TECHNICAL MEMORANDUM

TO: Jim Homolya / OAQPS

FROM: Michael S. Clark / NAREL

COPY: Dr. John Griggs / NAREL

DATE: March 12, 2003

SUBJECT: Second Quarterly Performance Evaluation of R&P 8400 Ambient Air Monitors

Executive Summary

A second quarterly Performance Evaluation (PE) study has been completed. Five sites located in different states are currently operating at least one of the 8400 series ambient air monitors manufactured by R&P. The 8400N and the 8400S units are designed to capture $PM_{2.5}$ from the ambient air and provide measurements of nitrate and sulfate respectively, every ten minutes. Aqueous spike solutions have been used again to evaluate performance of these semi-continuous monitors. Five blind spikes were analyzed in triplicate by each instrument. All five sites were given the same set of PE samples, and for this study, the PE solutions contained a wide range of concentrations extending well above the normal calibration range. One of the PE solutions produced a spike level almost five times above the normal calibration range. The operators were instructed to analyze the local blank water and the local calibration standard along with the PE samples. Scatter plots were prepared for each monitor showing the mass of analyte reported versus the mass of analyte spiked into the instrument. Similar results were observed again from all of the sites even though each instrument produced a slightly different efficiency for generating and analyzing the signal pulse from the aqueous spike. Most of the instruments produced a linear response over the concentration range tested.

To further examine the data reported from the sites, a linear calibration curve based upon analysis of the PE solutions themselves was generated for each instrument, and new results were calculated. Based upon the new results from the calibration curves, all sites report about the same value for each PE solution, and good accuracy can be achieved over a wide calibration range for aqueous spikes. It is worth stating that an aqueous spike is not a captured ambient air deposit. However, the aqueous spike may be the most valuable single method to evaluate instrument performance, and it provides a basis for adjusting the raw data output from the pulse analyzer.

This study as well as the previous study indicates a possible error in the local nitrate solutions. Based upon analysis of the PE solutions at all sites, the local nitrate solution appears to be about 15 % more concentrated than the accepted value of 100 ng/µL. The local nitrate solution utilized at each site should be re-validated using ion chromatography.

More PE samples are planned at quarterly intervals over the next year.

Experimental Design

Blind aqueous spike solutions were prepared at the National Air and Radiation Environmental Laboratory (NAREL) located in Montgomery, AL. All PE solutions were prepared from the same salts and chemicals that are present in the local calibration solutions used at each field site. Nitrate PE solutions were prepared using KNO_3 and 18 mega-ohm laboratory water which was passed through a 0.2-µm membrane filter immediately before use. Sulfate PE solutions were prepared by dissolving NH_4SO_4 and oxalic acid into the same laboratory water previously described. The oxalic acid was added to each sulfate solution at a rate of 4 mg of carbon (from the oxalic acid) per 3 mg of sulfate (from the NH_4SO_4). All PE solutions were analyzed using a Dionex DX500 Ion Chromatograph configured for the analysis of anions. All PE solutions were verified to be within 5 % of the nominal concentration of nitrate and sulfate before they were shipped to the site operator. The concentration of nitrate and sulfate present in each PE solution is listed in Table 2 and Table 4 respectively, at the end of this report.

A new syringe was provided to each site operator with instructions to use the new syringe for all spiking during this study. Normally each instrument is calibrated by injecting different volumes of one [local] spike solution to establish the calibration range. For this study five PE solutions were provided for each instrument to establish a calibration range using only one spike volume. The purpose for using only one spike volume was to keep the amount of water deposited onto the flash strip constant for all spikes.

The site operator was instructed to perform a manual audit of the pulse analyzer before starting the aqueous spikes. Audit results from the 8400N and the 8400S are presented in Table 1 and Table 3 respectively, at the end of this report.

Analysis of Aqueous Nitrate Spike Solutions

Site operators were instructed to perform triplicate analysis of the aqueous solutions using only one spike volume, 0.5 µL. The analysis began with the local blank water followed by analysis of the local 100 ng/µL nitrate standard. The study continued by running the five *blind* solutions identified simply as N1-01-03 through N5-01-03. The results reported from the sites are included in Table 2 at the end of this report along with the previously undisclosed concentration of each PE solution. An extra column of "Re-calculated Results" has also been added to Table 2. Results from each site were re-calculated from a calibration curve based upon the PE solutions analyzed at that site. By re-calculating all results from a calibration curve, the new results are corrected for inefficient pulse generation and analysis. This is our way of normalizing the data to, hopefully, achieve better agreement from all the sites.

Results from a single site are presented as a scatter plot in Figure 1 through Figure 5. The mass measured versus the mass deposited is plotted for each spike. Results from the PE solutions are colored red in the plots, and results from the local blank water and local 100 ng/µL solution are presented in blue. Each plot also shows a green "One-to-One" line which represents perfect agreement between the mass measured and the mass deposited.

Figure 1

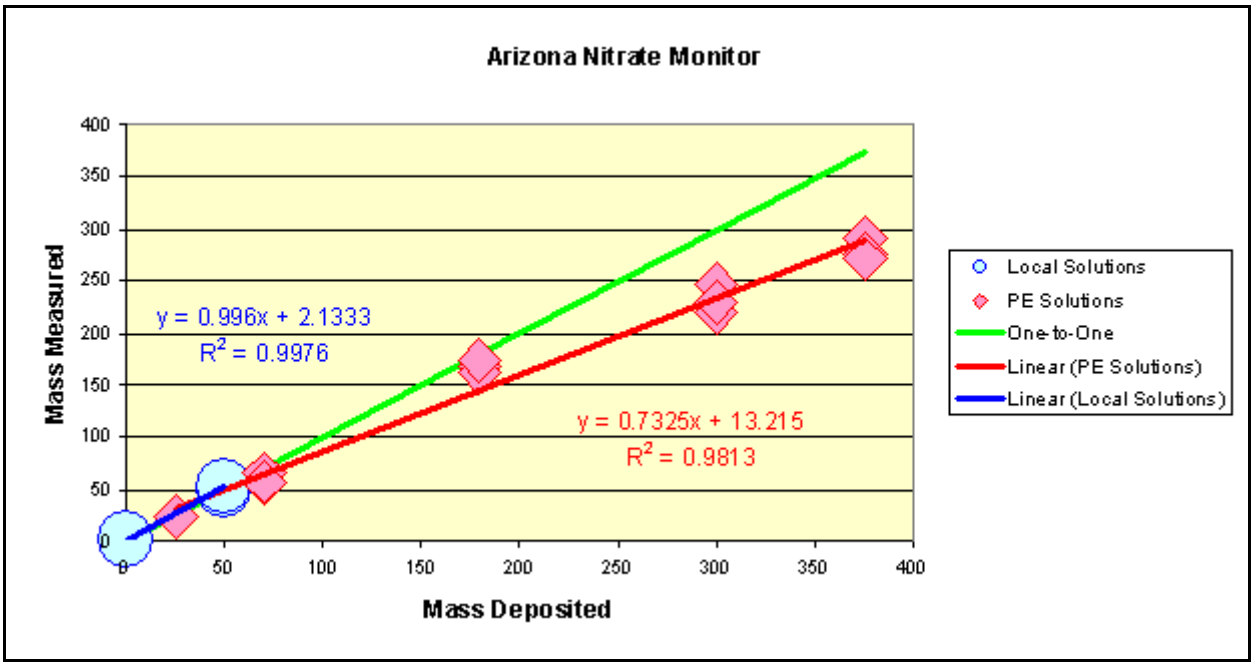


Figure 2

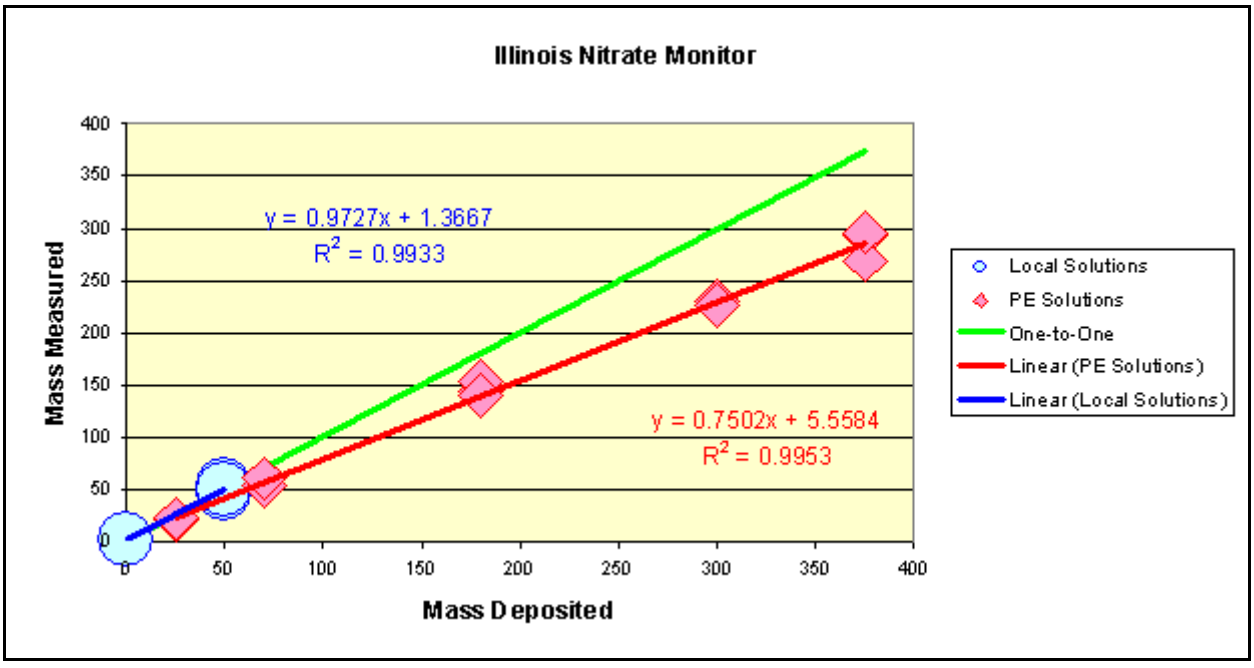


Figure 3

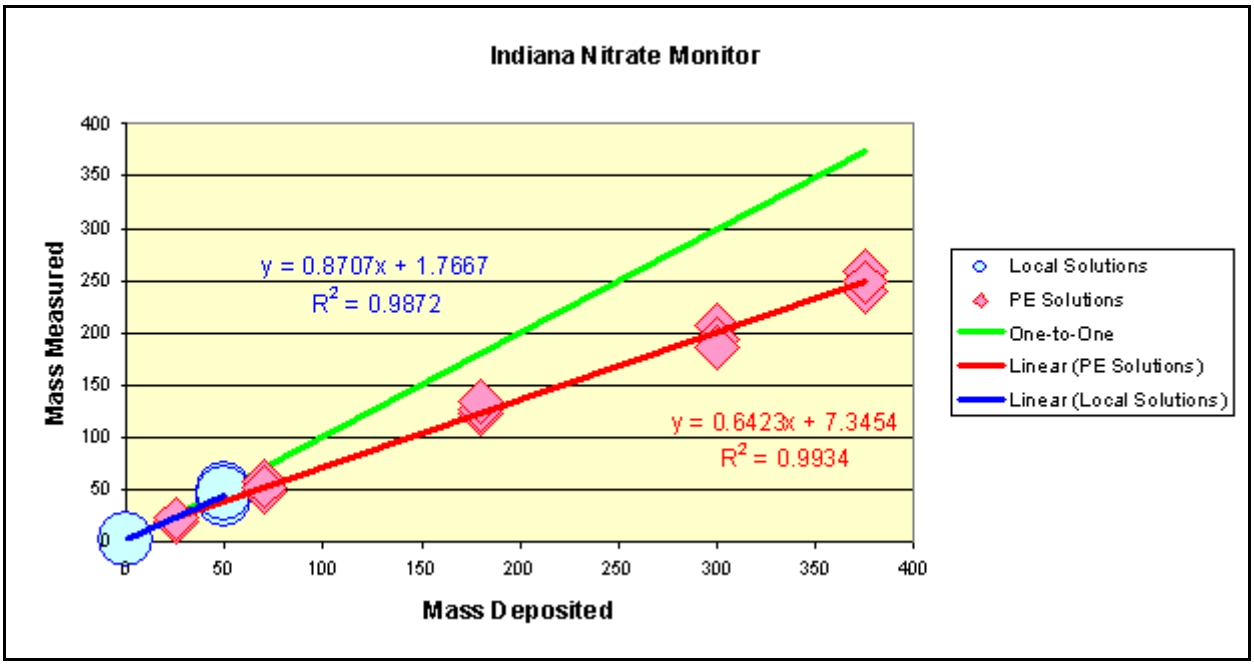


Figure 4

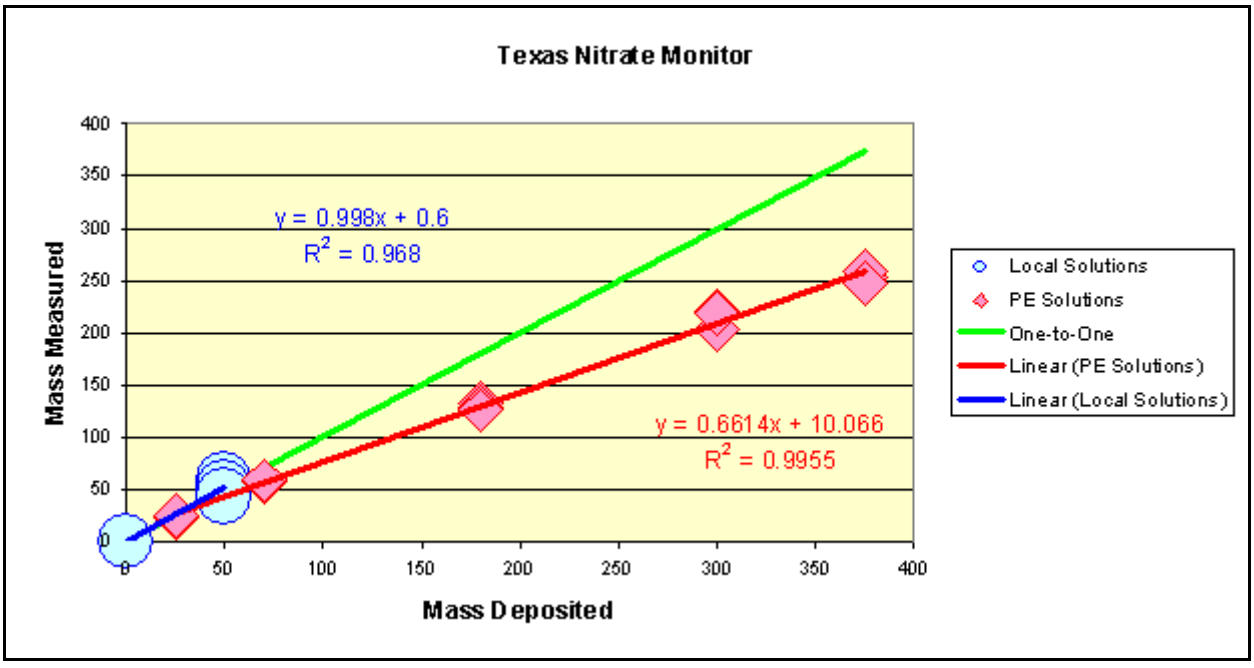


Figure 5

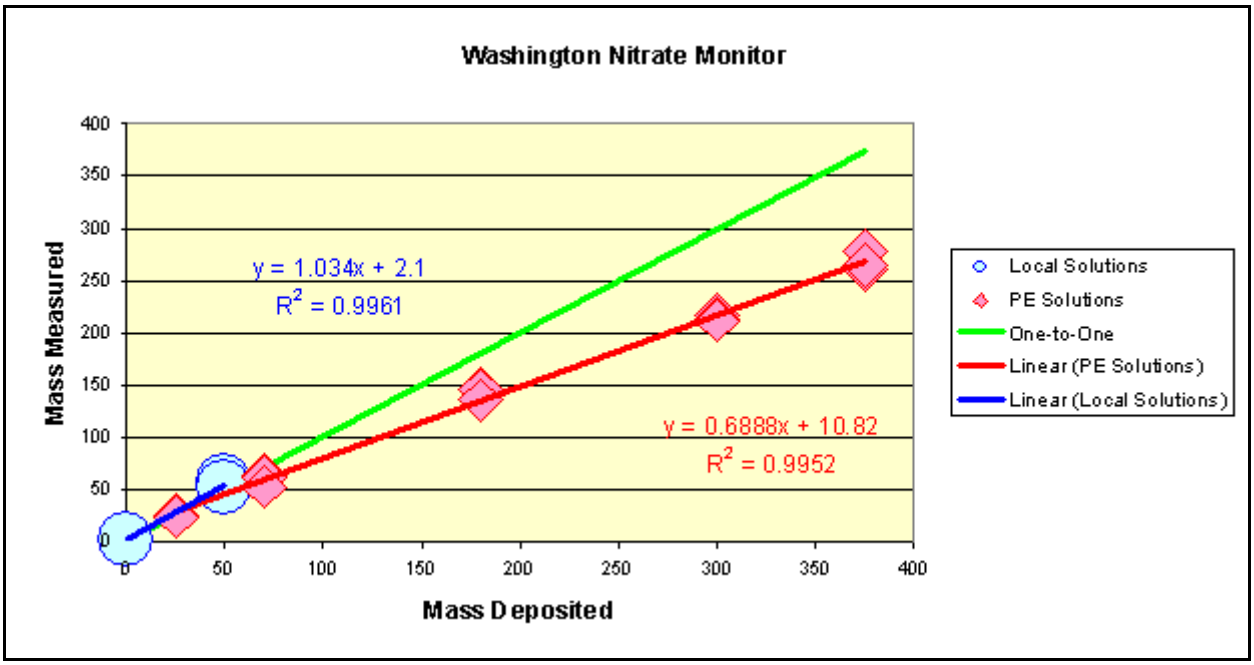


Figure 6 contains results from all five sites. To simplify the graph, each point represents an average result from three replicate spikes of the same spike solution. Each site is represented by a different symbol as shown in the plot legend.

Figure 6

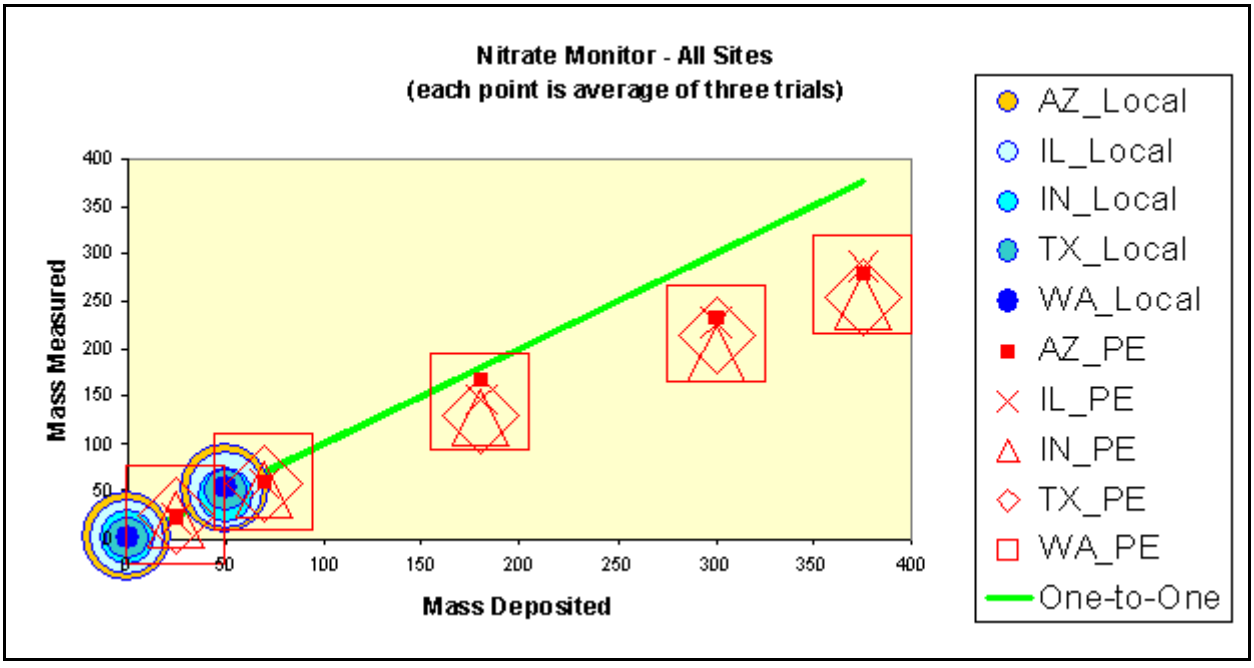


Figure 7

Figure 7 shows re-calculated mass from all of the sites. Results were re-calculated from a calibration curve established at each instrument by the analysis of PE samples. This graph clearly shows an apparent difference between the 100 ng/µL PE solution and the Local 100 ng/µL solution. Also notice how well the PE solutions fit the green One-to-One line.

Analysis of Aqueous Sulfate Spike Solutions

The Arizona site and the Indiana site did not analyze the sulfate PE solutions for this study. Therefore only three sites reported sulfate results. Site operators were instructed to perform triplicate analysis of the aqueous solutions using only one spike volume, 0.2 µL. The analysis began with the local blank water followed by analysis of the local 300 ng/µL sulfate standard. The study continued by running the five *blind* solutions identified simply as S1-01-03 through S5-01-03. The results reported from the sites are included in Table 4 at the end of this report along with the previously undisclosed concentration of each PE solution. An extra column of "Re-calculated Results" has also been added to Table 4. Results from each site were re-calculated from a calibration curve based upon the PE solutions analyzed at that site. By re-calculating all results from a calibration curve, the new results are corrected for inefficient pulse generation and analysis. This is our way of normalizing the data to, hopefully, achieve better agreement from all the sites.

Results from a single site are presented as a scatter plot in Figure 8 through Figure 10. The mass measured versus the mass deposited is plotted for each spike. Results from the PE solutions are colored red in the plots, and results from the local blank water and local 300 ng/µL solution are presented in blue. Each plot also shows a green "One-to-One" line which represents perfect agreement between the mass measured and the mass deposited.

Figure 8

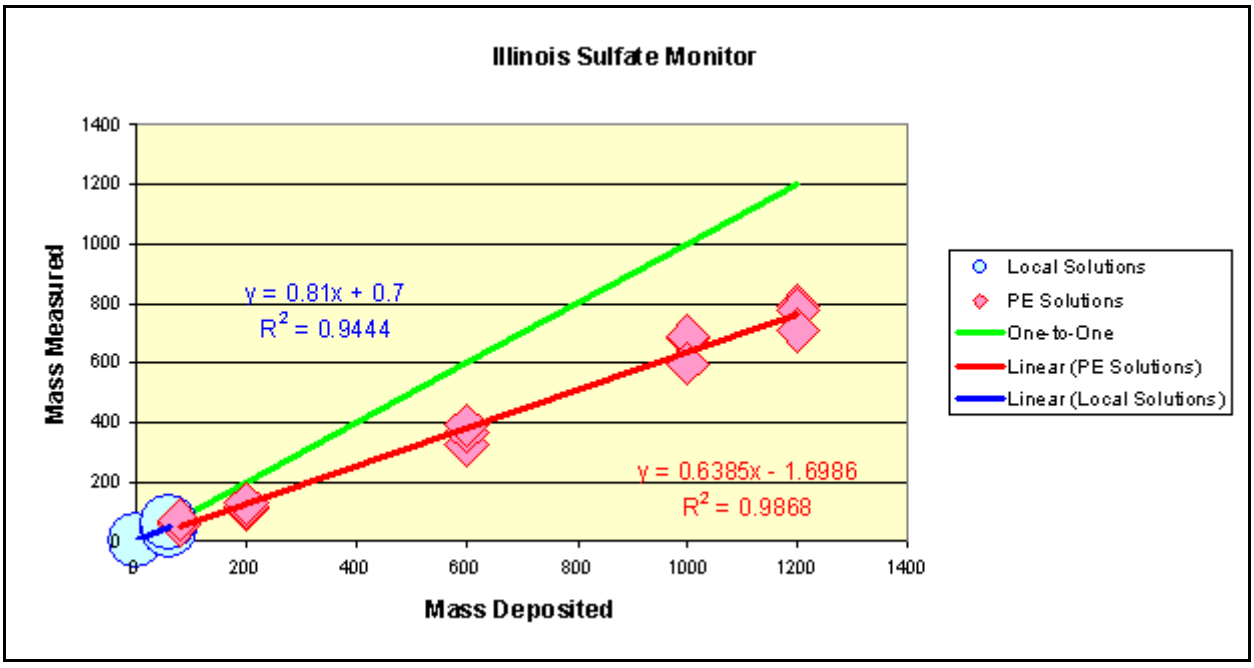


Figure 9

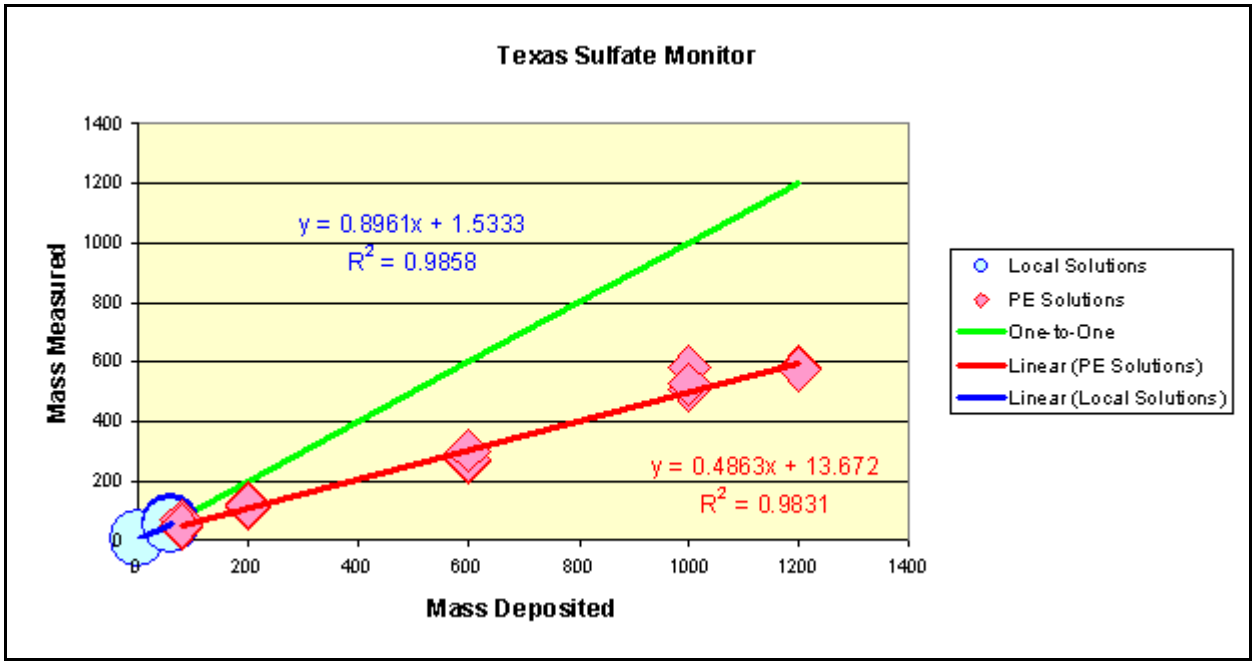


Figure 10

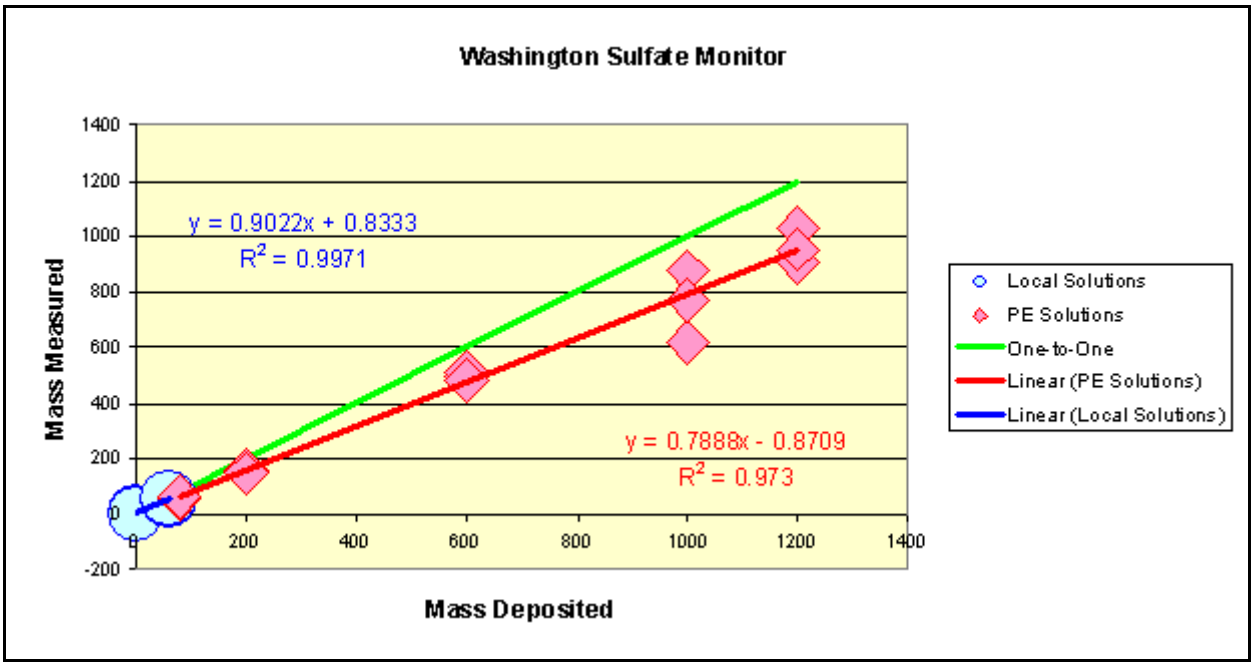


Figure 11 contains results from all four sites. To simplify the graph, each point represents an average result from three replicate spikes of the same spike solution. Each site is represented by a different symbol as shown in the plot legend.

Figure 11

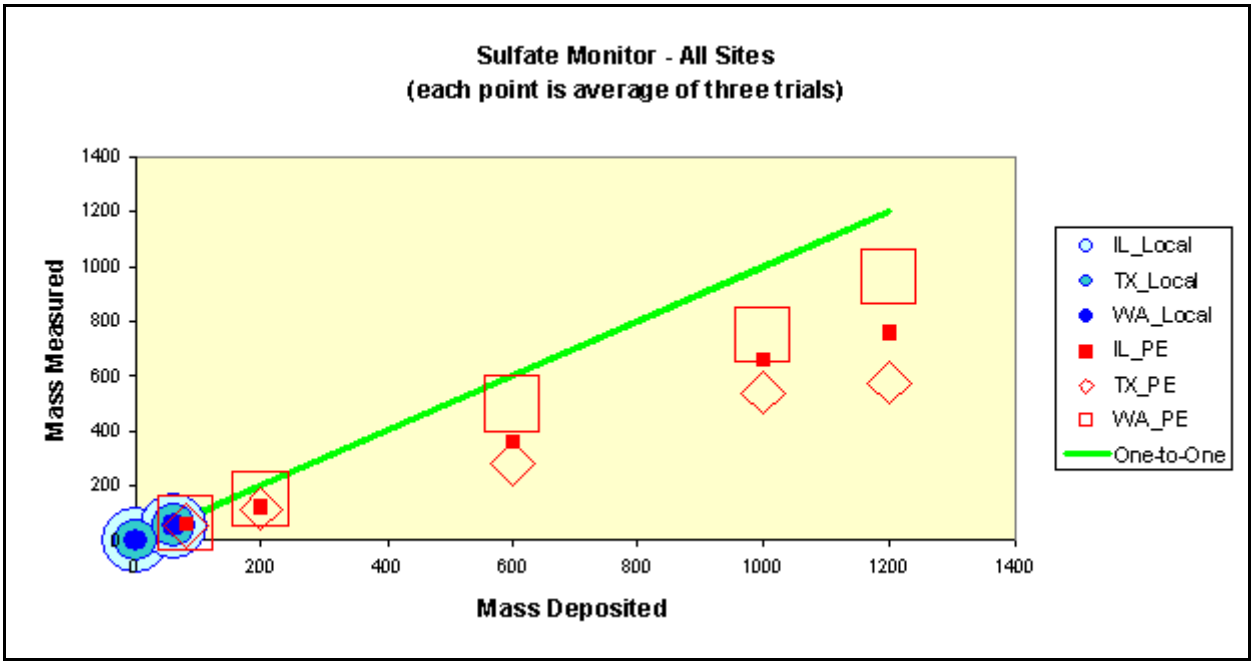
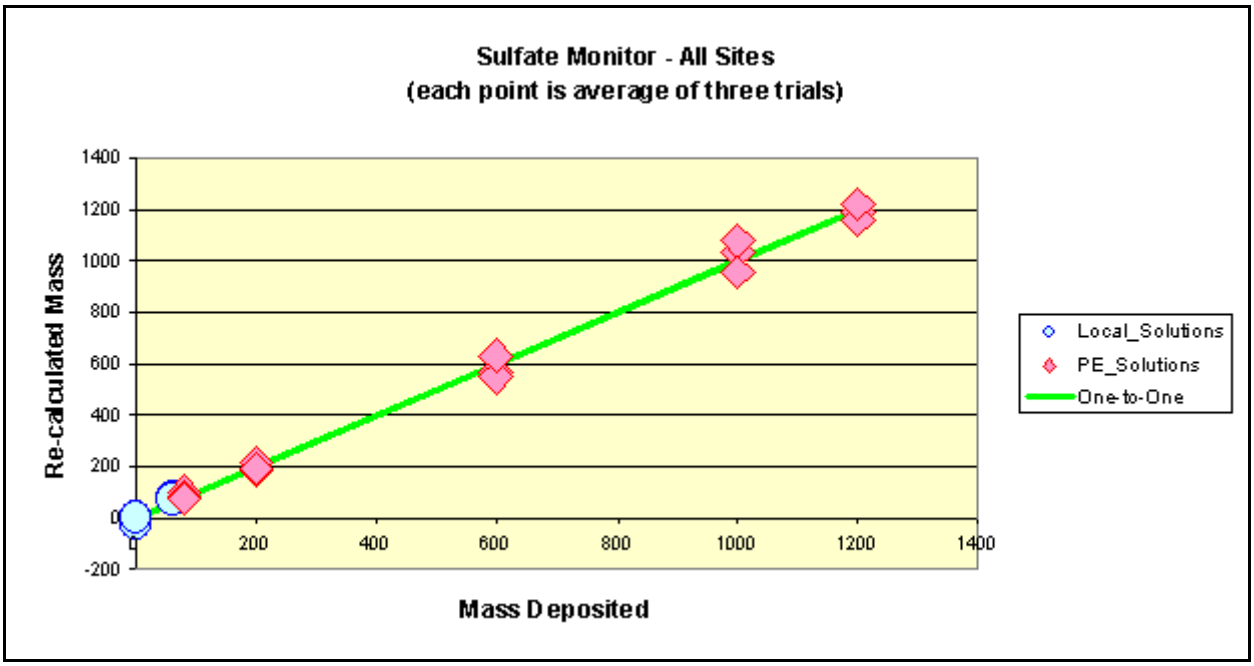


Figure 12 shows re-calculated mass from all of the sites. Results were re-calculated from a calibration curve established at each instrument by the analysis of PE samples. Again, notice how well the re-calculated results in Figure 13 fit the green One-to-One line, but the uncorrected results in Figure 12 consistently fall below the One-to-One line.

Figure 12



Conclusions

This study was modified from the previous study to investigate aqueous spike levels significantly above the normal range of calibration. A linear response was observed for four of the five nitrate monitors tested with aqueous spikes up to 375 ng deposited onto the flash strip. This corresponds to an ambient nitrate concentration of about 47 µg/m^3. The PE results from Arizona's instrument show a deviation from linear response which is most noticeable at the 180 ng spike level. This can be seen most clearly in Figure 1 and again in Figure 6. A linear response was also observed for all three of the sulfate monitors. They were tested with aqueous spikes up to 1200 ng deposited onto the flash strip. This corresponds to an ambient sulfate concentration of about 150 µg/m^3.

This study and the previous study both indicate a possible discrepancy between the local nitrate solutions and the PE solutions. Considering the importance of the local aqueous spike solution in the overall analytical scheme, the field solutions should be evaluated for accuracy at NAREL using ion chromatography.

All stakeholders are encouraged to offer suggestions for improving our next PE study.

Table 1. Evaluation of the 8400N Pulse Analyzer

Site	Audit Date	Audit Time	*** Span Gas Conc. (ppb)	Steady State Check (ppb)	Flow Balance Check (ppb)	Line Purge (ppb)	NOx Pulse Read (ppb*s)	Age of Flash Strip (days)
Arizona	24-Feb-03	3:30 PM	4910	4934.8	4294.2	1.6	3024.4	60
Illinois	12-Feb-03	10:00 AM	5420	5257.3	4607	-0.4	3529	21
Indiana	04-Feb-03	1:15 PM	5100	5067.3	4478.3	-0.2	2956.4	4
Texas	18-Feb-03	10:00 AM	5593	5492.5	4826.1	1.3	3131.8	12
Washington	10-Feb-03	10:15 AM	5140	5034.6	4433.1	-2.8	2874.5	31
*** Span gas concentration as labeled on the bottle (should be 5000 ppb).								

Table 2. Aqueous Nitrate Standards

Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Arizona	Local blank water	0.5	0	66.6	83.6	3	0.84	-13.9
Arizona	Local blank water	0.5	0	59.6	43.5	1.5	0.84	-16.0
Arizona	Local blank water	0.5	0	56.2	54.6	1.9	0.84	-15.4
Arizona	Local 100ng/uL std	0.5	50	57.7	1511.9	53.3	0.84	54.7
Arizona	Local 100ng/uL std	0.5	50	60.4	1410	49.7	0.84	49.8

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Arizona	Local 100ng/uL std	0.5	50	66	1497.3	52.8	0.84	54.0
Arizona	N1-01-03	0.5	25	55.1	677.9	23.9	0.84	14.6
Arizona	N1-01-03	0.5	25	56.3	659.2	23.3	0.84	13.8
Arizona	N1-01-03	0.5	25	62.4	661.3	23.3	0.84	13.8
Arizona	N2-01-03	0.5	70	59.4	1833.3	64.7	0.84	70.3
Arizona	N2-01-03	0.5	70	61.8	1595.1	56.3	0.84	58.8
Arizona	N2-01-03	0.5	70	58.6	1634.8	57.7	0.84	60.7
Arizona	N3-01-03	0.5	180	58.2	4723.8	166.7	0.84	209.5
Arizona	N3-01-03	0.5	180	59.2	4599.8	162.3	0.84	203.5
Arizona	N3-01-03	0.5	180	54.9	4923.6	173.7	0.84	219.1
Arizona	N4-01-03	0.5	300	57.2	6994	246.8	0.84	318.9
Arizona	N4-01-03	0.5	300	57.2	6237.9	220.1	0.84	282.4
Arizona	N4-01-03	0.5	300	42.8		229	0.84	294.6
Arizona	N5-01-03	0.5	375	24.5	8278.5	291.2	0.83	379.5
Arizona	N5-01-03	0.5	375	31.1	7850.7	276.2	0.83	359.0
Arizona	N5-01-03	0.5	375	40	7695.3	270.7	0.83	351.5
Illinois	Local blank water	0.5	0	-24.3	40.6	1.4	0.84	-5.5

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Illinois	Local blank water	0.5	0	-21.4	37.3	1.3	0.84	-5.7
Illinois	Local blank water	0.5	0	-23.4	39.6	1.4	0.84	-5.5
Illinois	Local 100ng/uL std	0.5	50	-29	1323.5	47	0.84	55.2
Illinois	Local 100ng/uL std	0.5	50	-30.2	1514	53.8	0.84	64.3
Illinois	Local 100ng/uL std	0.5	50	-21.8	1384.4	49.2	0.84	58.2
Illinois	N1-01-03	0.5	25	-20.2	623.1	22.1	0.84	22.1
Illinois	N1-01-03	0.5	25	-21.7	587.6	20.9	0.84	20.5
Illinois	N1-01-03	0.5	25	-17.3	609.4	21.6	0.84	21.4
Illinois	N2-01-03	0.5	70	-30	1542.8	54.8	0.84	65.6
Illinois	N2-01-03	0.5	70	-25.8	1689.5	60	0.84	72.6
Illinois	N2-01-03	0.5	70	-26.8	1709.2	60.7	0.84	73.5
Illinois	N3-01-03	0.5	180	-22.1	4058.5	144.1	0.84	184.7
Illinois	N3-01-03	0.5	180	-26.8	4311.5	153.1	0.84	196.7
Illinois	N3-01-03	0.5	180	-26.8	3962.6	140.7	0.84	180.1
Illinois	N4-01-03	0.5	300	-40.1	6357.8	225.8	0.84	293.6
Illinois	N4-01-03	0.5	300	-32.5	6509.5	231.2	0.84	300.8
Illinois	N4-01-03	0.5	300	-34.4	6381.6	226.6	0.84	294.6

Table 2. Aqueous Nitrate Standards

Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Illinois	N5-01-03	0.5	375	-33.1	8263	293.5	0.84	383.8
Illinois	N5-01-03	0.5	375	-36.1	7589.3	269.5	0.84	351.8
Illinois	N5-01-03	0.5	375	-30.6	8356.5	296.8	0.84	388.2
Indiana	Local blank water	0.5	0	-1.2	52.5	1.9	0.84	-8.5
Indiana	Local blank water	0.5	0	-14.4	47.2	1.7	0.84	-8.8
Indiana	Local blank water	0.5	0	-15.8	47.8	1.7	0.84	-8.8
Indiana	Local 100ng/uL std	0.5	50	3.6	1151.7	40.7	0.84	51.9
Indiana	Local 100ng/uL std	0.5	50	1.6	1391	49.2	0.84	65.2
Indiana	Local 100ng/uL std	0.5	50	6	1302.6	46	0.84	60.2
Indiana	N1-01-03	0.5	25	-7.8	546.5	19.3	0.84	18.6
Indiana	N1-01-03	0.5	25	-12.1	641.3	22.7	0.84	23.9
Indiana	N1-01-03	0.5	25	-1	651.8	23	0.84	24.4
Indiana	N2-01-03	0.5	70	1.8	1335.9	47.2	0.84	62.1
Indiana	N2-01-03	0.5	70	-8.9	1611.2	56.9	0.84	77.2
Indiana	N2-01-03	0.5	70	-12.6	1472.4	52	0.84	69.5
Indiana	N3-01-03	0.5	180	7.8	3490.9	123.4	0.84	180.7
Indiana	N3-01-03	0.5	180	0.8	3572.8	126.3	0.84	185.2

Table 2. Aqueous Nitrate Standards

Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Indiana	N3-01-03	0.5	180	-1.1	3803.6	134.4	0.84	197.8
Indiana	N4-01-03	0.5	300	2.8	5881.5	207.8	0.84	312.1
Indiana	N4-01-03	0.5	300	0.2	5497.8	194.3	0.84	291.1
Indiana	N4-01-03	0.5	300	-7.6	5261.6	185.9	0.84	278.0
Indiana	N5-01-03	0.5	375	-3.4	6751.3	238.6	0.84	360.1
Indiana	N5-01-03	0.5	375	1.8	7340.3	259.4	0.84	392.5
Indiana	N5-01-03	0.5	375	-4.9	7057.6	249.4	0.84	376.9
Texas	Local blank water	0.5	0	8.2	14.8	0.6	0.91	-14.3
Texas	Local blank water	0.5	0	-19.2	13.7	0.5	0.91	-14.5
Texas	Local blank water	0.5	0	-10	18.2	0.7	0.91	-14.2
Texas	Local 100ng/uL std	0.5	50	-10.3	1514.3	58.3	0.91	72.9
Texas	Local 100ng/uL std	0.5	50	6.3	1314.9	50.6	0.91	61.3
Texas	Local 100ng/uL std	0.5	50	-9.9	1106.2	42.6	0.91	49.2
Texas	N1-01-03	0.5	25	-1.6	591.2	22.7	0.91	19.1
Texas	N1-01-03	0.5	25	-21.2	586.5	22.6	0.91	19.0
Texas	N1-01-03	0.5	25	3.8	671.9	25.8	0.91	23.8
Texas	N2-01-03	0.5	70	-37.1	1516	58.3	0.91	72.9

Table 2. Aqueous Nitrate Standards

Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Texas	N2-01-03	0.5	70	-6.6	1474	56.7	0.91	70.5
Texas	N2-01-03	0.5	70	-28.8	1540.5	59.3	0.91	74.4
Texas	N3-01-03	0.5	180	0	3450.6	132.7	0.91	185.4
Texas	N3-01-03	0.5	180	-43	3353.5	129	0.91	179.8
Texas	N3-01-03	0.5	180	-14.2	3274	126	0.91	175.3
Texas	N4-01-03	0.5	300	-34.7	5298.8	203.8	0.91	292.9
Texas	N4-01-03	0.5	300	2.3	5777.6	222.3	0.91	320.9
Texas	N4-01-03	0.5	300	-7.8	5661.3	217.8	0.91	314.1
Texas	N5-01-03	0.5	375	-10.4	6567.9	252.7	0.91	366.9
Texas	N5-01-03	0.5	375	-31	6735.3	259.1	0.91	376.5
Texas	N5-01-03	0.5	375	-1.6	6439.2	247.1	0.91	358.4
Washington	Local blank water	0.5	0	-65.4	60.2	2.3	0.91	-12.4
Washington	Local blank water	0.5	0	-71	48.8	1.9	0.91	-12.9
Washington	Local blank water	0.5	0	-72.4	54.3	2.1	0.91	-12.7
Washington	Local 100ng/uL std	0.5	50	-71.2	1344.9	51.9	0.91	59.6
Washington	Local 100ng/uL std	0.5	50	-70.4	1478	57	0.91	67.0
Washington	Local 100ng/uL std	0.5	50	-71.1	1360.3	52.5	0.91	60.5

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Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Washington	N1-01-03	0.5	25	-76	642	24.8	0.91	20.3
Washington	N1-01-03	0.5	25	-63.4	607.7	23.4	0.91	18.3
Washington	N1-01-03	0.5	25	-72.7	637.9	24.6	0.91	20.0
Washington	N2-01-03	0.5	70	-73.4	1649.3	63.6	0.91	76.6
Washington	N2-01-03	0.5	70	-70.4	1592.9	61.4	0.91	73.4
Washington	N2-01-03	0.5	70	-69.8	1356.3	52.3	0.91	60.2
Washington	N3-01-03	0.5	180	-77.2	3793.4	146.3	0.91	196.7
Washington	N3-01-03	0.5	180	-74.6	3775.2	145.6	0.91	195.7
Washington	N3-01-03	0.5	180	-77.5	3526.4	136	0.91	181.7
Washington	N4-01-03	0.5	300	-71	5630.5	217.1	0.91	299.5
Washington	N4-01-03	0.5	300	67.4	5544.7	213.8	0.91	294.7
Washington	N4-01-03	0.5	300	-73	5514	212.6	0.91	292.9
Washington	N5-01-03	0.5	375	-64.4	6763.1	260.8	0.91	362.9
Washington	N5-01-03	0.5	375	-73	7238.6	279.2	0.91	389.6
Washington	N5-01-03	0.5	375	-68	6844.7	264	0.91	367.5

*** Results from each site were re-calculated from a calibration curve based upon the PE solutions analyzed at that site.

Table 3. Evaluation of the 8400S Pulse Analyzer

Site	Audit Date	Audit Time	*** Span Gas Conc. (ppb)	Steady State Check (ppb)	Flow Balance Check (ppb)	Line Purge (ppb)	Age of Flash Strip (days)
Arizona	-----	-----	-----	-----	-----	-----	-----
Illinois	12-Feb-03	10:00 AM	1200	1194.7	1043.2	-0.2	1
Indiana	-----	-----	-----	-----	-----	-----	-----
Texas	18-Feb-03	10:38 AM	912	843.9	713.8	2.7	7
Washington	13-Feb-03	9:30 AM	1089	1090.9	937.2	1.8	31
*** Span gas concentration as labeled on the bottle (should be 1000 ppb).							

Table 4. Aqueous Sulfate Standards

Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Illinois	Local blank water	0.2	0	-18.5	1.6	0.1	1.17	2.8
Illinois	Local blank water	0.2	0	-14.8	4	0.3	1.17	3.1
Illinois	Local blank water	0.2	0	-28.4	22.3	1.7	1.17	5.3
Illinois	Local 300ng/FL std	0.2	60	-33	612.7	47.1	1.17	76.4
Illinois	Local 300ng/FL std	0.2	60	-32.6	526.1	40.4	1.17	65.9

Table 4. Aqueous Sulfate Standards

Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Illinois	Local 300ng/FL std	0.2	60	-36.7	785.2	60.4	1.17	97.3
Illinois	S1-01-03	0.2	80	-45.4	794.1	61	1.17	98.2
Illinois	S1-01-03	0.2	80	-38.3	760.8	58.5	1.17	94.3
Illinois	S1-01-03	0.2	80	-50.6	924	71	1.17	113.9
Illinois	S2-01-03	0.2	200	-55.4	1441.3	110.8	1.17	176.2
Illinois	S2-01-03	0.2	200	-34.3	1527.9	117.4	1.17	186.5
Illinois	S2-01-03	0.2	200	-50.8	1653.2	127.1	1.17	201.7
Illinois	S3-01-03	0.2	600	-50.4	4209.8	323.6	1.17	509.5
Illinois	S3-01-03	0.2	600	-51.6	4774.9	367	1.17	577.4
Illinois	S3-01-03	0.2	600	-66	5081.9	390.6	1.17	614.4
Illinois	S4-01-03	0.2	1000	-58.4	8879.4	682.5	1.17	1071.6
Illinois	S4-01-03	0.2	1000	-51.3	9027.7	693.9	1.17	1089.4
Illinois	S4-01-03	0.2	1000	-42.4	7797.8	599.4	1.17	941.4
Illinois	S5-01-03	0.2	1200	-50.8	10284.1	790.5	1.17	1240.7
Illinois	S5-01-03	0.2	1200	-35.8	10081.2	774.9	1.17	1216.3
Illinois	S5-01-03	0.2	1200	-31.4	9186.2	706.1	1.17	1108.5
Texas	Local blank water	0.2	0	62.2	4.8	0.4	1.38	-27.3

Table 4. Aqueous Sulfate Standards

Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Texas	Local blank water	0.2	0	103.4	-0.1	0	1.38	-28.1
Texas	Local blank water	0.2	0	22.8	45.9	4.2	1.38	-19.5
Texas	Local 300ng/FL std	0.2	60	80.8	674.7	61.1	1.38	97.5
Texas	Local 300ng/FL std	0.2	60	56.8	587.6	53.2	1.38	81.3
Texas	Local 300ng/FL std	0.2	60	64	569.9	51.6	1.38	78.0
Texas	S1-01-03	0.2	80	72.5	710.2	64.3	1.38	104.1
Texas	S1-01-03	0.2	80	79.6	523.8	47.4	1.38	69.4
Texas	S1-01-03	0.2	80	84.6	570	51.6	1.38	78.0
Texas	S2-01-03	0.2	200	58.6	1330.4	120.4	1.38	219.5
Texas	S2-01-03	0.2	200	84.6	1262	114.2	1.38	206.7
Texas	S2-01-03	0.2	200	81.2	1275.5	115.5	1.38	209.4
Texas	S3-01-03	0.2	600	60.2	2925.5	264.8	1.38	516.4
Texas	S3-01-03	0.2	600	63.4	3033.1	274.6	1.38	536.5
Texas	S3-01-03	0.2	600	59.8	3309.3	299.6	1.38	588.0
Texas	S4-01-03	0.2	1000	69.1	5612.7	508.1	1.38	1016.7
Texas	S4-01-03	0.2	1000	81	6436.1	582.6	1.38	1169.9
Texas	S4-01-03	0.2	1000	22	5785.4	523.7	1.38	1048.8

Table 4. Aqueous Sulfate Standards

Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Texas	S5-01-03	0.2	1200	54	6393.7	578.8	1.38	1162.1
Texas	S5-01-03	0.2	1200	68.5	6371	576.7	1.38	1157.8
Texas	S5-01-03	0.2	1200	72.8	6366	576.3	1.38	1156.9
Washington	Local blank water	0.2	0	-32	20.3	1.8	1.36	3.4
Washington	Local blank water	0.2	0	-37	17.2	1.5	1.36	3.0
Washington	Local blank water	0.2	0	-22.1	-9.5	-0.8	1.36	0.1
Washington	Local 300ng/FL std	0.2	60	-34.2	630.5	55.9	1.36	72.0
Washington	Local 300ng/FL std	0.2	60	-48.1	593.3	52.6	1.36	67.8
Washington	Local 300ng/FL std	0.2	60	-23.1	636.2	56.4	1.36	72.6
Washington	S1-01-03	0.2	80	-41.2	645	57.2	1.36	73.6
Washington	S1-01-03	0.2	80	-37.8	702.3	62.3	1.36	80.1
Washington	S1-01-03	0.2	80	-51.7	692	61.4	1.36	78.9
Washington	S2-01-03	0.2	200	-7.3	1793.6	159.1	1.36	202.8
Washington	S2-01-03	0.2	200	-25.1	1649.2	146.3	1.36	186.6
Washington	S2-01-03	0.2	200	-22.2	1651	146.4	1.36	186.7
Washington	S3-01-03	0.2	600	-36	5648.9	501	1.36	636.3
Washington	S3-01-03	0.2	600	-8.7	5773.9	512.1	1.36	650.3

Table 4. Aqueous Sulfate Standards

Site	Sample ID	Volume Deposited (µL)	Mass Deposited (ng)	Baseline (ppb*s)	Corrected Pulse (ppb*s)	Measured Mass (ng)	Analyzer Flow (L/min)	Re-calculated Mass*** (ng)
Washington	S3-01-03	0.2	600	-19.7	5414.3	480.2	1.36	609.9
Washington	S4-01-03	0.2	1000	-40	9857.7	875.2	1.36	1110.7
Washington	S4-01-03	0.2	1000	-15.6	6968.6	618	1.36	784.6
Washington	S4-01-03	0.2	1000	-44.2	8667.8	768.7	1.36	975.7
Washington	S5-01-03	0.2	1200	-42.5	11642	1032.5	1.36	1310.1
Washington	S5-01-03	0.2	1200	-46	10165	901.5	1.36	1144.0
Washington	S5-01-03	0.2	1200	-32	10748	953.2	1.36	1209.6

*** Results from each site were re-calculated from a calibration curve based upon the PE solutions analyzed at that site.