TECHNICAL MEMORANDUM

TO: Solomon Ricks / OAQPS
FROM: Eric Boswell / NAREL
AUTHOR: Steve Taylor / NAREL
DATE: August 24, 2006
SUBJECT: Performance Evaluation of R&P 8400N, 8400S, and Sunset Carbon Air Monitors

Introduction

EPA has completed another round of performance testing for the R&P 8400N [nitrate], the R&P 8400S [sulfate], and the Sunset [carbon] semi-continuous monitors. The R&P units are designed to capture $PM_{2.5}$ from the ambient air and provide measurements of nitrate and sulfate every ten minutes. The Sunset carbon units are also designed to capture $PM_{2.5}$ from the ambient air and provide measurements of organic carbon (OC) and elemental carbon (EC) every hour. As with previous testing, split single-blind aqueous spike solutions were used to evaluate the nitrate and sulfate monitors, and split single-blind filter segments were used to evaluate the carbon monitors. EPA performance evaluation studies of the R&P monitors began in 2002 with five participating field sites located in or near Phoenix, Chicago, Indianapolis, Houston, and Seattle. The Sunset carbon analyzers were put into service at three sites, Phoenix, Chicago, and Seattle in 2004 and have since participated in four PE studies including the current study. Seattle was not able to participate in this study due to the relocation of their field site and Indianapolis has discontinued the use of their R&P 8400N and 8400S semi-continuous monitors.

Experimental Design

Each site operator received an equivalent set of performance evaluation (PE) samples with detailed instructions for analyzing and reporting all of the samples. Five blind spike solutions covering a wide range of concentrations were analyzed in triplicate by each nitrate and each sulfate instrument. Each carbon instrument analyzed three different filter samples in duplicate. Each set of filters included a blank filter, a filter spiked with sucrose, and a filter loaded with fine particulate matter ($PM_{2.5}$). Operators for the nitrate and sulfate instruments were instructed to analyze the local blank water and the local calibration standard along with the PE test solutions. This requirement served to help document the instrument performance immediately before the PE solutions were analyzed.

All of the PE samples for this study were prepared at the National Air and Radiation Environmental Laboratory (NAREL) located in Montgomery, AL. Five nitrate spike solutions and five sulfate spike solutions were prepared and tested for accuracy at NAREL using a Dionex DX500 Ion Chromatograph (IC). After all of the PE solutions were verified using the IC, portions of each solution were placed into clean labeled screw-cap vials for shipment to the field operators. Each site operator received a set of five nitrate PE solutions labeled N1-03-06 through N5-03-06 and a set of five sulfate PE solutions labeled S1-03-06 through S5-03-06.

The concentration of nitrate and sulfate present in each PE solution is listed in Table 3 and Table 5 respectively, at the end of this report. The solutions were prepared from the same salts and chemicals that are present in the local calibration solutions used at each field site. The five nitrate PE solutions were prepared using potassium nitrate 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 ammonium sulfate 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 ammonium sulfate).

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 new syringe was used to deliver one spike volume for all solutions described in this report. 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 3 and Table 5 respectively, at the end of this report.

The Sunset field instruments have been programmed to collect $PM_{2.5}$ from the ambient air onto a quartz fiber filter for a period of forty-seven minutes after which time the filter is heated and purged for approximately thirteen minutes to determine the OC and EC present in the sample. The same quartz collection filter can be used repeatedly to collect many samples over several days, but periodically it is replaced by the operator due to non-volatile residues that gradually accumulate. Each PE filter was analyzed at the field site by replacing the collection filter with a PE filter after which time it is heated and purged to determine the OC and EC present on the PE filter.

Several PE filters were prepared at NAREL for this study. All of the samples were prepared by using 47-mm quartz fiber filters purchased from Gelman. A large batch of the new filters was cleaned by heating to 500 °C inside a muffled furnace for at least two hours after which the filters were placed into sealed Petri dishes and stored at freezer temperature until needed. Two of the filters in the batch were analyzed for EC and OC residues using a Sunset laboratory instrument set up to perform the Thermal Optical Transmittance (TOT) analytical method approved for the Speciation Trends Network (STN method). The STN method performed at NAREL is similar to the field method but includes some fundamental differences in the software and hardware configuration. Results from the two test filters showed less than 0.2 $\mu gC/cm^2$, so the batch of filters was declared sufficiently clean for use.

Several of the clean 47-mm filters were assembled into canisters which were used to collect $PM_{2.5}$ from the Montgomery air. Collocated Super SASS units were programmed to load the filters with a lengthy 163-hour collection event. The long collection time was necessary to get the amount of captured EC high enough for the study. After the collection event was completed, the loaded filters were recovered from the canisters and placed individually into labeled Petri slides and stored at freezer temperature until needed. To gain confidence in the quality of filter replication, a small punched segment was removed from each of the loaded filters and analyzed using the STN method. Good precision was observed for the measured EC and OC with relative standard deviations at 5% and 2.6% respectively.

This study was designed to submit small circular punches of the quartz filter to the field sites so that each test sample could be installed into the instrument with minimum effort from the operator. Each circular punch must have a 16-mm diameter to fit properly into the field instrument. A circular punch device was used to cut 16-mm circles from the larger 47-mm quartz filters. A large number of the blank 16-mm quartz circles were required for this study. Some of them were analyzed directly as a test sample. Some of them were spiked with an aqueous solution of sucrose. The sucrose spikes were allowed to air dry for about thirty minutes before they were packaged for shipment. Therefore it was not possible for the field operator to visually see a difference between the blank test samples and the test samples spiked with sucrose. Each field site was supplied with four Petri slides as described in Table 1.

Table 1. Components of the Sample Kit Submitted To Each Field Site

Petri Slide Count	Petri Label	Description of the Petri Slide Contents
First	C1-03-06	Test sample replicates (four blank quartz circles)
Second	C2-03-06	Test sample replicates (four circles spiked with sucrose)
Third	C3-03-06	Test sample replicates (four circles loaded with $PM_{2.5}$)
Fourth	Blank quartz	Twelve designated blank quartz circles **
***** each test sample must be mounted into the instrument with a designated blank circle***		

This study required the operator to temporarily interrupt the automated analysis of ambient air at his site, remove the collection filter from his instrument, and then use his instrument to analyze the test samples listed in Table 1. Table 1 shows each site receiving twelve test samples and twelve designated blank circles. A designated blank circle was available for each test sample provided to the site. The operator was instructed to mount a designated blank circle into the instrument along with each test sample. This procedure was necessary to maintain normal behavior of the transmitted laser signal. The laser normally shines through the collection filter. The collection filter, which was temporarily removed from the instrument, is actually two filters mounted together for extra strength. Since each PE sample will be a replacement for the collection filter, the PE sample should be doubly thick as well.

Analysis of the Blind 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 N1-03-06 through N5-03-06. The results reported from the sites are included in Table 3 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 3. Results from each site were re-calculated from a calibration curve based upon the five potassium nitrate 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 3. The mass measured versus the mass deposited is plotted for each spike. Results from the potassium nitrate 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.

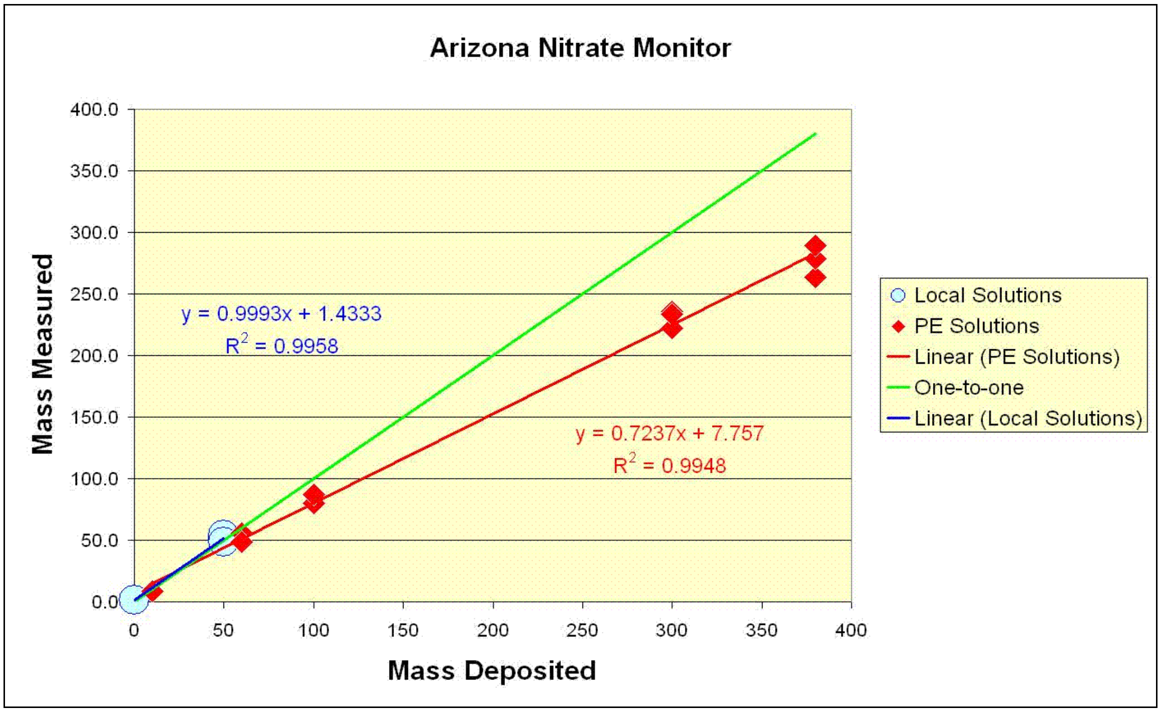

Figure 1

Reasonably good precision was observed for the nitrate spikes shown in Figure 1. A linear regression was performed using the results from the local solutions and also using the results from the five PE solutions shown in red. The regression equations in Figure 1 show a larger slope for the local solutions (0.9993) than for the PE solutions (0.7237). This may indicate that the local calibration standard is more concentrated than the nominal 100 ng/µL. We have seen evidence in previous studies that the local nitrate calibration standard at most of the field sites is too concentrated.

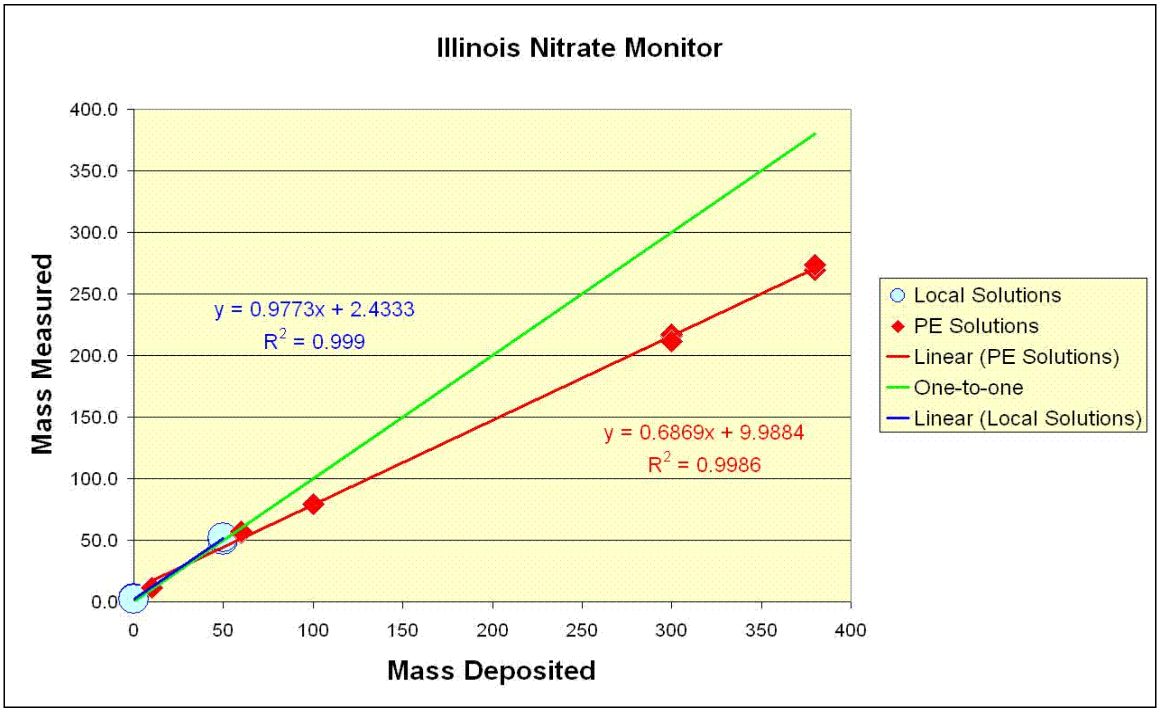

Figure 2

Excellent precision was observed for the nitrate spikes shown in Figure 2, and good precision was observed for the spikes shown in Figure 3.

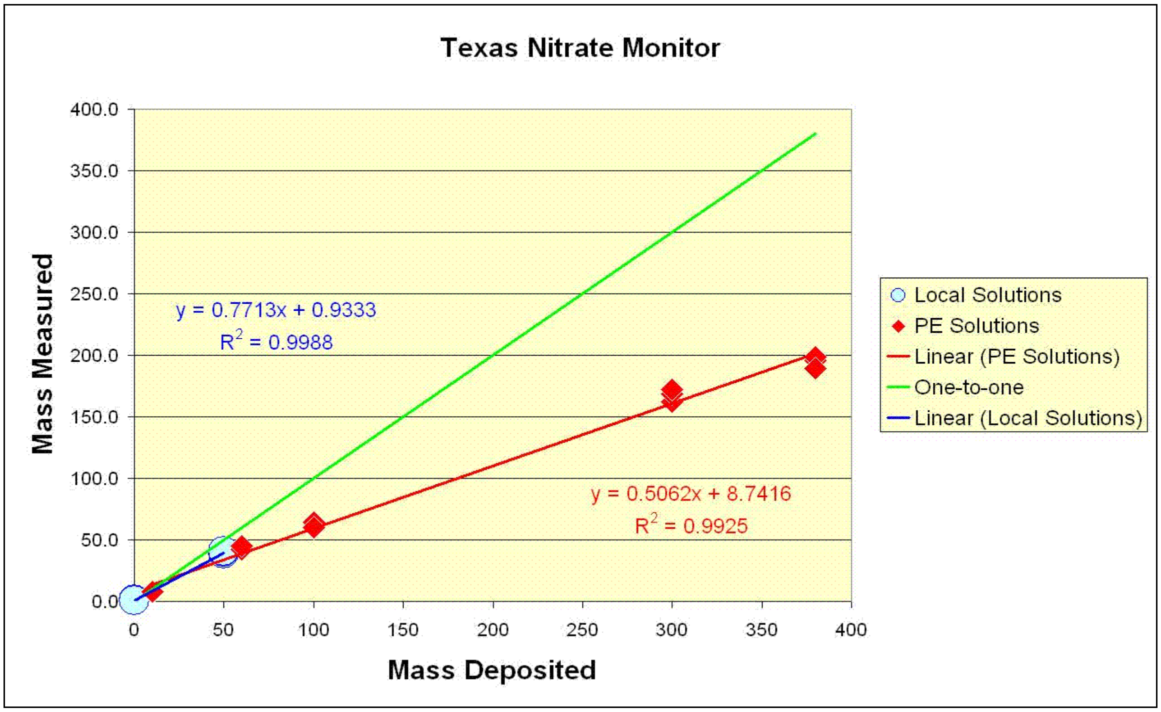

Figure 3

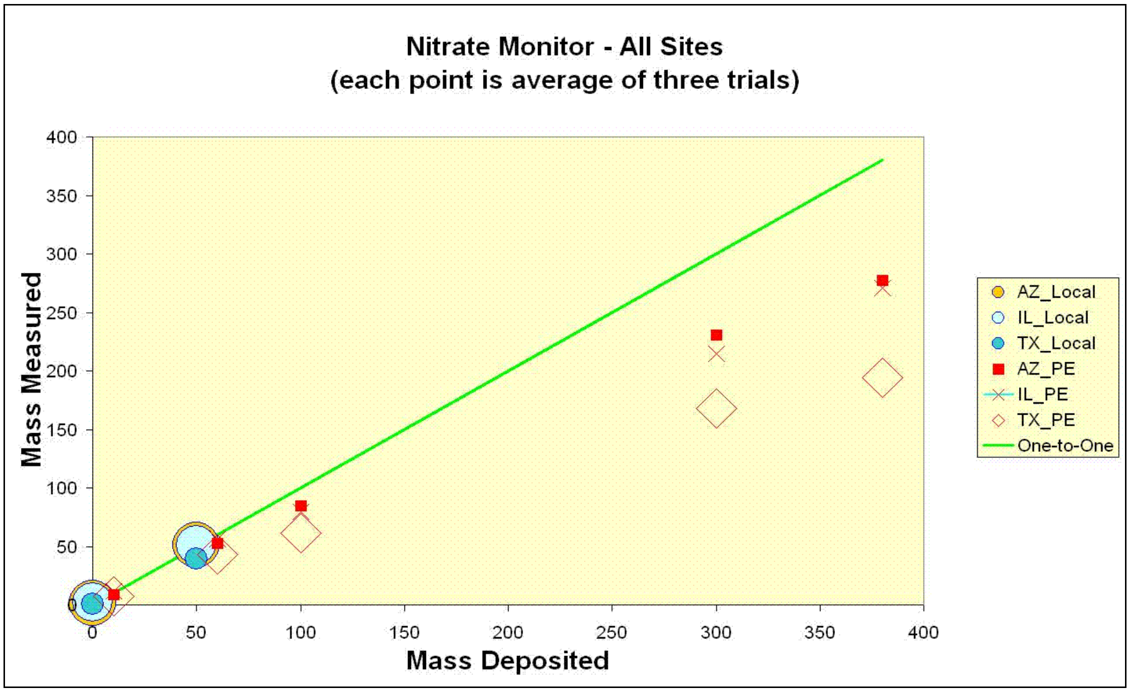

Figure 4

Results from all of the sites are presented together in Figure 4. To simplify the plot, each point represents an average result from three separate spikes of the same aqueous solution.

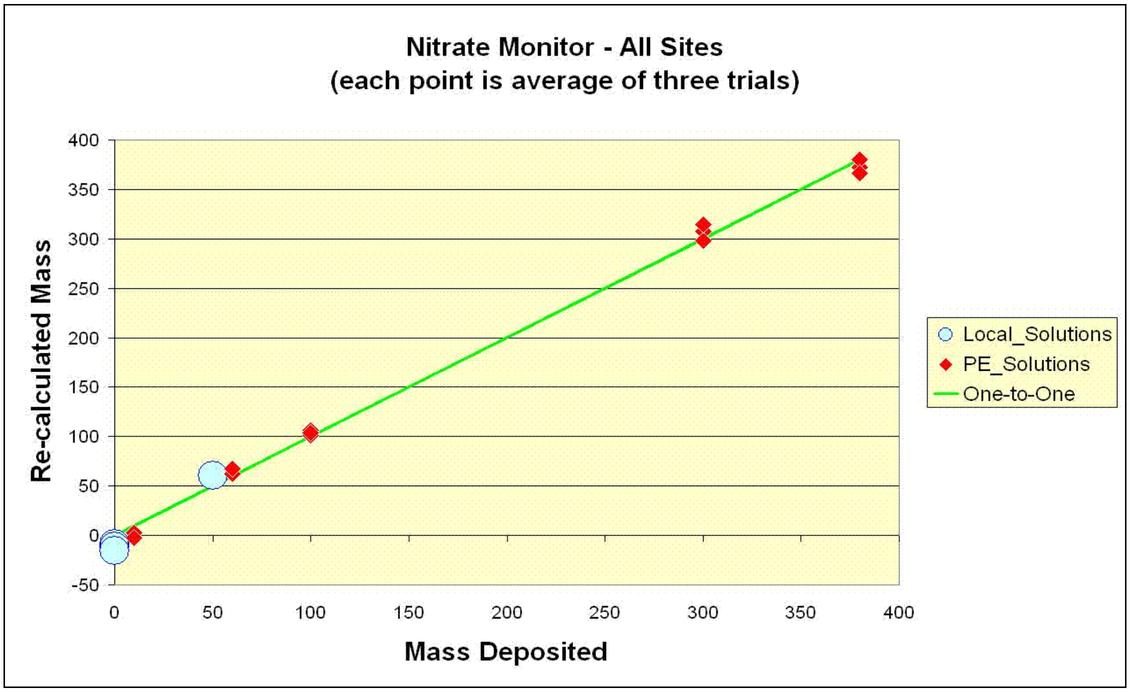

Figure 5

Figure 5 shows re-calculated mass from all of the sites. A linear calibration curve based upon analysis of the five PE solutions 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. Those results from all of the aqueous solutions that do not lie on the One-to-One line indicate less than perfect precision.

Analysis of the Blind Aqueous Sulfate Spike Solutions

R&P 8400S PE results were received from two instruments. Only the Houston and Chicago sites were able to participate in this study. 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 300 ng/µL sulfate standard. The study continued by running the five blind solutions identified simply as S1-03-06 through S5-03-06. The results reported from the sites are included in Table 5 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 5.

Results from a single site are presented as a scatter plot in Figures 6 and 7. 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.

Good precision was observed for the sulfate spikes shown in Figure 6. A linear regression was performed using the results from the local solutions and also using the results from the five PE solutions shown in red.

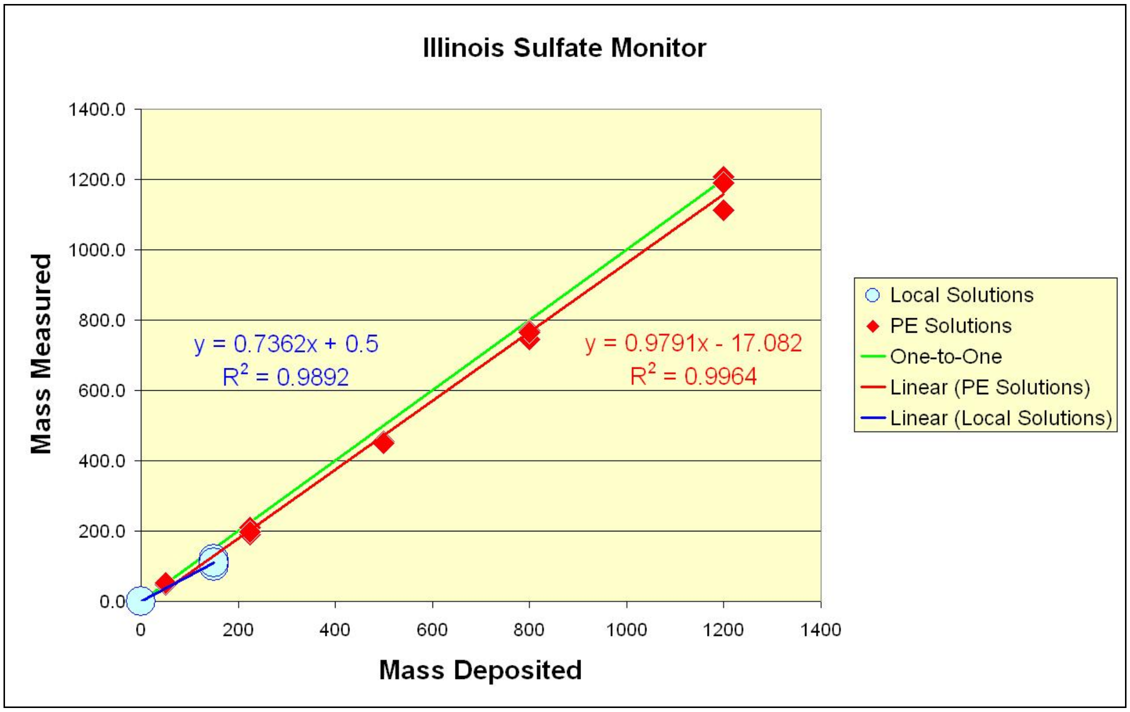

Figure 6

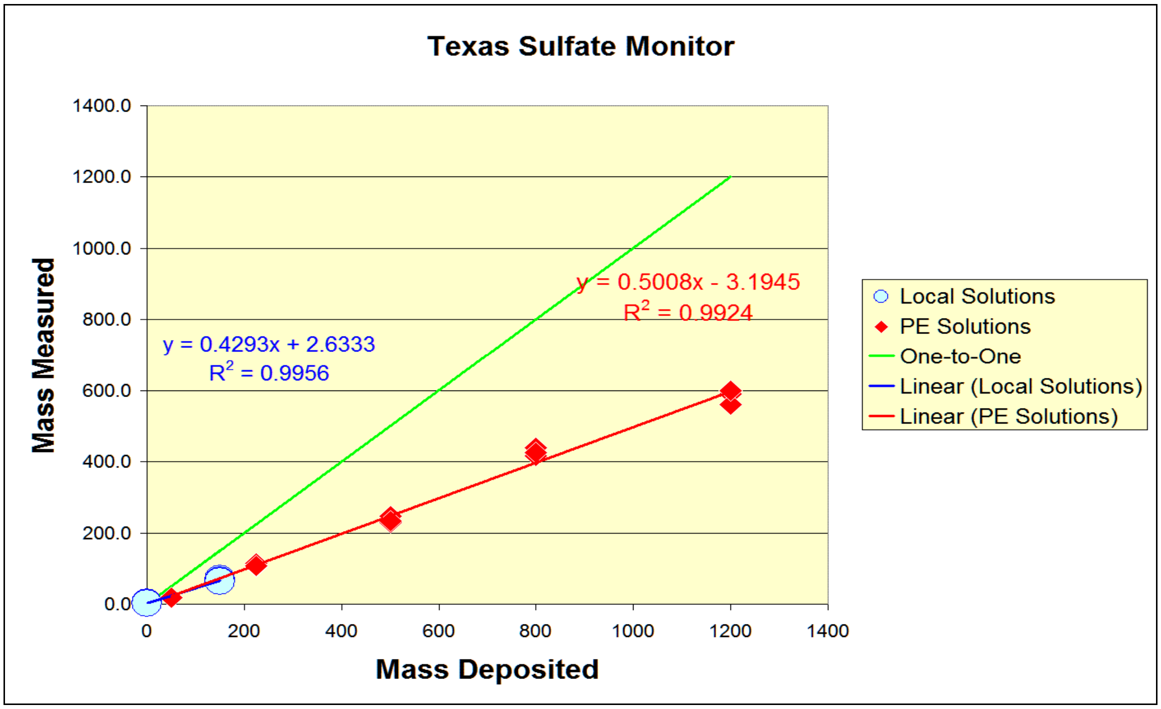

Figure 7

Good precision was observed for the sulfate spikes shown in Figure 7.

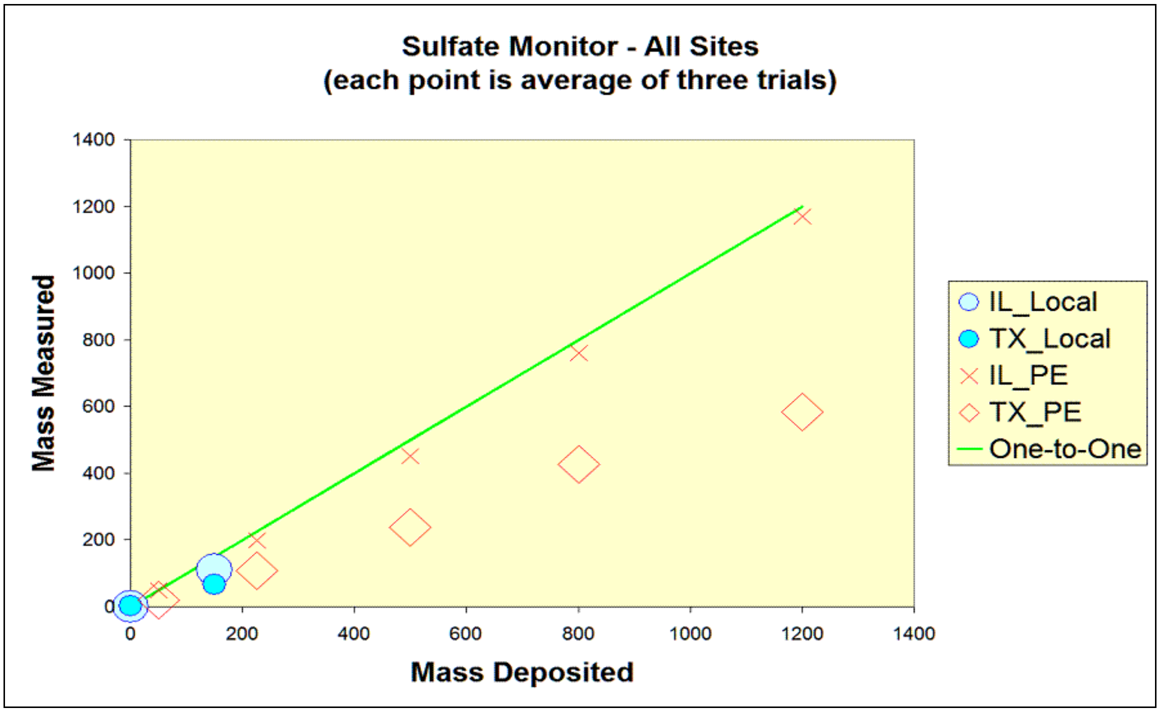

Figure 8

Results from both sulfate instruments are shown together in Figure 8.

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. Figure 9 shows re-calculated mass from all of the sites. A linear calibration curve based upon analysis of the five PE solutions themselves was generated for each instrument, and new results were calculated. Results in Figure 9 that do not lie on the One-to-One line indicate less than perfect precision.

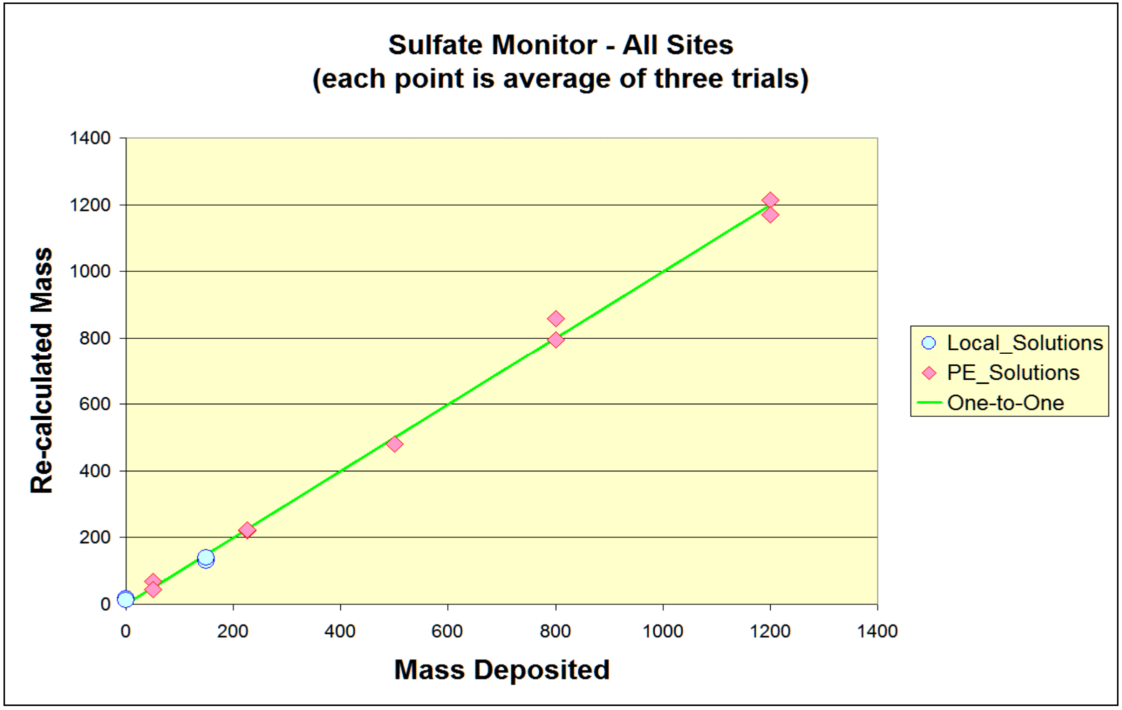

Figure 9

Analysis of the Blind Quartz Filters for Organic Carbon and Elemental Carbon

Sunset carbon results were received from Phoenix and Chicago. Detailed instructions for analyzing the PE samples were provided to the site operators. As stated earlier, the normal automated analysis of ambient air was halted, and the collection filter was removed from the instrument. This study was designed to replace the collection filter with one of the test samples, and then run the instrument through the analysis cycle. There was concern that results from the blank test samples might be high. High blank values can be caused by shipping and handling, but the greatest concern was for opening the instrument's oven every time a new test sample was installed. Because of this concern, the sucrose spike level was relatively high, and the $PM_{2.5}$ test sample was loaded with a relatively high level of OC.

Figure 10 shows the total carbon (TC) results for the sucrose spikes and the $PM_{2.5}$ test samples presented as a bar graph. TC is simply the sum of the EC and the OC for this study. The results are expressed as micrograms of carbon released from the test sample. Results determined at NAREL are shown along with the results reported from the two field sites. It is important to understand that the results reported for NAREL were determined using the STN analytical method since NAREL does not have a field instrument. Figure 10 also includes the sucrose spike level as well as the uncertainty of measurements performed at NAREL. Good duplicate precision was observed for the sites.

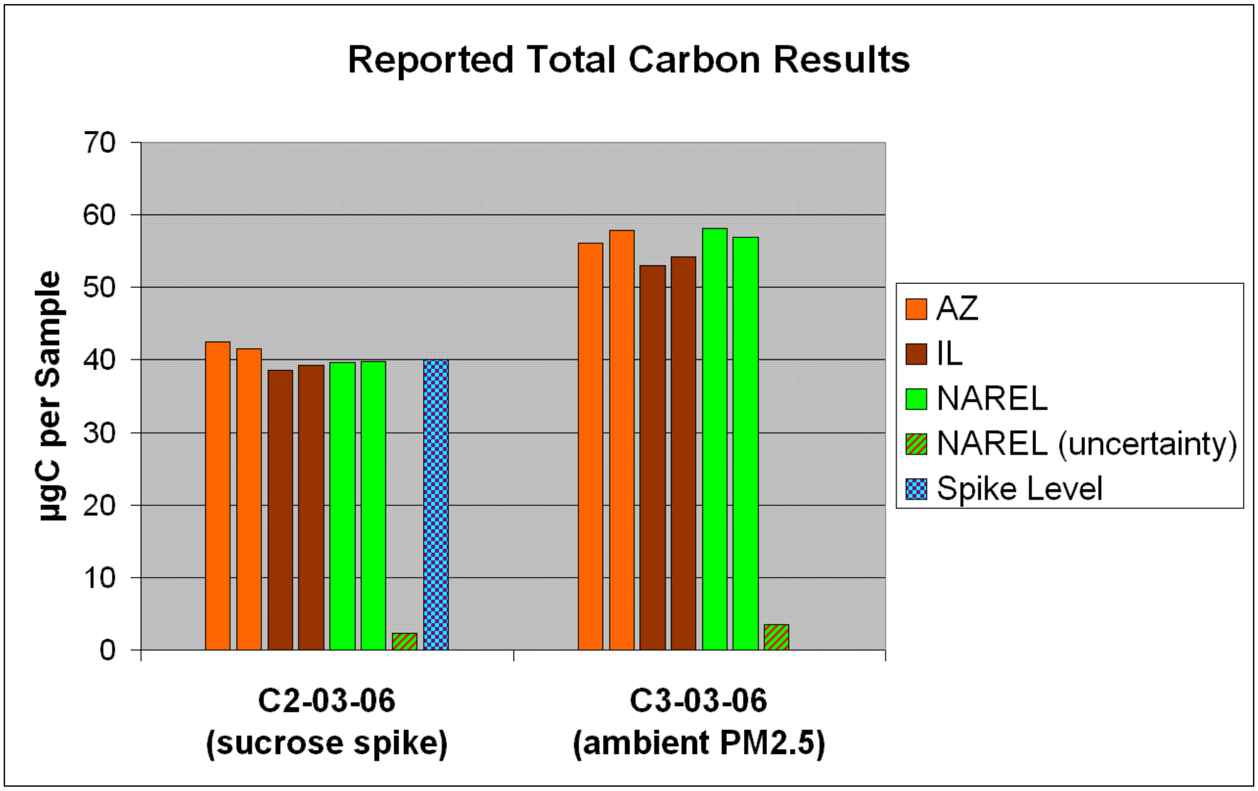

Figure 10

Figure 11 includes the EC and OC values along with the TC for the ambient $PM_{2.5}$ test sample. The sucrose spike sample is not presented in Figure 11 because all sites reported essentially zero EC for the sucrose test sample. That is good because sucrose does not contain EC, and therefore the OC should be equal to the TC.

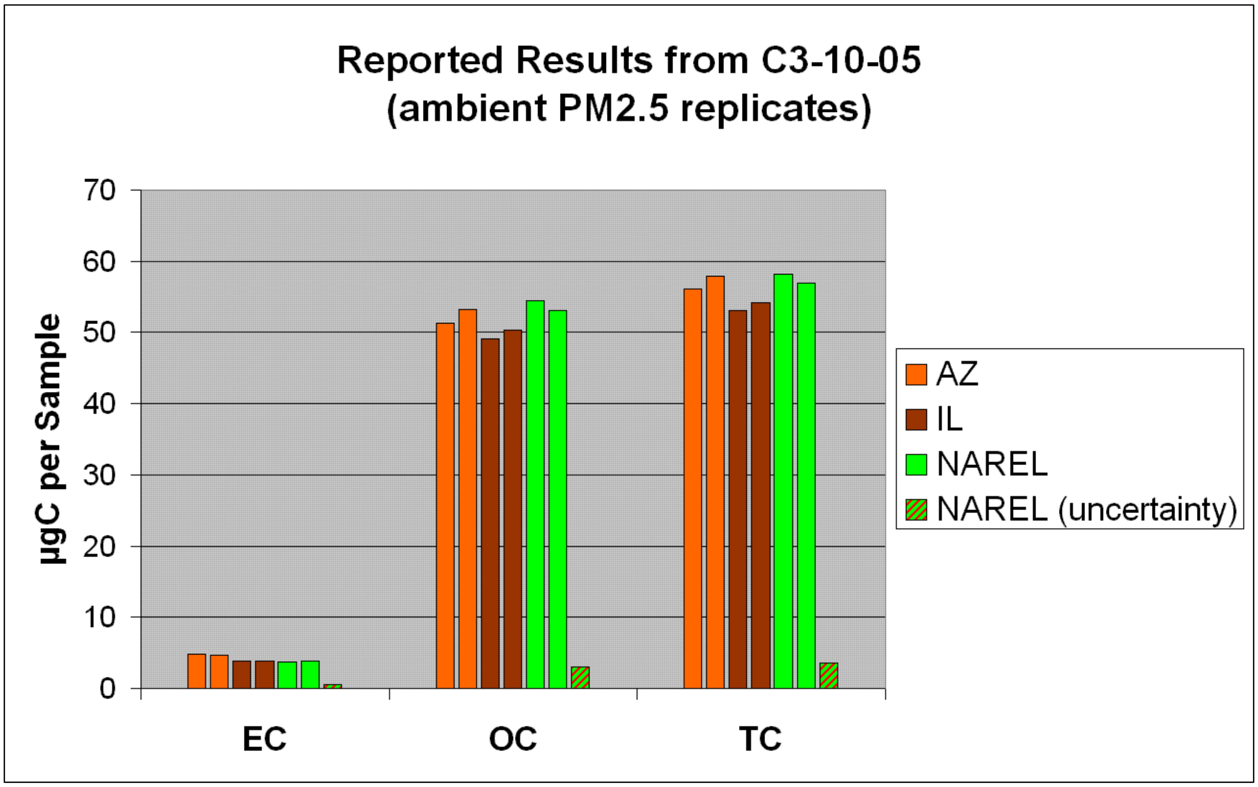

Figure 11

All of the results reported from the sites and determined at NAREL, including blank results, are available in Table 6 at the end of this report.

Conclusions

This PE study included the R&P 8400 series nitrate and sulfate analyzers as well as the Sunset carbon analyzer. These monitors are designed to operate unattended at remote field sites for many hours as they collect $PM_{2.5}$ from the ambient air and provide measurement data for nitrate, sulfate, OC/EC. This study was not designed to evaluate the overall performance of the monitors since the overall performance includes both sample collection and sample analysis. This study was designed, however, to evaluate the accuracy and precision of the sample analysis. This study, similar to previous studies, used single-blind spike solutions to evaluate the R&P and Sunset analyzer performance. The Sunset analyzers were also able to analyze samples created by collecting $PM_{2.5}$ on quartz filters. In all cases the PE results reported from the field were compared to an expected value.

As in previous studies, both the R&P nitrate and sulfate analyzers continued to show reasonably good precision and linear response over a wide the range of concentration. 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. The normalized data indicate that 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.

Two sites, Arizona and Illinois, were able to analyze PE sample sets for carbon using the Sunset field units. Sample sets consisted of three types of 16-mm diameter quartz filter circles. Each set contained blank circles, duplicate circles spiked with sucrose, and duplicate circles loaded with $PM_{2.5}$. NAREL also analyzed a replicate set of samples using a Sunset laboratory analyzer. Both field sites reported OC/EC/TC results that demonstrated good accuracy and precision as well as good agreement with NAREL's analysis.

The Sunset laboratory analyzer used by NAREL as well as the Sunset field units are thermal/optical carbon analyzers which operate by thermally desorbing carbon from a quartz filter segment while monitoring a laser signal transmitted through the filter. During an analysis cycle, OC is first thermally desorbed from the filter segment in a pure helium atmosphere and carried to the detector. Helium/oxygen carrier is then introduced and EC is removed and detected. TC is the sum of the OC and EC. Monitoring of the laser signal is used to optically correct for any EC that may be produced by charring of OC. The measurements produced by laboratory analyzers using the STN method are referred to as thermal OC/EC. A special feature of the Sunset semi-continuous field monitors is the ability to monitor the laser signal transmitted through the sample collection filter and use this optical information to continuously calculate the elemental carbon as it collects on the filter. Subtracting the optically determined EC from the TC produces optical OC. Both thermally calculated OC/EC as well as optically calculated OC/EC is available in the results files generated by the field monitors. The most recent version of software available from Sunset gives the field units a serial output that allows the user to choose either thermal OC/EC or optical OC/EC output to a data acquisition system. In order to be consistent with the STN carbon analysis method, EPA requires that only the thermal OC/EC results should be reported.

Table 2. 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	23-Apr-06	4:42 PM	4500	4527.5	3842.2	2.3	2784	3
Illinois	14-Jun-06	7:00am	4830	4818.1	4229.5	-0.1	3122.1	19
Texas	11-Jul-06	3:00 PM	4216	4076.3	3578.4	1	2206.7	2
****** Span gas concentration as labeled on the bottle (should be approximately 5000 ppb).***								

Table 3. 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***
Arizona	Local blank water	0.5	0	82.8	38.9	1.4	0.84	-8.8
Arizona	Local blank water	0.5	0	65.4	35	1.2	0.84	-9.1
Arizona	Local blank water	0.5	0	67.9	48.4	1.7	0.84	-8.4
Arizona	Local 100ng/µL std	0.5	50	78.1	1466.6	51.4	0.84	60.3
Arizona	Local 100ng/µL std	0.5	50	74.3	1546.2	54.2	0.84	64.2
Arizona	Local 100ng/µL std	0.5	50	72.5	1388.3	48.6	0.84	56.4
Arizona	N1-03-06	0.5	10	64.4	269.2	9.4	0.84	2.3
Arizona	N1-03-06	0.5	10	75.6	251.3	8.8	0.84	1.4
Arizona	N1-03-06	0.5	10	79.5	251.6	8.8	0.84	1.4
Arizona	N2-03-06	0.5	60	74	1568.4	54.9	0.84	65.1
Arizona	N2-03-06	0.5	60	76.6	1580.7	55.4	0.84	65.8
Arizona	N2-03-06	0.5	60	63.4	1381.5	48.4	0.84	56.2
Arizona	N3-03-06	0.5	100	70	2275	79.7	0.84	99.4
Arizona	N3-03-06	0.5	100	71.1	2480.9	86.9	0.84	109.4
Arizona	N3-03-06	0.5	100	73.4	2479.7	86.9	0.84	109.4

Arizona	N4-03-06	0.5	300	59.7	6336.3	222	0.84	296.1
Arizona	N4-03-06	0.5	300	75.8	6718.9	235.4	0.84	314.6
Arizona	N4-03-06	0.5	300	66	6669.7	233.7	0.84	312.2
Arizona	N5-03-06	0.5	380	80.3	7528.8	263.8	0.84	353.8
Arizona	N5-03-06	0.5	380	75.6	7949.7	278.5	0.84	374.1
Arizona	N5-03-06	0.5	380	75.8	8251.4	289.1	0.84	388.8
Illinois	Local blank water	0.5	0	1.1	72.4	2.6	0.85	-10.8
Illinois	Local blank water	0.5	0	-9.4	68.6	2.5	0.85	-10.9
Illinois	Local blank water	0.5	0	-17.2	62	2.2	0.85	-11.3
Illinois	Local 100ng/µL std	0.5	50	-13.2	1435.8	51.5	0.85	60.4
Illinois	Local 100ng/µL std	0.5	50	-6	1391.3	49.9	0.85	58.1
Illinois	Local 100ng/µL std	0.5	50	-15.6	1463.6	52.5	0.85	61.9
Illinois	N1-03-06	0.5	10	-17.4	351.4	12.6	0.85	3.8
Illinois	N1-03-06	0.5	10	-3.2	332.4	11.9	0.85	2.8
Illinois	N1-03-06	0.5	10	-8.1	308.2	11.1	0.85	1.6
Illinois	N2-03-06	0.5	60	-16.8	1593.8	57.2	0.85	68.7
Illinois	N2-03-06	0.5	60	-13.4	1544.8	55.4	0.85	66.1
Illinois	N2-03-06	0.5	60	-7.8	1585.6	56.9	0.85	68.3
Illinois	N3-03-06	0.5	100	-14.6	2230.3	80.1	0.85	102.1
Illinois	N3-03-06	0.5	100	-11.8	2217.5	79.6	0.85	101.3
Illinois	N3-03-06	0.5	100	-16	2199.6	79	0.85	100.5
Illinois	N4-03-06	0.5	300	-11	6002.5	215.5	0.85	299.2
Illinois	N4-03-06	0.5	300	-14	6056.2	217.4	0.85	302.0
Illinois	N4-03-06	0.5	300	-14.4	5894.5	211.6	0.85	293.5
Illinois	N5-03-06	0.5	380	-15.5	7525.8	270.1	0.85	378.7
Illinois	N5-03-06	0.5	380	-7.8	7499.8	269.2	0.85	377.4
Illinois	N5-03-06	0.5	380	-11	7626.7	273.8	0.85	384.1
Texas	Local blank water	0.5	0	21	31	1.2	0.92	-14.9
Texas	Local blank water	0.5	0	11.2	18.7	0.7	0.92	-15.9
Texas	Local blank water	0.5	0	-4	22.8	0.9	0.92	-15.5

Texas	Local 100ng/µL std	0.5	50	10.5	988.1	38.3	0.92	58.4
Texas	Local 100ng/µL std	0.5	50	6.6	1023.7	39.7	0.92	61.2
Texas	Local 100ng/µL std	0.5	50	1.4	1044.8	40.5	0.92	62.7
Texas	N1-03-06	0.5	10	16.6	179.5	7	0.92	-3.4
Texas	N1-03-06	0.5	10	8.6	179.4	7	0.92	-3.4
Texas	N1-03-06	0.5	10	6.8	207.8	8.1	0.92	-1.3
Texas	N2-03-06	0.5	60	4.5	1097.6	42.5	0.92	66.7
Texas	N2-03-06	0.5	60	12.5	1078.2	41.8	0.92	65.3
Texas	N2-03-06	0.5	60	7.4	1157.3	44.8	0.92	71.2
Texas	N3-03-06	0.5	100	0.1	1529.2	59.3	0.92	99.9
Texas	N3-03-06	0.5	100	0.8	1665.8	64.5	0.92	110.1
Texas	N3-03-06	0.5	100	-7.8	1551.9	60.1	0.92	101.5
Texas	N4-03-06	0.5	300	-13.6	4194.4	162.5	0.92	303.7
Texas	N4-03-06	0.5	300	-8.2	4359.2	168.9	0.92	316.4
Texas	N4-03-06	0.5	300	1.8	4447.9	172.4	0.92	323.3
Texas	N5-03-06	0.5	380	1.7	5041.9	195.4	0.92	368.7
Texas	N5-03-06	0.5	380	-0.2	5128.5	198.7	0.92	375.2
Texas	N5-03-06	0.5	380	2.7	4878.8	189	0.92	356.1
****** Results from each site were re-calculated from a calibration curve based upon the PE solutions analyzed at that site.***								

Table 4. 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)	Steady State Check Efficiency
Illinois	14-Jun-06	7:00am	700	694.2	614.6	0	5	99%
Texas	11-Jul-06	3:00 PM	1130	1109.4	952.2	0.2	2	98%

****** Span gas concentration as labeled on the bottle (should be approximately 1000 ppb).***

Table 5. 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***
Illinois	Local blank water	0.5	0	-22.4	4.5	0.4	1.47	17.9
Illinois	Local blank water	0.5	0	14.4	11.1	1.1	1.47	18.6
Illinois	Local blank water	0.5	0	29.4	0.3	0.0	1.47	17.4
Illinois	Local 300ng/µL std	0.5	150	24.7	1259.3	121.1	1.47	141.1
Illinois	Local 300ng/µL std	0.5	150	-13.2	1052.1	101.2	1.47	120.8
Illinois	Local 300ng/µL std	0.5	150	7.9	1148.7	110.5	1.47	130.3
Illinois	S1-03-06	0.5	50	-45.7	492.7	47.4	1.47	65.9
Illinois	S1-03-06	0.5	50	-33.0	504.8	48.6	1.47	67.1
Illinois	S1-03-06	0.5	50	-22.4	555.1	53.4	1.47	72.0
Illinois	S2-03-06	0.5	225	-27.1	2185.8	210.2	1.47	232.1
Illinois	S2-03-06	0.5	225	-13.1	1981.1	190.5	1.47	212.0
Illinois	S2-03-06	0.5	225	-33.5	2047.1	196.9	1.47	218.5
Illinois	S3-03-06	0.5	500	-16.0	4732.1	455.1	1.47	482.3
Illinois	S3-03-06	0.5	500	-13.4	4686.7	450.7	1.47	477.8
Illinois	S3-03-06	0.5	500	24.8	4689.1	451.0	1.47	478.1

Illinois	S4-03-06	0.5	800	-29.6	7748.1	745.2	1.47	778.5
Illinois	S4-03-06	0.5	800	-11.8	7993.7	768.8	1.47	802.6
Illinois	S4-03-06	0.5	800	-6.2	7959.1	765.5	1.47	799.3
Illinois	S5-03-06	0.5	1200	-35.9	12566.9	1208.6	1.47	1251.8
Illinois	S5-03-06	0.5	1200	-23.6	11562.2	1112.0	1.47	1153.2
Illinois	S5-03-06	0.5	1200	5.7	12383.3	1191.0	1.47	1233.9
Texas	Local blank water	0.5	0	8.4	43.4	4.3	1.51	15.0
Texas	Local blank water	0.5	0	-13.5	14.3	1.4	1.51	9.2
Texas	Local blank water	0.5	0	-13.5	22.6	2.2	1.51	10.8
Texas	Local 300ng/µL std	0.5	150	-11.0	715.6	70.9	1.51	147.9
Texas	Local 300ng/µL std	0.5	150	-15.6	662.2	65.5	1.51	137.2
Texas	Local 300ng/µL std	0.5	150	-12.7	653.4	64.7	1.51	135.6
Texas	S1-03-06	0.5	50	-11.2	193.5	19.1	1.51	44.5
Texas	S1-03-06	0.5	50	-15.4	177.1	17.5	1.51	41.3
Texas	S1-03-06	0.5	50	-19.2	193.9	19.2	1.51	44.7
Texas	S2-03-06	0.5	225	-12.0	1156.0	114.4	1.51	234.8
Texas	S2-03-06	0.5	225	-20.8	1061.4	105.0	1.51	216.0
Texas	S2-03-06	0.5	225	-8.4	1072.6	106.6	1.51	219.2
Texas	S3-03-06	0.5	500	-18.9	2314.7	229.1	1.51	463.8
Texas	S3-03-06	0.5	500	-23.4	2507.0	248.1	1.51	501.7
Texas	S3-03-06	0.5	500	-19.2	2362.6	233.8	1.51	473.2
Texas	S4-03-06	0.5	800	-6.6	4204.1	416.1	1.51	837.2
Texas	S4-03-06	0.5	800	1.9	4429.5	438.4	1.51	881.7
Texas	S4-03-06	0.5	800	-4.9	4302.0	425.7	1.51	856.3
Texas	S5-03-06	0.5	1200	6.5	5955.3	589.3	1.51	1183.0
Texas	S5-03-06	0.5	1200	-17.0	5667.6	560.9	1.51	1126.3
Texas	S5-03-06	0.5	1200	-5.2	6047.1	598.4	1.51	1201.2

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

Table 6. Carbon Reported Results

Sample ID	Sample Description	AZ Results (µg/sample)			IL Results (µg/sample)			NAREL Results – STN Method (µg/sample)		
		EC	OC	TC	EC	OC	TC	EC	OC	TC
C1	blank filter	0.00	2.98	2.98	0.00	2.99	2.99	0.00	0.29	0.29 +/- 0.61
C1 dup	blank filter	0.00	3.65	3.65	0.00	1.73	1.73	0.00	0.38	0.38 +/- 0.62
C2	40 ugC sucrose spike	0.00	42.50	42.50	0.00	38.53	38.54	0.00	39.61	39.61 +/- 2.28
C2 dup	40 ugC sucrose spike	0.00	41.51	41.51	0.00	39.30	39.30	0.00	39.84	39.84 +/- 2.29
C3	ambient PM2.5	4.81	51.35	56.16	3.89	49.13	53.02	3.78	54.40	58.17 +/- 3.51
C3 dup	ambient PM2.5	4.65	53.25	57.90	3.79	50.40	54.19	3.83	53.12	56.95 +/- 3.45