
EEMS#

Description: DIGITAL MULTIMETER
Manufacturer: FLUKE
Model Number: 287
Serial Number: 95740135
Technician: JOSH LOPEZ
On-Site Calibration: ☐
Comments:

Calibration Date: 1/22/2015
Calibration Due: 1/22/2016
Procedure: METCAL FLUKE 287 Rev: 8/30/2012
Temperature: 68 °F
Humidity: 42 % RH
As Found Condition: IN TOLERANCE
Calibration Results: IN TOLERANCE

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

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Results contained in this document relate only to the item calibrated. Calibration due dates appearing on the certificate or label are determined by the client for administrative purposes and do not imply continued conformance to specifications.

FRANK BAHMANN, BRANCH MANAGER

Jack Shuler
JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
7040208	FLUKE	5520A	4/9/2014	4/9/2015

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 01312
EEMS #

Description: DIGITAL MULTIMETER
Manufacturer: FLUKE
Model Number: 287
Serial Number: 95740243
Technician: JOSH LOPEZ
On-Site Calibration: ☐
Comments:

Calibration Date: 1/22/2015
Calibration Due: 1/22/2016
Procedure: METCAL FLUKE 287
Rev: 8/30/2012
Temperature: 68 °F
Humidity: 42 % RH
As Found Condition: IN TOLERANCE
Calibration Results: IN TOLERANCE

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

TMI's Quality System is accredited to ISO/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC 17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1.

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FRANK BAHMANN, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
7040208	FLUKE	5520A	4/9/2014	4/9/2015

Certificate Number
A1808109
Issue Date: 01/28/15

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

EEMS #

P.O. Number:

ID Number: 01230 and 01231

Description: TEMPERATURE INDICATOR
Manufacturer: EUTECHNICS
Model Number: 4600-1.2.5
Serial Number: 01D102193
Technician: STEVE TORRES
On-Site Calibration: ☐
Comments:

Calibration Date: 1/28/2015
Calibration Due: ~~1/28/2016~~
Procedure: NA 17-20ST-132
Rev: 11/1/2011
Temperature: 72 °F
Humidity: 42 % RH
As Found Condition: IN TOLERANCE
Calibration Results: IN TOLERANCE

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

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Results contained in this document relate only to the item calibrated. Calibration due dates appearing on the certificate or label are determined by the client for administrative purposes and do not imply continued conformance to specifications.

FRANK BAHMANN, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
30946	FLUKE	5616	9/8/2014	2/25/2016
A06118	HART SCIENTIFIC	9103	1/13/2015	5/13/2016
A88072	FLUKE/HART	1502A	12/22/2014	3/17/2015

TMI
Technical Maintenance, Inc.
12530 TELECOM DRIVE, TEMPLE TERRACE, FL 33637
Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

Technical Maintenance, Inc.

Eutechnics
Model 4600
Digital Thermometer/Probe

INSTRUMENT DATA SHEET

Asset Number: 01230 & 01231
Date Tested: 01/28/15

Customer: EE & MS

Parameter Tested	Nominal Value In °C	Tolerance ±.13 °C	Lower Limit	Upper Limit	As Found	Pass/Fail	As Left
Temperature Accuracy							
	0.028	0.130	-0.102	0.158	-0.01	PASS	AS FOUND
	9.985	0.130	9.855	10.115	9.95	PASS	AS FOUND
	19.949	0.130	19.819	20.079	19.91	PASS	AS FOUND
	29.918	0.130	29.788	30.048	29.88	PASS	AS FOUND
	39.870	0.130	39.740	40.000	39.82	PASS	AS FOUND
	49.854	0.130	49.724	49.984	49.79	PASS	AS FOUND

Slope = 0.99950102
Inter = -0.0315584

Warren-Knight Instrument Company
2045 Bennett Road
Philadelphia, PA 19116
Phone: 215-464-9300; Fax: 215-464-9303
Web: http://www.warrenind.com

CERTIFICATION OF CALIBRATION AND CONFORMANCE

We hereby certify that the equipment below has been manufactured and/or inspected by standards traceable to NIST. Calibration of the specified instrument has been performed in compliance with ANSI Z540-1 requirements. It is warranted that the equipment has been calibrated to be in full conformance with the drawings and specifications of the instrument. Calibration tests were performed on the material specified below and were in accordance with all applicable quality assurance requirements with data on file at our facility.

Customer Name:	EE & MS # 01269
Purchase Order #:	
Instrument:	BRUNTON COMPASS
Serial Number:	5064612690
Quantity:	1
Calibration Due:	01/2016

John Noga, Quality Control

January 29, 2015

Measurement Standards:

Measurement Standards
Theodolite Wild T-3 S/N 18801 Calibration 05/08/14 Due 05/08/15 NIST Number 738/229329-83 738/223398
Optical Wedge K&E 71-2020 S/N 5167 Calibration 02/27/14 Due 02/27/19 731/244084-89

Project: **Bios NEXUS EEMS # 01420/01410 Certification**
Project #:
Contact Name:
Contact Phone #:
Contact Address:

Flow Rate Standard: **BIOS Definer 220-H**
EEMS # **01416**
Certification Date: **1/7/2015**
Certification #: **5052575**
slope = 0.998682
inter = 0.007551

Date:
2/5/2015 Flow rates are corrected to STP of one atmosphere and 25.0 degrees C. were plumbed together in series.
All tests were conducted with dry air. Nexus #1420, Definer 220-H EEMS# 01416

UNADJUSTED:

BIOS Nexus, EEMS # 01420 / 01410

Flow Rate Standard--Definer 220-H

01420 / 01410	
Slope =	**0.966641**
Intercept =	**0.030779**
Correl =	**0.99996**

	Temp deg C	Press mmHg
Definer	20.5	761
NEXUS	20.0	764

SL/m: standard liters per minute

Definer 220-H	**6103**	**NEXUS / DC-LITE**		
STP SL/M Corrected X	Flow SL/m	reading SL/m Y	Diff Y - X	% Diff (Y - X)/X
0.768	0.4	0.766	-0.002	-0.2%
1.193	0.6	1.188	-0.005	-0.4%
1.61	0.8	1.59	-0.019	-1.2%
2.23	0.95	2.19	-0.036	-1.6%
3.04	1.5	2.96	-0.083	-2.7%
3.53	1.75	3.45	-0.083	-2.3%

Average Error (SL/m) = -0.038

NEXUS / DC_LITE Corrected Values (using slope and intercept)		
SL/m	Diff	% Diff
0.760	-0.007	-0.9%
1.197	0.004	0.3%
1.613	0.004	0.2%
2.234	0.008	0.3%
3.031	-0.012	-0.4%
3.537	0.004	0.1%

Average Error (Sl/m) -0.001

Warren-Knight Instrument Company
2045 Bennett Road
Philadelphia, PA 19116
Phone: 215-464-9300; Fax: 215-464-9303
Web: http://www.warrenind.com

CERTIFICATION OF CALIBRATION AND CONFORMANCE

We hereby certify that the equipment below has been manufactured and/or inspected by standards traceable to NIST. Calibration of the specified instrument has been performed in compliance with ANSI Z540-1 requirements. It is warranted that the equipment has been calibrated to be in full conformance with the drawings and specifications of the instrument. Calibration tests were performed on the material specified below and were in accordance with all applicable quality assurance requirements with data on file at our facility.

Customer Name:	Environmental Engineering & Measurement Services, Inc.
Purchase Order #:	
Instrument:	Ushikata Tracon S-25 Compass
Serial Number:	190037 EEMS # 01265
Quantity:	1
Calibration Due:	2/2016

John Noga
John Noga, Quality Control

February 19, 2015

Measurement Standards
Theodolite Wild T-3 S/N 18801 Calibration 02/12/14 Due 02/12/15 NIST Number 738/229329-83 738/223398
Optical Wedge K&E 71-2020 S/N 5167 Calibration 02/12/14 Due 02/12/19 731/244084-89 731/221617

Warren-Knight Instrument Company
2045 Bennett Road
Philadelphia, PA 19116
Phone: 215-464-9300; Fax: 215-464-9303
Web: http://www.warrenind.com

CERTIFICATION OF CALIBRATION AND CONFORMANCE

We hereby certify that the equipment below has been manufactured and/or inspected by standards traceable to NIST. Calibration of the specified instrument has been performed in compliance with ANSI Z540-1 requirements. It is warranted that the equipment has been calibrated to be in full conformance with the drawings and specifications of the instrument. Calibration tests were performed on the material specified below and were in accordance with all applicable quality assurance requirements with data on file at our facility.

Customer Name:	Environmental Engineering & Measurement Services, Inc.
Purchase Order #:	
Instrument:	Ushikata Tracon S-25 Compass #
Serial Number:	191832 EEMS 01272
Quantity:	1
Calibration Due:	2/2016 on loan to SEG

John Noga

John Noga, Quality Control

February 19, 2015

Measurement Standards
Theodolite Wild T-3 S/N 18801 Calibration 02/12/14 Due 02/12/15 NIST Number 738/229329-83 738/223398
Optical Wedge K&E 71-2020 S/N 5167 Calibration 02/12/14 Due 02/12/19 731/244084-89 731/221617

NVLAP Lab Code 200661-0

Calibration Certificate

Certificate No.	533691	**Sold to:**	Environmental Engineering & Measurement Services, Inc - Gainesville
Product	Definer 220 Low Flow		1128 NW 39th Drive
Serial No.	143301		Gainesville, FL 32605
Cal. Date	13-Aug-2015		USA
Sales Date	8-Sep-2015 *Calibration interval commences on sale date.*		

All calibrations are performed at Mesa Laboratories, Inc., 10 Park Place, Butler, NJ, 07405, an ISO 17025:2005 accredited laboratory through NVLAP of NIST. This report shall not be reproduced except in full without the written approval of the laboratory. Results only relate to the items calibrated. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

Calibration Data

Technician Lilianna Malinowska

Lab. Pressure 751 mmHg
Lab. Temperature 22.8 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
482.18 ccm	481.51 ccm	0.14 % %	1.00%	In Tolerance
108.17 ccm	108.12 ccm	0.05 % %	1.00%	In Tolerance
33.13 ccm	33.09 ccm	0.12 % %	1.00%	In Tolerance
22.8 °C	22.8 °C	-	±0.8°C	In Tolerance
751 mmHg	751 mmHg	-	±3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML_800_10	103743	8-Apr-2015	7-Apr-2016
Precision Thermometer	305460	9-Sep-2014	9-Sep-2015
Precision Barometer	2981392	29-Jun-2015	28-Jun-2016

MesaLabs

NVLAP Lab Code 200661-0

Calibration Notes

The expanded uncertainty of flow, temperature, and pressure measurements all have a coverage factor of k = 2 for a confidence interval of approximately 95%.

Flow testing is in accordance with our test number PR18-13 with an expanded uncertainty of 0.18% using high-purity nitrogen or filtered laboratory air. Flow readings in sccm are performed at STP of 21.1°C and 760 mmHg.

Pressure testing is in accordance with our test number PR18-11 with an expanded uncertainty of 0.16 mmHg.

Temperature testing is in accordance with our test number PR18-12 with an expanded uncertainty of 0.04 ºC.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Louis Guido, Quality Engineer