2017 Quality Assurance Report
Atmospheric Mercury Network

National Atmospheric Deposition Program

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Abbreviations

AMNet	Atmospheric Mercury Network
GEM	Gaseous Elemental Mercury (expressed in ng/m^3)
GOM	Gaseous Oxidized Mercury (expressed in pg/m^3)
MDN	Mercury Deposition Network
NADP	National Atmospheric Deposition Program
$PBM_{2.5}$	Particulate-Bound Mercury less than 2.5 μm in diameter (expressed in pg/m^3)
QAP	Quality Assurance Plan
SOP	Standard Operating Procedures

Units and Conversion Factors

°F	degrees Fahrenheit
°C	degrees Celsius
cm	centimeters
L	liters
µl	microliter (1 µl = 10^{-6} L)
lpm	liters per minute
ng	nanograms (1 ng = 10^{-9} g)
ng/m^3	nanograms per cubic meter
pg	picograms (1 pg = 10^{-12} g)
pg/m^3	picograms per cubic meter

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1.0 Introduction

The Atmospheric Mercury Network (AMNet) started in 2009. Twenty AMNet sites operated in 2017, including one site (Mt Lulin) in Taiwan (Table 1). The concentration of gaseous elemental mercury (GEM) was measured at all sites. Speciated mercury measurements including gaseous oxidized mercury (GOM) and particulate bound mercury ($PBM_{2.5}$), were measured at 14 sites in 2017 as shown in Table 1. Six sites (AK03, MA22, NJ54, NY06, NY20 and NY43) measure GEM only. One site (NY20) transitioned from speciated mercury measurements to GEM-only measurements in 2017. All measurements followed the AMNet Standard Operating Procedures (SOPs) found at http://nadp.slh.wisc.edu/AMNet/docs.aspx.

The AMNet Site Liaison provides remote technical support to site operators in the operation of AMNet equipment, performs site performance and systems surveys, and reviews the data on a monthly basis to identify problems. Data review includes both manual and automated quality control checks. Site operators are notified whenever problems are discovered.

In 2017, thirteen sites were surveyed by the AMNet Site Liaison. This report includes a summary of the findings from each of the surveys.

Changes in 2017 include the following:

- One site (UT97) closed in 2017.
- One site (MA22) started in 2017.
- One site (NY20) transitioned from speciated mercury measurements to GEM-only measurements in December 2017, and speciation instrumentation was removed.
- Two sites (ME97 and OK99) did not submit data for 2016 or 2017 and were assumed closed.

Table 1. AMNet Sites

NADP Site ID	State	Operating Agency	Parameters	Start Date	End Date	Lapse
AK03	Alaska	National Park Service	GEM	2/5/2014	Current	
AL03	Alabama	ARA Inc.	GEM, GOM, & $PBM_{2.5}$	1/29/2016	11/9/2016	
AL19	Alabama	ARA Inc.	GEM, GOM, & $PBM_{2.5}$	1/1/2009	6/28/2016	
FL96	Florida	ARA Inc.	GEM, GOM, & $PBM_{2.5}$	1/1/2009	10/5/2016	
GA40	Georgia	ARA Inc.	GEM, GOM, & $PBM_{2.5}$	1/1/2009	10/4/2016	
HI00	Hawaii	NOAA/EPA	GEM, GOM, & $PBM_{2.5}$	12/30/2010	Current	
IL11	Illinois	NADP/CAL	GEM, GOM, & $PBM_{2.5}$	3/30/2017	Current	
IN21	Indiana	LADCO	GEM, GOM, & $PBM_{2.5}$	4/29/2016	Current	
MA22	Massachusetts	MIT	GEM	7/29/2017	Current	
MD08	Maryland	University of Maryland	GEM, GOM, & $PBM_{2.5}$	1/1/2008	Current	6/30/2011 - 1/12/2012
MD98	Maryland	NOAA	GEM, GOM, & $PBM_{2.5}$	11/7/2006	Current	
ME97	Maine	Micmac Tribe	GEM, GOM, & $PBM_{2.5}$	12/3/2013	12/31/2015	
MI09	Michigan	University of Michigan	GEM, GOM, & $PBM_{2.5}$	8/10/2015	7/11/2016	
MS12	Mississippi	NOAA	GEM, GOM, & $PBM_{2.5}$	9/29/2006	Current	
NJ30	New Jersey	State of New Jersey	GEM, GOM, & $PBM_{2.5}$	10/11/2016	Current	
NJ54	New Jersey	State of New Jersey	GEM	10/12/2016	Current	
NS01	Nova Scotia, Canada	Environment Canada	GEM, GOM, & $PBM_{2.5}$	1/26/2009	Current	
NU15	Nunavut, Canada	Environment Canada	GEM, GOM, & $PBM_{2.5}$	1/4/2002	Current	
NY06	New York	State of New York	GEM	8/27/2008	Current	
NY20	New York	SUNY ESF	GEM	11/21/2007	Current	
NY43	New York	State of New York	GEM	11/21/2007	Current	
OH02	Ohio	Ohio University	GEM, GOM, & $PBM_{2.5}$	1/1/2007	Current	2/15/2012 – 9/24/2013
OH52	Ohio	Ohio State University	GEM, GOM, & $PBM_{2.5}$	1/1/2012	Current	
OK99	Oklahoma	Cherokee Nation	GEM, GOM, & $PBM_{2.5}$	10/20/2008	5/31/2015	
TW01	Taiwan	EPA Taiwan	GEM, GOM, & $PBM_{2.5}$	1/1/2010	Current	
UT97	Utah	State of Utah	GEM, GOM, & $PBM_{2.5}$	11/23/2008	8/14/2017	
VT99	Vermont	University of Vermont	GEM, GOM, & $PBM_{2.5}$	1/1/2008	1/4/2016	
WI07	Wisconsin	State of Wisconsin	GEM, GOM, & $PBM_{2.5}$	2/1/2012	Current	

2.0 Site Performance and Systems Surveys

The network goal calls for sites to be surveyed at least once every two years by the AMNet Site Liaison. All NADP networks except for AMNet receive site performance and systems surveys by an independent auditor. The expertise required to operate and troubleshoot the AMNet instrumentation inhibits an independent third party from providing this service. Site survey reports are completed to document any problems that are discovered during the survey and their resolution.

Site surveys evaluate both field and laboratory operations (including equipment operation), and siting criteria. Site surveys ensure data comparability within the network, resolve operational problems that may not be apparent in data review, and address training needs at each site. Siting criteria obstructions are either towers or trees. Recommendations and influences are explained to the Site Operators. Repairs or charges are left to the sites to resolve although some are difficult or impossible to rectify.

Typically the data before repairs was invalid. Repairs and data evaluation is explained at each Site Visit. Following the repair that data should be valid.

Additional information regarding site surveys may be found in the document titled *Atmospheric Mercury Network: Site Performance and Systems Survey*. This document is available from the NADP website (http://nadp.slh.wisc.edu/AMNet/docs.aspx).

2.1 AMNet Sites Surveyed in 2017

Site surveys were conducted at thirteen AMNet sites in 2017. Station ID's, survey dates and station names are presented in Table 2.

Table 2. AMNet Sites Surveyed in 2017.

Site ID	State/Province/Country	Station Name	Survey Date
AK03	Alaska	Denali	8/8/2017
IN21	Indiana	Clifty Falls	1/31/2017
MA22	Massachusetts	Boston	8/29/2017
MD08	Maryland	Frostburg	5/8/2017
MD98	Maryland	Beltsville	5/10/2017
NJ30	New Jersey	New Brunswick	3/9/2017
NJ54	New Jersey	Elizabeth	3/8/2017
NS01	Nova Scotia	Kejimkujik	11/16/2017
NY20	New York	Huntington Forest	12/5/2017
OH02	Ohio	Athens	4/11/2017
OH52	Ohio	South Bass Island	4/12/2017
TW01	Taiwan	Mt Lulin	9/25/2017
UT97	Utah	Salt Lake City	2/15/2017

2.2 Instrument Test Results

As part of the instrument performance testing, instrument sensitivity (i.e., response factor) and the internal calibration source are verified. Independent, third party calibration certificates for the survey test equipment are kept on file.

Table 3 lists the serial numbers for the AMNet instruments at each site. Illegible serial numbers are listed as "n/a" (not available). Not present instruments are listed as "n/p".

Table 3. Serial Numbers for Instruments at Surveyed Sites.

Site ID	Instrument Model					
	1102	2537	1130P	1130	1135	2505
AK03	n/p	349	n/p	n/p	n/p	150
IN21	n/p	66	83	N30 010	N35 008	n/p
MA22	n/p	133	n/p	n/p	n/p	n/p
MD08	85	220	61	n/a	n/a	73
MD98	43	5115	88	n/a	n/a	28, 86, 147
NJ30	140	5114	167	162	152	54
NJ54	n/p	5110	n/p	n/p	n/p	n/p
NS01	127	189	110	n/a	n/a	90
NY20	14	326	83	144	133	n/a
OH02	52	174	49	n/a	n/a	81
OH52	94	397	112	n/a	n/a	196
TW01	136	5095	162	167	148	100
UT97	77	364	105	103	88	169

Table 4. Instrument Descriptions

Instrument ID	Description
1102	Tekran Air Dryer for Speciation system.
2537	Tekran CVAFS Automated Mercury Analyzer
1130P	Tekran Speciation Pump Module
1130	Tekran Oxidized Mercury Speciation Module
1135	Tekran Particulate Mercury Speciation Module
2505	Mercury Vapor Calibration Unit

Table 5 lists the results [i.e., pass (p), fail (f)] for each test of the field instruments. If there were a significant deviation from the test criteria they would be indicated with an uppercase "F". Warning and control limits are set and published in the *Atmospheric Mercury Data Management Manual.* http://nadp.slh.wisc.edu/lib/manuals/AMNet-2406_Data_Management_Manual_v_2.pdf.
If a parameter exceeds control limits upon departure, that parameter receives a failing grade. The failing grade can apply to both analytical and siting criteria. Parameters that were not tested are listed as "n/a." Equipment not present is "n/p". MD08 and UT97 evaluations were incomplete due to lack of argon.

Table 5. Survey Results.

Site ID	Air Flow and Leak Tests				Cartridge A and B Recoveries			
	Temps OK	Inlet Flow	2537 Flow	Leak Check	Response Factor	Low Level	High Level	Ambient Air
AK03	p	p	p	p	p	p	p	p
IN21	p	P	p	p	f	f	f	f
MA22	p	p	p	p	p	p	p	p
MD08	p	p	p	n/a	n/a	n/a	n/a	n/a
MD98	p	p	p	p	p	p	p	p
NJ30	p	p	p	p	p	p	p	p
NJ54	p	p	p	p	p	p	p	p
NS01	p	p	p	p	p	p	p	p
NY20	p	p	p	p	p	p	p	p
OH02	p	p	p	f	p	p	p	p
OH52	p	p	p	p	p	p	p	p
TW01	p	p	p	p	p	p	p	p
UT97	p	n/a	n/a	n/a	p	n/a	n/a	n/a

Note: 2537 = Tekran continuous mercury vapor analyzer

2.3 Siting Criteria

Compliance with siting criteria is evaluated in regard to obstructions (>20°) in each of 8 cardinal/intercardinal directions (i.e., N, NE, E, SE, S, SW, W, and NW) from the instrument inlet. Also, the height from the ground to each inlet is measured. Results are presented in Table 6. Obstructions are evaluated as pass (p) or fail (f). Deviations from the siting criteria are discussed with the operator during the site survey. Failures of siting criteria failures can affect the speciated data because turbulence is changed by the obstruction. Analytical failures should be corrected during or soon after the site visit. Corrective action, when possible, is the responsibility of the site operator and the site supervisor. Site photos can be found at: http://nadp.slh.wisc.edu/AMNet/.

Table 6. Siting Criteria Obstructions and Inlet Heights.

Site	Inlet Height (m)	N	NE	E	SE	S	SW	W	NW
AK03	3.2	p	p	p	p	p	p	p	p
IN21	3.6	p	p	p	p	p	p	p	p
MA22	18.5	p	p	p	p	p	p	p	p
MD08	3.1	p	p	p	p	p	p	p	p
MD98	10.0	p	p	f	p	p	p	p	p
NJ30	4.9	p	p	p	p	p	p	p	p
NJ54	3.2	p	p	p	p	p	p	p	p
NS01	6.0	p	p	p	p	p	p	p	p
NY20	4.9	f	p	p	p	p	p	p	f
OH02	2.5	p	p	p	p	p	p	p	p
OH52	3.2	p	p	f	p	p	p	p	p
TW01	8	f	p	p	p	p	p	f	p
UT97	8.2	p	p	p	p	p	p	p	p

2.4 Instrument Repairs

In 2017, three instruments (IN21, UT97 and TW01) needed repair prior to performance testing.

2.5 Test Equipment Calibration

Starting in 2015 the field Bios Definer 220 flow meters were checked against the laboratory flow meters prior to each visit because "as-received" annual certifications tolerances were being exceeded. Since 2015, twenty-seven internal checks have been performed, none exceeded more than 1.2% difference, yet the "as-received" tolerances were exceeded in 2015 and 2017. In 2018 a TetraCal venturi flow meter was purchased for use in the field. The TetraCal has no moving parts, can measure the complete dynamic range, continuously measures both standardized and volumetric flow, and has an operating range down to -30°C. The TetraCal is expected to perform better "as-received" and will only require one certification saving the program hundreds of dollars a year.

The Bios field and lab meters were checked against the TetraCal over 3 separate days; the average difference was < 1% and the greatest difference noted was 3% for the medium Bios and 1.5% for the high range Bios.

Two Bios Definer 220 flow meters are used to verify analyzer and inlet flow rates. The high range meter (3-30 lpm) is used to measure the inlet flow rate. The medium range meter (0.5-5 lpm) is used to measure the 2537 sample flow rate. Each flow meter is certified annually checking the thermocouple, the barometer and three flow rates across the range of the instrument. Values are reported both pre- and post-calibration (i.e., as-received and as-shipped). Table 7 lists the calibration results for the two flow meters as reported in January 2016 (the start of the reporting year) and in August 2018 (when TetraCal checks were performed).

Table 7. Flow Meter Calibration Results for 2017 and 2018.

Flow Meter		Calibration Date	
		01/2017	08/2018 TetraCal
Medium range (0.5 – 5.0 lpm)	As-received	Flow rates low by 6.5%	0.43% average difference
	As-shipped	Within tolerance for all parameters	Out of service
High range (3 – 30 lpm)	As-received	Flow rates low by 7.0%	0.51% average difference
	As-shipped	Within tolerance for all parameters	Out of Service

Before each site visit, field flow meters were verified against the laboratory flow meters. Both meters were checked 5 times during the year. The greatest difference measured was 0.7% on the medium and 1.2% on the high range meter, both on 02/14/2017. All other checks were below 1% difference.

A Tekran 2505 Mercury Vapor Primary Calibration Unit and a certified Hamilton 25 µL syringe (model 1702RN) are used to validate instrument internal permeation sources. On September 10, 2018 syringes SN 5647 and SN 7473 were found to be within tolerance both as-received and as-shipped.

The syringes and flowmeters are certified annually by the manufacturer, the syringe is NIST traceable, while the flow meters are NELAP certified.

3.0 Training

No formal AMNet training sessions held in 2017. Operator performance is reviewed with each site visit.

4.0 Data

AMNet data are evaluated using a series of automated checks and through manual inspection by the AMNet Site Liaison. Additional information on this process is available in the *Atmospheric Mercury Network Data Management Manual*. Table 8 lists problems impacting data completeness for individual sites. Table 9 lists the % of valid data collected at each site in 2017. Values are presented for each of the three forms of mercury measured including: GEM, GOM, and $PBM_{2.5}$. One site (UT97) did not meet data quality objectives (≥ 75% data completeness annually) or GEM in 2017. Two sites (MD08 and UT97) did not meet data quality objectives for GOM and $PBM_{2.5}$. The UT97 site experienced several problems throughout 2017 and was found without argon during the site visit; making repairs impossible.

Table 8. Problems Impacting Data Completeness.

SiteID	Problem Description	Period Impacted
MD08	Trap bias	July - September
UT97	Trap bias and low response factor	February - August

Table 9. Percent Valid Data by Site for 2017*.

Site ID	GEM	GOM	$PBM_{2.5}$
AK03	81	n/a	n/a
HI00	97	80	82
IL11	92	n/a	n/a
IN21	80	80	80
MA22	97	n/a	n/a
MD08	79	73	73
MD98	94	98	98
MS12	98	92	94
NJ30	97	97	97
NJ54	93	n/a	n/a
NS01	92	92	92
NY06	100	n/a	n/a
NY20	90	92	92
NY43	93	n/a	n/a
OH02	95	91	91
OH52	96	91	91
TW01	Data QA performed external to NADP.		
UT97	3	3	3
WI07	90	87	84
Average	88	82	83

* Based on period of operation.

5.0 References

- AMNet Data Management: http://nadp.slh.wisc.edu/lib/manuals/AMNet-406_Data_Management_Manual_v_2.pdf
- AMNet Standard Operating Procedures: http://nadp.slh.wisc.edu/AMNet/docs.aspx