ADVANCED SAMPLING AND DATA ANALYSIS FOR SOURCE ATTRIBUTION OF AMBIENT PARTICULATE ARSENIC AND OTHER AIR TOXICS METALS IN ST. LOUIS

Final Technical Report
US EPA Grant XA987912-01

Missouri
Department of
Natural Resources

Air Pollution Control Program and
Environmental Services Program

Washington University, St. Louis
Department of Energy,
Environmental, and Chemical
Engineering

March 2010

CONTENTS

APPENDICES

EXECUTIVE SUMMARY

This report presents the results of measurement and analysis funded under Grant XA987912-01 from the United States Environmental Protection Agency (US EPA) to the Missouri Department of Natural Resources (MDNR). The period of performance for the grant was from October 1, 2007 to December 31, 2009.

The St. Louis Community Air Project featured detailed measurements of air toxics in an urban residential neighborhood. Annual-average ambient concentrations were compared to benchmarks for 1 in 100,000 increased cancer risk from a 70-year exposure sustained at the observed annual-average ambient concentration. Hazardous air pollutants (HAPs) of concern identified through this process included arsenic. For the St. Louis CAP study, the annual average (2001-2003) $PM_{2.5}$ arsenic concentration was 2.0 nanograms per cubic meter (ng/m^3), which was at the established benchmark of 2 ng/m^3 for designation as a pollutant of concern for increased cancer risk. More recent measurements show levels of arsenic similar to those observed in the CAP study but also highlight challenges in performing data reduction and understanding the behavior of airborne arsenic in the urban environment. The minimum detection limit (MDL) for arsenic of 1.6 ng/m^3 for the Chemical Speciation Network (CSN) is close to the benchmark concentration and is high enough that a significant fraction of samples are nondetects. Measurements at the Blair Street station in St. Louis as a part of the National Air Toxics Trends Stations (NATTS) program using high volume PM_{10} samplers and inductively coupled plasma-mass spectrometry (ICP-MS) analysis provide lower detection limits (on the order of 0.02 ng/m^3) with a 1.4 ng/m^3 2005-2008 average at the single St. Louis area site .

Metal smelting operations, cement kilns, agricultural burning, and combustion engines are all sources of arsenic compounds. Other sources include tobacco smoke, wood burning (treated and untreated), gasoline, oil, coal, and use of arsenic-containing pesticides and herbicides. Multiple industrial and other area sources release small quantities of arsenic compounds that are difficult to estimate and include in existing emission inventories. The 1996 National Toxics Inventory for St. Louis City indicates an annual release of about 500 pounds of arsenic compounds, 94% from industrial sources. Ambient arsenic concentrations in the US have been modeled based on known emissions as a part of the National-Scale Air Toxics Assessment (NATA). The 1999 NATA reported that the modeled concentration in the census tract that includes the Blair Street station was 0.25 ng/m^3. This concentration is an order of magnitude lower than the measured concentration, suggesting that the inventory of arsenic sources may be incomplete, and suggesting that more measurement of ambient arsenic concentrations would be beneficial.

This project sought to more comprehensively understand the temporal and spatial variability of arsenic and other air toxic metals with the use of more extensive and intensive monitoring and of new monitoring and data analysis methods. Our hope was to discern where and under what conditions the highest levels of certain metals are occurring, and to increase our ability to say what sources may be causing them. This project has advanced our ongoing effort to investigate and address HAPs of concern in St. Louis. It demonstrates the use of a suite of measurement strategies towards understanding pollutant behavior on various temporal and spatial scales, and as such can serve as a national model for similar studies. The core objectives of the project were to describe the climatology of and develop a conceptual model (including identifying sources) for ambient particle arsenic and selected other air toxics metals in the St. Louis area.

The work proceeded in two phases. Phase I featured operation of a network of four PM_{10} air toxics metals sampling sites. 24-hour integrated PM_{10} samples were collected at 1-in-3 day frequency at four sites in the St. Louis area for one year and analyzed by ICP-MS. Sampling and analysis protocols generally followed the NATTS air toxics procedure with minor modifications. The 1-in-3 day frequency, which is double the NATTS 1-in-6 day frequency, was intended to provide enough data from one year of measurements to support detailed exploratory data analyses. One sampling site was the Blair Street station. Sampling at that site provided a direct linkage between this one-year study and the sustained NATTS measurements. The chemical analysis was performed independently from the NATTS program; thus, the Blair Street data provide an important quality check. The two urban sites, Blair Street and Hall Street, are located in the City of St. Louis near the industrialized Mississippi Riverfront. Two suburban sites, Washington University and Arnold, are located about 10 km west and 25 km south/southwest of the urban core, respectively.

Phase II featured high time resolution measurements at six sites for periods of nominally one month each. A Cooper Environmental Services (CES) Xact Ambient Air Toxics Monitor (AATM) was used to collect and analyze ambient particulate matter at high time resolution and with sufficient air volume sampled to overcome detection limit issues. Samples were typically collected and analyzed with time resolution of two hours.

In addition to field sampling, laboratory analysis, and analysis of data generated by this study, MDNR staff analyzed the ambient PM_{10} arsenic data collected from 2005 through 2008 at the Blair Street NATTS, reviewed the National-Scale Air Toxics Assessments (NATA), and compared annual average arsenic concentrations to cancer risk benchmarks. These concentrations were greater than the ambient concentration associated with a cancer risk of 1-in-1,000,000 for all four years, varying between five and 12 additional cases of cancer per 1,000,000 people exposed for 70 years. The National Emissions Inventories (NEI) identified fossil fuel electric power generation facilities as the largest emitters of arsenic compounds in the seven surrounding counties and St. Louis City, but there was some apparent inconsistency between the inventory used in the NATA modeling and the NEI.

One year of 1-in-3 day air toxics metals measurements at four sites in St. Louis (Phase I) has provided important insights into the spatial variability of PM_{10} arsenic. The Blair Street NATTS site is strongly influenced by both regional and local sources. Annual-average arsenic is about evenly apportioned between these two emission source scales. Air mass trajectory analyses implicate the eastern United States, and in particularly the Ohio River Valley, as a major source of arsenic transported to St. Louis. Surface winds analyses identified a spatial zone northeast of the Blair Street station and nominally along the industrial Mississippi Riverfront as a major source of local arsenic emissions. Annual-average arsenic across the four-site network was below the 2 ng/m^3 health-based benchmark established for the St. Louis Community Air project. In the case of Blair Street, however, annual-average PM_{10} arsenic was within a factor of two of that benchmark. The data generated from this study – in particular the apportionment of PM_{10} arsenic into local and regional contributions – could be used in validating the NATA modeling.

PM_{10} selenium exhibits spatial patterns grossly similar to arsenic with a high regional contribution. Local contributions are estimated to be at most 30% of the annual-average selenium. PM_{10} lead in is strongly influenced by the lead smelter south of St. Louis with relatively high impacts at the suburban Arnold site.

One-month deployments of the Xact instrument at six sites in St. Louis (Phase II) have demonstrated the potential for such measurements to identify local emission source bearings that could not otherwise be extracted from the 24-hour average data. The wind direction dependence of arsenic is consistent with a significant contribution from regional transport. Relatively higher arsenic was observed for surface winds from the southeast, and in many cases this corresponds to synoptic transport from the eastern United States. Local emission source impacts are clearly evident at the Blair NATTS station and include an intermittent emitter northwest of the site. Other features observed in the Blair data are consistent with the four-site filter-based network results, but the low frequency of wind directions from certain sectors precludes a detailed comparison. Most sites show a strong lead signature for winds from the south, consistent with the bearing of the Doe Run Herculaneum lead smelter. This observation is consistent with the results from the four-site filter-based network with the higher time resolution Xact measurements sharpening the relationship between wind direction and high concentration excursions. This data set provides preliminary information about the behavior of air toxics metals in St. Louis. A refined analysis would require longer duration deployments to more thoroughly capture the climatological surface winds patterns.

On April 13, 2009, an unusually high arsenic concentration, a two- hour average arsenic concentration of 2,345 ng/m^3 was monitored from 10 AM to 12 noon at the East St. Louis site. This data point appears to be of reasonable quality. This observation helps to demonstrate the value of shorter time scale measurements to help identify potential emission sources.

Recommendations for future work, as resources allow, include:

- Review by Missouri and Illinois agencies of the elevated arsenic levels monitored on April 13, 2009 at the East St. Louis site to determine the source of these emissions and take corrective actions as appropriate.

- Improvement of the toxic metals inventory to allow a greater understanding of the potential ambient air quality and reconciliation of modeled and monitored concentrations.

- Longer term deployments of the Xact instrument at multiple sites to obtain a representative number of observations from each wind direction. Deployment length could be determined by routine examination of the air quality and meteorological data being collected.

- Analysis of data from this study and from future deployments of the Xact to better determine data quality for other elements in addition to the ones focused on in this study.

- Additional receptor modeling using these data after identifying the subset of elements that have sufficiently high quality to be included in such modeling.

1.0 INTRODUCTION

This report presents the results of measurement and analysis funded under Grant XA987912-01 from the United States Environmental Protection Agency (US EPA) to the Missouri Department of Natural Resources (MDNR). The period of performance for the grant was from October 1, 2007 to December 31, 2009.

1.1 Background and Motivation

The St. Louis Community Air Project (CAP, 2005) featured detailed measurements of air toxics in an urban residential neighborhood. Annual-average ambient concentrations were compared to benchmarks for 1 in 100,000 increased cancer risk from a 70-year exposure sustained at the observed annual-average ambient concentration. Six hazardous air pollutants (HAPs) of concern were identified through this process (**Table 1-1**) and the Missouri Department of Natural Resources (MDNR) has taken a proactive approach to addressing these CAP findings. Formaldehyde exhibited the highest ambient concentrations relative to the cancer benchmarks. Thus, a second phase of measurements was commissioned which included both urban and rural integrated sampling and a UV-DOAS deployment for continuous formaldehyde measurements. Key findings from that work are summarized in the CAP final report (CAP, 2005). The agency subsequently turned its attention to toxic metals, most importantly, arsenic. Table 1-1 also includes the eleven pollutants of concern for St. Louis identified from the 2005 Urban Air Toxics Monitoring Program (UATMP, 2006). Arsenic is one of four pollutants common to both lists (italics) and air toxic metals (underlined) account for two of the CAP pollutants of concern and three of the UATMP pollutants of concern.

Table 1-1. Air Toxic Pollutants of Concern (City of St. Louis)

CAP Study	2005 UATMP
o *acetaldehyde*	o *acetaldehyde*
o *arsenic*	o *arsenic*
o *benzene*	o *benzene*
o *formaldehyde*	o *formaldehyde*
o chromium$^{(1)}$	o 1,3-butadiene
o "diesel exhaust"$^{(2)}$	o p-dichlorobenzene
	o cadmium
	o carbon tetrachloride
	o hexaclhoro-1,3-butadiene
	o manganese
	o tetrachlorethylene

(1) Chromium not reported as pollutant of concern for 2005 UATMP due to filter contamination.

(2) "Diesel exhaust" not measured as part of the CAP study but was deemed a pollutant of concern by the stakeholder

Heavy metals are of significant concern as air toxics and indeed metals and/or metal compounds represent eight of the thirty-three species considered as priority pollutants in the US EPA Integrated Urban Air Toxics Strategy (64 FR 38706-38740). For the St. Louis CAP study, the annual average (2001-2003) PM$_{2.5}$ arsenic concentration was 2.0 nanograms per cubic meter (ng/m^3) which was at the established benchmark of 2 ng/m^3 for being designated as a pollutant of concern for increased cancer risk. More recent measurements show levels of arsenic similar to those observed in the CAP study but also highlight some of the challenges in both performing data reduction and understanding the true behavior of these species in the urban environment.

Table 1-2 summarizes the annual average arsenic concentrations for 2000 through July 2009. Measurements were conducted at Arnold (a suburban site about 30 kilometers (km) south of the City of St. Louis central business district (CBD); Blair Street[1] (an urban site about five km north of the CBD), and Bonne Terre (a rural site about 85 km south of St. Louis) using $PM_{2.5}$ Chemical Speciation Network (CSN) samplers. Assuming a representative minimum detection limit (MDL) for arsenic of 1.6 ng/m^3 for the CSN data (the MDL varies by sampler type and laboratory performing the XRF analysis), 42% of the 1093 samples collected at Blair Street are below this effective MDL and only 0.3% of the samples have concentrations more than ten times the MDL. The other two $PM_{2.5}$ sites have even lower signal-to-noise and thus spatial patterns in arsenic cannot be inferred from the $PM_{2.5}$ data.

Table 1-2. Annual Average Arsenic Concentration(1), ng/m^3

	PM_{10} - NATTS	$PM_{2.5}$ - CSN		
	Blair St.	Blair St.	Arnold	Bonne Terre
2000	--	1.6	--	--
2001	--	2.0	2.6	--
2002	--	1.9	1.9	--
2003	2.5(2)	2.6	2.0	0.9
2004	1.6	2.9	2.5	1.1
2005	2.4	2.6	2.2	1.0
2006	1.0	1.7	1.5	0.9
2007	1.9	1.7	1.3	0.7
2008	1.0	1.4	1.5	0.7
2009(3)	1.7	1.7	0.9	0.7

(1) ½ MDL imputed for non-detects
(2) July – December only
(3) NATTS: January – September only; CSN: January – July only

Figure 1-1a further demonstrates the limitations of the CSN data for characterizing arsenic. Both Blair St. and Arnold exhibit similar annual mean concentrations which are greater than observed at the rural site (the prevalence of samples below MDL, including non-detects, confounds a quantitative comparison). However, there are very few days with at least one site exhibiting an arsenic concentration above three times the MDL (about 4.5 ng/m^3) and thus relatively few days are available to examine the drivers for intraurban variability. For the few samples at least three times the MDL, there is poor correlation in concentrations between the two sites. Taken together with the urban/rural contrast data, this suggests there are significant local (urban scale)

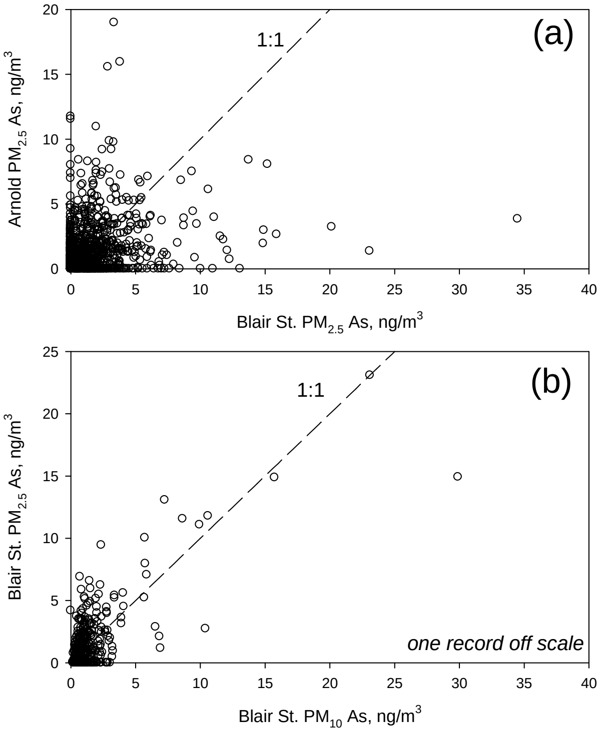

Figure 1-1. 24-hour integrated Arsenic concentrations: (a) $PM_{2.5}$ As at the Arnold and Blair Street sites, 2001-2009; and (b) $PM_{2.5}$ and PM_{10} As at the Blair Street site, 2003- September 2009.

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[1] The Blair Street site is also one of the original NATTS sites and features a battery of HAPs measurements.

sources of arsenic.

CSN data provide an opportunity to examine spatiotemporal patterns for many PM$_{2.5}$ components. In the St. Louis area, routine measurements are currently conducted at three sites: Blair Street in the City of St. Louis, which is one of the 54 Speciation Trends Network (STN) sites; Arnold, MO; and Granite City, IL. Two additional PM$_{2.5}$ speciation monitoring will be start operations in 2010: Roxana, IL, which will be operated by Washington University for the period 2010-2014; and Belleville, IL, which will be operated by ARA for at least three years. MetOne SASS samplers will be used at all of these sites, and XRF will be used to determine elemental composition. Unfortunately, as described above the data quality for arsenic from CSN measurements is inferior to quantify concentrations at levels of interest such as the aforementioned 2 ng/m^3 benchmark. This conclusion is reinforced by examining sample-specific relationships between concentration and the associated uncertainty. **Figure 1-2** shows the cumulative distribution of PM$_{2.5}$ concentrations measured at the Blair Street site scaled to the sample-specific minimum detection limit (MDL). 24% of the samples were no-detects (reported concentration of zero), 13% of the concentration values exceeded 3×MDL, and only 1.2% of the concentration values exceeded 10×MDL. To place these data in context, **Figure 1-3**

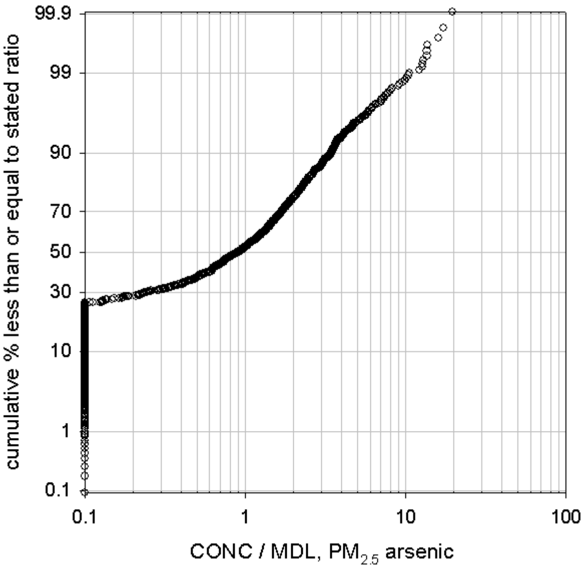

Figure 1-2. Cumulative distribution of PM$_{2.5}$ arsenic concentration scaled to the sample-specific MDL for Blair Street CSN data, February 2000 – July 2009 (N = 1,091). Concentration-to-MDL ratios below 0.1 were reset to 0.1 prior to making this plot.

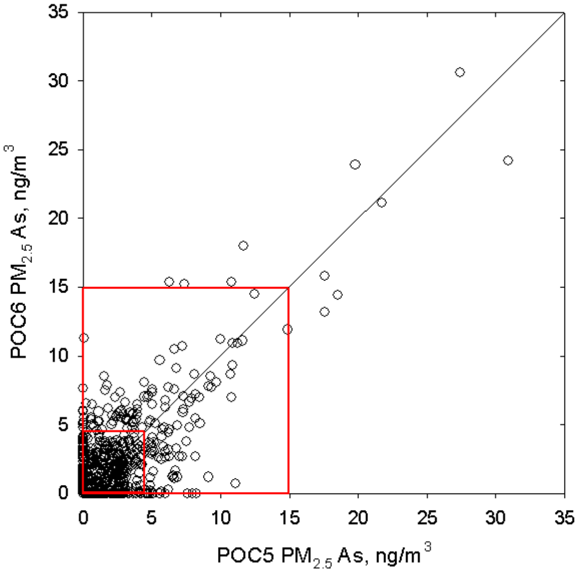

Figure 1-3. Collocated PM$_{2.5}$ arsenic data from the G.T. Craig CSN site in Cleveland, OH, for the period May 2001 – May 2009. Red squares denote concentration windows 3×MDL and 10×MDL for the median MDL value 1.5 ng/m^3.

shows collocated $PM_{2.5}$ arsenic data collected at the G.T. Craig site in Cleveland, OH, using MetOne SASS samplers. The small and large red squares represent 3×MDL and 10×MDL, respectively, based on the median MDL of 1.5 ng/m^3 reported for both the Blair and Craig sites. Given that 87% of the Blair Street data would fall within the small red square and 98.8% of the Blair Street data would fall within the large red square, it is clear that the $PM_{2.5}$ arsenic data for Blair Street suffers from very poor measurement precision. (Note: this does not relate to overall precision of Blair $PM_{2.5}$ speciation data, but only to limitations specific to $PM_{2.5}$ arsenic results).

Table 1-2 also lists the arsenic concentrations measured at Blair Street using a PM_{10} sampler with sampling and analysis protocols adopted for the National Air Toxics Trends Sites (NATTS) network. This approach captures particles over a broader portion of the inhalable size range and also features much better detection limits (on the order of 0.02 ng/m^3) than the conventional $PM_{2.5}$ speciation method. Virtually all of the PM_{10} arsenic concentrations are greater than ten times the MDL. Annual average concentrations for PM_{10} and $PM_{2.5}$ arsenic are similar (Table 1-2), and one might conclude that the day-to-day difference would merely reflect that the measurements are often near the $PM_{2.5}$ arsenic detection limit. However, Figure 1b shows that there is significant day-to-day variability in the relationship between $PM_{2.5}$ arsenic and PM_{10} arsenic and, disconcertingly, there are numerous days with $PM_{2.5}$ arsenic concentrations greater then three times the MDL yet with $PM_{2.5}$ arsenic much greater than the PM_{10} arsenic. This behavior cannot be explained by differences in the cutpoint curves for the samplers and is attributed to large uncertainties in the CSN x-ray fluorescence (XRF) measurements for concentrations near (within a factor of ten of) the MDL.

PM_{10} arsenic annual average concentrations measured at Blair Street are of the same order of magnitude as those measured at other NATTS sites in the US (www.epa.gov/air/data/reports.html, and Eastern Research Group, National Air Toxics Trends Sites Data Characterization, 2004-2007, September 2009). However, maximum 24-hour concentrations measured at Blair Street are frequently higher than those measured at other sites. These high individual day measurements suggest that there may be localized sources whose impact is only observed at a specific location when meteorological conditions are optimal for impacting that location. Thus, measurements at more sites using approaches with suitable detection limits will improve the characterization of ambient arsenic concentrations and provide data suitable for quantitative analysis including source apportionment.

Metal smelting operations, cement kilns, agricultural burning, and combustion engines are all sources of arsenic compounds. Other sources include tobacco smoke, wood burning (treated and untreated), gasoline, oil, coal, and use of arsenic-containing pesticides and herbicides. Multiple industrial and other area sources release small quantities of arsenic compounds that are difficult to estimate and include in existing emission inventories. The 1996 National Toxics Inventory for St. Louis City indicates an annual release of about 500 pounds of arsenic compounds, 94% from industrial sources. Ambient arsenic concentrations in the US have been modeled based on known emissions as a part of the National-Scale Air Toxics Assessment (NATA). The modeled concentration in the census tract that includes the Blair Street station is 0.25 ng/m^3 (www.epa.gov/ttn/atw/nata1999). This concentration is an order of magnitude lower than the measured concentration, suggesting that the inventory of arsenic sources may be incomplete, and suggesting that more measurement of ambient arsenic concentrations would be beneficial.

In summary:

- Ambient particulate matter arsenic has been identified as a pollutant of concern for St. Louis by both the St. Louis Community Air Project (CAP) study and the 2005 UATMP analysis.

- While $PM_{2.5}$ speciation network monitoring yields annual-average arsenic concentrations similar to annual-average PM_{10} arsenic from the air toxics program, arsenic intraurban variability at finer time scales (which could be used to infer emission source locations) cannot be determined due to the low signal-to-noise for the $PM_{2.5}$ speciation network arsenic data.

- PM_{10} arsenic from the air toxics program has high signal-to-noise (virtually all concentrations are more than ten times the MDL) and a network of such integrated measurements, complemented by additional high time resolution measurements, could be used to examine intraurban variability and identify emission source regions.

This project sought to more comprehensively understand the temporal and spatial variability of arsenic and other air toxic metals with the use of new monitoring and data analysis methods. Our hope was to discern where and under what conditions the highest levels of certain metals are occurring, and to increase our ability to say what sources may be causing them. This project has advanced our ongoing effort to investigate and address HAPs of concern in St. Louis. It demonstrates the use of a suite of measurement strategies towards understanding pollutant behavior on various temporal and spatial scales, and as such can serve as a national model for similar studies.

2.0 OBJECTIVES AND PROJECT PLAN

2.1 Project Objectives

The core objectives of the project were to describe the climatology of and develop a conceptual model (including identifying sources) for ambient particle arsenic and selected other air toxics metals in the St. Louis area.

The work proceeded in two phases. Phase I featured operation of a network of four PM_{10} air toxics metals sampling sites to refine our understanding of the spatial distribution of ambient particle arsenic burdens. Compared to $PM_{2.5}$ speciation monitoring this approach provides improved method detection limits due to the larger air volumes sampled. Variations in surface meteorology during sample collection still presented a limitation for interpreting data from this 24-hour integrated sampling, but the spatial coverage of the network provided an opportunity to constrain the probability fields for arsenic emissions. Samples were collected every third day for one year and analyzed by inductively coupled plasma-mass spectrometry (ICP-MS).

Phase II featured high time resolution measurements at six sites for periods of nominally one month each. A Cooper Environmental Services (CES) Xact Ambient Air Toxics Monitor (AATM) was used to collect and analyze ambient particulate matter at high time resolution and with sufficient air volume sampled to overcome detection limit issues. Samples were typically collected and analyzed with time resolution of two hours; some data were collected at one hour resolution.

2.2 Project Overview

Overall project planning, field measurement, and some data analysis and reporting were conducted by MDNR. Assistance with study design, Phase I chemical analysis, source apportionment and other data analysis and much of the reporting were done by Washington University in St. Louis (WUSTL). CES provided the CES Xact AATM used in Phase II and also provided training of MDNR field monitoring personnel in instrument setup and operation.

2.2.1 Phase I – Spatially and Temporally Enhanced 24-hour Integrated Measurements

Motivation. The St. Louis area has multiple $PM_{2.5}$ speciation monitoring sites, but the arsenic data quality is inadequate to probe intraurban variability and identify potential emission source locations. These goals were addressed by deploying and operating a network of PM_{10} samplers following the NATTS/UATMP metals sampling and analysis protocols. Phase I of this project included one year of 1-in-3 day PM_{10} metals measurements at four sites in the St. Louis area. About 120 samples were collected at each site and analyzed. This data set has been used to refine our understanding of ambient arsenic burdens and to narrow the probability fields for major arsenic emission source locations.

Ambient Sampling. 24-hour integrated PM_{10} sampling was conducted at 1-in-3 day frequency at four sites in the St. Louis area (**Figure 2-1**, circles and squares). Sampling and analysis protocols generally followed the NATTS air toxics procedure with minor modifications as noted in Appendix C. Quality Assurance activities included system audits and performance audits performed by the independently-reporting MDNR Air Quality Assurance Unit (AQAU). The 1-in-3 day frequency, which is double the NATTS 1-in-6 day frequency, was intended to provide enough data from one year of measurements to support detailed exploratory data analyses. One sampling site was the Blair Street station. Sampling at that site provided a direct linkage between this relatively short-term study (one year) and the sustained NATTS measurements. The chemical analysis was performed independently from the NATTS program; thus, the Blair Street data provide an important quality check. An additional site was to the west of central St. Louis on the Washington University campus. A third site was the Hall Street station near the Mississippi River to the north of central St. Louis. The fourth site was the $PM_{2.5}$ speciation site in Arnold (which has recently been relocated to a site, called Arnold West, that better meets siting criteria), since this site and Blair Street exhibit similar annual metrics for arsenic but poor day-to-day correlation. The two urban sites, Blair Street and Hall Street, are located in the City of St. Louis near the industrialized Mississippi Riverfront and about 3 and 7 km north of the urban core, respectively. Two suburban sites, Washington University (WashU) and Arnold, are located about 10 km west and 25 km south/southwest of the urban core, respectively. Meteorological monitoring was conducted by St. Louis City at the Blair Street site and by ESP/MDNR at the Arnold site. **Table 2-1** summarizes the site characteristics.

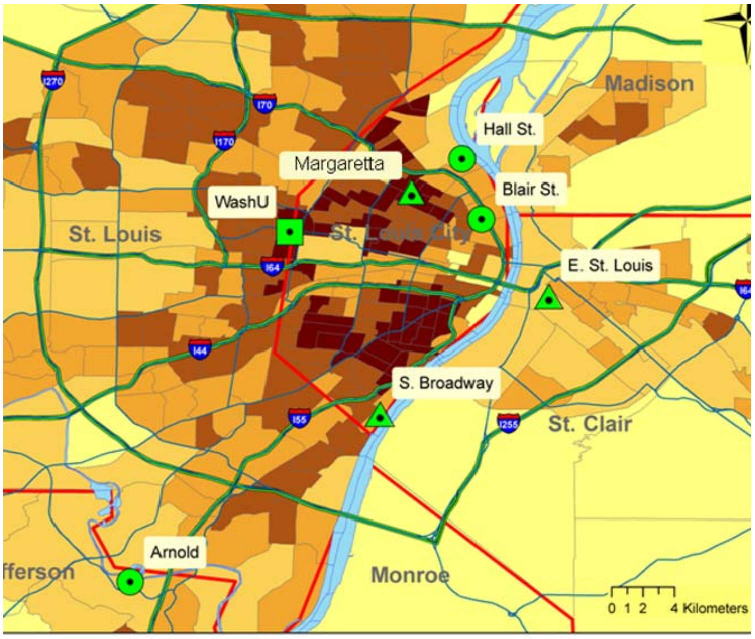

Figure 2-1. St. Louis area sampling sites for PM_{10} air toxics metals by 24-hour integrated HiVol sampling and 2-hour integrated Xact: HiVol only (square); HiVol and Xact (circles); and Xact only (triangle).

Elemental Analysis of Arsenic and Selected Other Air Toxics Metals. Elemental analysis of the Phase I PM_{10} filter samples was performed at WUSTL for arsenic and other selected elements using ICP-MS. Sample digestions were performed in an HCl/HNO_3 matrix using a "hot block" and analyzed using an Agilent Technologies 7500ce ICP-MS. Arsenic quantification can be confounded by an isobaric polyatomic ion interference from argon chloride, with the chlorine originating from complex sample matrices (Brown et al., 2004) or from the sample digestion reagents. However, the WUSTL ICP-MS unit is equipped with an Octopole Reaction System (ORS), also known as a collision cell, which efficiently suppresses this interference. Laboratory quality assurance followed best practices including suitable frequencies of multi-point calibrations, single-point check samples, and replicate analyses. Extraction recoveries were evaluated using a NIST Standard Reference Materials (SRM) for urban dust and coal fly ash. Performance evaluation included comparisons between the ERG and WUSTL data for collocated samples collected at the Blair Street site. Quality assurance protocols are described in detail in the QAPP.

Data Analysis. As described in Section 4.0, we performed a variety of data analyses to characterize the climatology of arsenic and selected other air toxics metals in St. Louis. The combination of four sites and relatively high sampling frequency supported trend analyses with substantial statistical power. Conditional probability function plots and nonparametric regression (Henry *et al.* 2002, Yu *et al.* 2004) using concentration data and surface winds were performed to identify likely emission source locations. The design of the four-site network was exploited to apportion daily concentration values into contributions from urban- and regional scale sources and contributions from neighborhood- and microscale sources.

2.2.2 Phase II - High Time Resolution Measurements

Motivation. High time resolution measurements of air toxics metals can provide tremendous insights into their climatology and emission sources. While Phase I focused on 24-hour integrated sampling and provided very useful information, it has two major limitations towards source identification and emissions quantification. First, sample collection is quite labor intensive to compile a large database for analysis. Second, even if such a database is assembled, variations in emissions and/or wind fields over the course of a day smear out what is otherwise a crisp signal such as a distinct plume event. No statistical analysis can tease out the temporal features lost by time averaging. High time resolution measurements circumvent these issues by collecting a large volume of data in a short deployment and providing data at time scales similar to the meteorological variations.

Ambient Sampling. Elemental concentration values in PM_{10} were quantified at high time resolution using an Ambient Metals Monitor (Xact 620, Cooper Environmental Services, Portland, OR). This instrument features ambient particulate matter collection at 16.7 LPM onto a PTFE filter tape for a user-defined sampling period. The filter tape is subsequently advanced to transfer the deposit (½ - ¾ cm^2) into an analysis chamber where the elemental mass loadings are quantified by energy dispersive XRF. Simultaneous collection of a new deposit while the previous deposit is being analyzed provides a continuous stream of elemental data at the user-defined sampling time base. The selection of this time base depends on the measurement objectives. Longer sampling time bases provide greater measurement sensitivity because a larger air volume is sampled (and thus more particle mass is deposited onto the filter tape) and the XRF analysis time is longer (indeed, nearly equal to the sampling time). Both of these factors lower the minimum detection limit (MDL) which are reported by the manufacturer for time bases from 15 minutes to 4 hours. **Figure 2-2** (solid line) shows the reported MDL values for arsenic. The dashed line is the corresponding MDL for 15-minute sampling time and XRF analysis times up to four hours. The compounding benefits of increased deposit mass and increased XRF analysis time are evident from Figure 2-2. However, longer time bases necessarily sacrifice the time resolution of the resulting data set and too much mass deposited onto the filter tape can cause excessive pressure drop which affects the air flow sampling rate. These tradeoffs must be considered when choosing a time base.

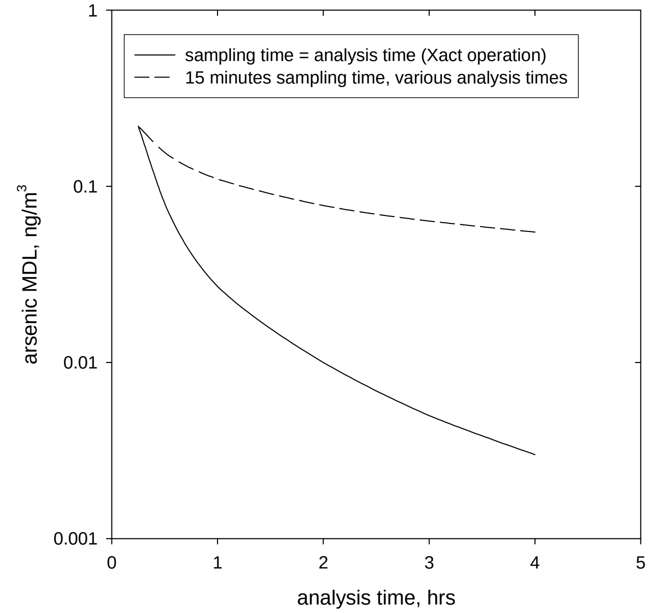

Figure 2-2. Dependence of MDL on XRF analysis time for a 15 minute sampling time (dashed line) and a sampling time equal to the XRF analysis time (solid line). The latter case represents Xact operation.

The Xact instrument uses a molybdenum tube anode and a silicon drift detector. The excitation energy is ~50 keV and given the focus on arsenic in this project, the detector was optimized for measurements in the 8-12 keV range. In this study the instrument was used to measure 25 elements with atomic numbers from K to Pb including ten of the eleven air toxics metals (Cr, Mn, Co, Ni, As, Se, Cd, Sb, Hg and Pb) excluding Be which cannot be detected because the molybdenum anode has a beryllium window. No data were recorded for Mo because this is the anode material, and Pd measurements correspond to an internal standard because a Pd rod was placed immediately below the filter tape to track long-term drift in analysis system. The additional thirteen elements quantified in this study were K, Ca, Ti, V, Fe, Cu, Zn, Ga, Br, Ag, Sn, Ba, and Th. Calibrations are performed using pure element standards with the sample mass deposited onto Nuclepore substrates. Exceptions included As and Cd with standards of GaAs and CdSe, respectively, and Hg which was calibrated using sensitivity curves based on elements with similar atomic number. Elemental mass densities on the filter are determined using spectrum analysis and quantification software which uses the calibration standards as a reference spectrum library for deconvolution of the sample spectra.

The sampling and analysis instrument system was installed in a transportable shelter that was be moved between sampling locations. On-site meteorology (wind speed and direction, temperature) was collected using a 10 meter tower attached to the side of the shelter. Six deployments – each nominally one-month in duration – were conducted over a twelve-month period. These deployments were originally planned to occur over a nine-month period, but relocation of the system from the first location was delayed because of initial operational difficulties, as discussed in the appendix. The circles and triangles in Figure 2-1 show the Xact monitoring locations with the site characteristics are summarized in Table 2-1.

The Department of Natural Resources (MDNR) Field Services Division, Environmental Services Program operated and maintained the Xact instrument. Measurements commenced at Blair on 8/18/08; there were several hardware and software issues that resulted in relatively low data capture during the first four months. The X-ray tube anode failed in mid-November and measurements restarted on 12/13/08 after replacing the anode and high voltage power supply, and recalibrating the XRF system.

Data Analysis. As described in Section 5.0, the data were interpreted by examining the wind direction dependence of 2-hour average concentration. Both concentrations and surface winds can vary dramatically over the course of a conventional 24-hour sampling period which will smear the relationship between these parameters. In contrast, the high time resolution measurements provide a more direct linkage between observed concentrations and the bearings of putative emissions sources. We intended to perform multivariate receptor modeling on these data. While the data quality for certain elements (including arsenic) has been established, additional work is needed to determine the data quality for many of the measured elements that would be included in the multivariate receptor modeling. This data quality evaluation is in progress but is beyond the scope of the tasks programmed for this project.

3.0 MODELED ARSENIC CONCENTRATIONS AND ARSENIC EMISSIONS INVENTORY

3.1 Background

MDNR staff analyzed the ambient PM_{10} arsenic (Chemical Abstracts Service Number 7440-38-2) data collected from 2005 through 2008 at the National Air Toxics Trends Station (NATTS) located in census tract 29510126700 in St. Louis City. Staff obtained ambient air data collected at the Blair Street NATTS monitor (AIRS ID 29-510-0085) from the U.S. Environmental Protection Agency's (EPA) Air Quality System Data Mart. MDNR staff also compared these annual arithmetic mean PM_{10} arsenic concentrations to the ambient arsenic concentration associated with a 70-year exposure and a cancer risk of 1-in-1,000,000. U.S. EPA's Integrated Risk Information System identified this ambient arsenic concentration as 2E-04 micrograms per cubic meter ($\mu g/m^3$). Table 3-1 presents these ambient PM_{10} arsenic concentrations and the estimated excess cancer risk associated with a 70-year exposure to these annual arithmetic mean PM_{10} arsenic concentrations measured from 2005 through 2008.

U.S. EPA's Air Quality System Data Mart provided the annual arithmetic means determined from sets of between 59 and 63 observations per year. These data showed that the annual arithmetic mean PM_{10} arsenic concentrations decreased haltingly from 0.002328 to 0.000959 $\mu g/m^3$ between 2005 and 2008. Though the annual arithmetic mean PM_{10} arsenic concentrations decreased during these four years, these concentrations were still greater than the ambient concentration associated with a cancer risk of 1-in-1,000,000 for all four years. During this time, the excess cancer risks associated with the annual arithmetic mean PM_{10} arsenic concentrations fell between five and 12 additional cases of cancer per 1,000,000 people exposed for 70 years.

3.2 Modeled Arsenic Concentrations

MDNR staff also compared the 2005 to 2008 NATTS annual arithmetic mean PM_{10} arsenic concentrations to the Assessment System for Population Exposure Nationwide (ASPEN) computer air dispersion model estimates for arsenic and arsenic compounds found in the 1999, 2002, and draft 2005 National-Scale Air Toxics Assessments (NATA). Except for the 1999 NATA, the ASPEN model estimates for arsenic and arsenic compounds agreed favorably well with the 2005 to 2008 NATTS annual arithmetic mean PM_{10} arsenic concentrations. Furthermore, the ASPEN computer air dispersion model estimates for arsenic and arsenic compounds of the 2002 and draft 2005 NATA predicted excess cancer risks that also agreed favorably well the excess cancer risks associated with the 2005 to 2008 NATTS annual arithmetic mean PM_{10} arsenic concentrations. These agreements between the ambient monitoring data and the model estimates support the argument that the 2005 to 2008 NATTS annual arithmetic mean PM_{10} arsenic concentrations were an accurate reflection of ambient air quality.

The ASPEN computer air dispersion model also estimated the concentrations of arsenic and arsenic compounds attributable to major, area, and mobile sources; and to background and to total emissions in census tract 29510126700 in St. Louis City (Table 3-2). Between 1999 and 2005, the ASPEN computer air dispersion model estimated that the concentrations of arsenic and arsenic compounds attributable to total emissions increased from 2.473E-04 to 1.720E-03 μg/m^3. Leading this increase in the modeled concentrations of arsenic and arsenic compounds were both major and area sources. During this same time period, the modeled concentrations of arsenic and arsenic compounds attributable to mobile sources, both on-road and non-road sources, fell. The modeled concentrations of arsenic and arsenic compounds attributable to mobile sources were smaller than that attributable to the modeled background concentration of 9.451E-04 μg/m^3. Oddly, this background concentration is greater than the ambient arsenic concentration, 2E-04 μg/m^3, associated with a 70-year exposure and a cancer risk of 1-in-1,000,000.

3.3 Arsenic Emissions Inventory

3.3.1 NATA Emissions Inventory

The 1999, 2002, and draft 2005 NATA reported the tons per year of arsenic and arsenic compounds released from major, area, and mobile sources to the ambient air over St. Louis City (Federal Information Processing Standard (FIPS) Code 29510). Table 3-3 shows that between 1999 and 2005, the total emissions of arsenic and arsenic compounds released to the ambient air over St. Louis City decreased from 0.268 to 0.137 tons per year. Between 2002 and 2005, the tons of arsenic and arsenic compounds released from mobile sources remained steady, about 0.009 tons per year reported for on-road mobile sources and 0.002 tons per year reported for non-road mobile sources. The amount of arsenic and arsenic compounds released from area sources however increased, about 12-fold for area point sources and about 10-fold for area non-point sources, between 1999 and 2005. According to the draft 2005 NATA, area non-point sources released the most arsenic and arsenic compounds to the ambient air over St. Louis City. However, these emissions tend to be widely dispersed throughout areas. Correspondingly, the amount of arsenic and arsenic compounds released from major sources decreased during this time from 0.259 to 0.0304 tons per year. Point sources identified in St. Louis City for the 2005 NATA are presented in Table 3-4. As emissions from these sources are dispersed they will affect locations near to them more significantly than at more distant locations.

3.3.2 National Emissions Inventory

MDNR staff attempted to identify and locate the sources of the emissions of arsenic and arsenic compounds that the 1999, 2002, and draft 2005 NATA tabulated. Staff obtained the 1999 National Emissions Inventory (NEI) from the 1999 NATA, and downloaded the 2002 and 2005 NEI from U.S. EPA's Clearinghouse for Inventories and Emissions Factors website. Staff then queried these emissions inventories for point sources of arsenic compounds (inorganic, including arsine) located in Jefferson, St. Charles, and St. Louis Counties, and St. Louis City, Missouri; and Madison, Monroe, Randolph, and St. Clair Counties, Illinois.

Table 3-5 shows one result of the analysis of the 1999, 2002, and 2005 NEI displaying the number of point sources and reporting facilities, and total emissions of arsenic compounds (inorganic, including arsine) among the seven surrounding counties and St. Louis City. All together, the 1999 NEI reported 472 point sources and 220 reporting facilities, the 2002 NEI reported 267 point sources and 115 reporting facilities, and the 2005 NEI reported 301 point sources and 129 reporting facilities in the seven surrounding counties and St. Louis City. Though the number of point sources and reporting facilities decreased between 1999 and 2005, the tons of arsenic compounds (inorganic, including arsine) released in these seven surrounding counties and St. Louis City increased from 2.63 to 3.32 tons per year during this time.

In Illinois, Madison and St. Clair Counties had the greatest number of point sources of arsenic compounds (inorganic, including arsine). In Madison County there were 267,145, and 133 of these point sources in the 1999, 2002, and 2005 NEI, respectively. In St. Clair County there were 111, 76, and 100 of these point sources in the 1999, 2002, and 2005 NEI, respectively. Likewise, Madison and St. Clair Counties had the greatest number of facilities (93 and 62 facilities for 1999 NEI, 54 and 41 facilities for 2002 NEI, and 51 and 49 facilities for 2005 NEI, respectively) associated with the point sources of arsenic compounds (inorganic, including arsine) in Illinois. In Missouri, St. Louis City had the greatest number of point sources of arsenic compounds (inorganic, including arsine) and greatest number of facilities (29 and 19, respectively) in the 1999 NEI. St. Louis County however had the greatest number of point sources of arsenic compounds (inorganic, including arsine) and greatest number of facilities for both the 2002 (11 and 4, respectively) and the 2005 (20 and 6, respectively) NEI. Clearly, according to the 1999, 2002, and 2005 NEI, the majority of the point sources of arsenic compounds (inorganic, including arsine) and associated facilities were located on the eastern side of the Mississippi River.

The same was not true however with respect to the total emissions of arsenic compounds (inorganic, including arsine) released per year. In this regard, Missouri was the site of facilities that reported releasing the largest amount of arsenic compounds (inorganic, including arsine) to the ambient air. Facilities in Missouri released 1.50, 2.25, and 2.50 tons per year of arsenic compounds (inorganic, including arsine) to the ambient air; whereas, facilities in Illinois released 1.13, 0.79, and0.82 tons per year of these compounds to the ambient air according to the 1999, 2002, and 2005 NEI, respectively. Based on a summation of the 1999, 2002, and 2005 NEI, three Missouri counties; Jefferson, St. Charles, and St. Louis Counties, were sites of facilities reporting the largest releases of arsenic compounds (inorganic, including arsine). In Illinois, only Randolph County was the site of a facility that reported releasing a comparable amount of arsenic compounds (inorganic, including arsine) based on a summation of these NEI. Clearly, according to these NEI, the largest amount of arsenic compounds (inorganic, including arsine) released to the ambient air occurred on the western side of the Mississippi River. Interestingly, both the 2002 and 2005 NEI reported no point sources, associated facilities, or emissions of arsenic compounds (inorganic, including arsine) within St. Louis City itself.

3.3.3 Industry Classification

Based on the North American Industry Classification System (NAICS), the 1999, 2002, and 2005 NEI reported that the majority of the point sources of arsenic compounds (inorganic, including arsine) in the seven surrounding counties and St. Louis City were associated with petroleum refineries, general medical and surgical hospitals, fossil fuel electric power generation, ready-mix concrete manufacturing, and airport operations (Table 3-5). The 1999 NEI reported petroleum refineries (NAICS Code 324110) and general medical and surgical hospitals (NAICS Code 622110) as the dominant industries releasing arsenic compounds (inorganic, including arsine) to the ambient air. The 1999 NEI reported 60 and 38 point sources of arsenic compounds (inorganic, including arsine) associated with petroleum refineries (NAICS Code 324110) and general medical and surgical hospitals (NAICS Code 622110), respectively. The 2002 NEI reported fossil fuel electric power generation (NAICS Code 221112) as the dominant industry releasing arsenic compounds (inorganic, including arsine) from 28 point sources. The 2005 NEI however reported ready-mix concrete manufacturing (NAICS Code 327320) as the dominant industry as fossil fuel electric power generation (NAICS Code 221112) and airport operations (NAICS Code 48811) followed. The 2005 NEI reported 31, 28, and 10 point sources of arsenic compounds (inorganic, including arsine) associated with ready-mix concrete manufacturing (NAICS Code 327320), fossil fuel electric power generation (NAICS Code 221112), and airport operations (NAICS Code 48811), respectively. As alluded to earlier, these point sources were primarily located in Madison and St. Clair Counties.

It is therefore not surprising to discover that the 1999, 2002, and 2005 NEI identified the facilities releasing the largest amounts of arsenic compounds (inorganic, including arsine) in the seven surrounding counties and St. Louis City were associated with fossil fuel electric power generation (NAICS Code 221112). These facilities were all affiliated with the Illinois Power Company, AmerenUE, or Dynegy Midwest Generation, Incorporated (Table 3-6). The 1999 NEI identified the Illinois Power Company – Baldwin facility as the largest emitter of arsenic compounds (inorganic, including arsine), and the AmerenUE – Rush Island Plant as the second largest emitter of arsenic compounds (inorganic, including arsine). The 2002 NEI, as well as the 2005 NEI, identified the AmerenUE – Rush Island Plant, AmerenUE – Sioux Plant, and AmerenUE – Meramec Plant, and the Dynegy Midwest Generation, Incorporated facility in Randolph County as the largest emitters of arsenic compounds (inorganic, including arsine). Except for the 1999 NEI, which mistakenly reported the AmerenUE – Meramec Plant as being in St. Louis City, none of these facilities reported releases of arsenic compounds (inorganic, including arsine) in St. Louis City.

3.4 Conclusions

According to the draft 2005 NATA, sources of PM10 arsenic emissions in St. Louis City (FIPS Code 29510) include major sources and area non-point sources. The 1999, 2002, and 2005 NEI however identified point sources at facilities associated with fossil fuel electric power generation (NAICS Code 221112) as the largest emitters of arsenic compounds (inorganic, including arsine) in the seven surrounding counties, with no point sources in St. Louis City for 2002 and 2005. These divergent emissions inventories for PM_{10} arsenic in St. Louis City provide a questionable basis at this time for identifying sources of ambient concentrations.

TABLE 3-1 — Measured and Modeled Arsenic Concentrations in Census Tract 29510126700 and the Associated Lifetime Cancer Risk

Data Source	Air Toxic	Annual Arithmetic Mean ($\mu g/m^3$)	Cancer Risk Associated With 70-Year Exposure Risk = 1E-06
Monitoring Program			
2005 National Air Toxics Trends Station	Arsenic PM_{10}	0.002328	12
2006 National Air Toxics Trends Station	Arsenic PM_{10}	0.001055	5
2007 National Air Toxics Trends Station	Arsenic PM_{10}	0.00183	9
2008 National Air Toxics Trends Station	Arsenic PM_{10}	0.000959	5
ASPEN Computer Air Dispersion Model			
1999 National-Scale Air Toxics Assessment	Arsenic and arsenic compounds	0.000247	1
2002 National-Scale Air Toxics Assessment	Arsenic and arsenic compounds	0.001532	7
2005 National-Scale Air Toxics Assessment (draft)	Arsenic and arsenic compounds	0.001720	9

ASPEN = Assessment System for Population Exposure Nationwide

TABLE 3-2 — Modeled Arsenic Concentrations for Census Tract 29510126700 in the 1999, 2002, and draft 2005 National-Scale Air Toxics Assessment

	Modeled Micrograms per Cubic Meter of Arsenic Attributable to These Sources					
Year	Major Sources	Area Sources	Mobile Sources		Background	Total Emissions
			On-Road Sources	Non-Road Sources		
1999	9.143E-05	1.559E-04				2.473E-04
2002	3.325E-05	4.419E-04	5.563E-05	5.623E-05	9.451E-04	1.532E-03
2005 (draft)	2.958E-04	4.419E-04	3.054E-05	7.347E-06	9.451E-04	1.720E-03

TABLE 3-3 — Sources and Amounts (tons per year) of Arsenic Emissions Reported for St. Louis City (FIPS Code 29510) in the 1999, 2002, and draft 2005 National-Scale Air Toxics Assessment

Year	Major Sources	Area Sources		Mobile Sources				Total Emissions
		Point Sources	Non-Point Sources	On-Road Sources	Non-Road Sources	Commercial Marine Vessels	Rail	
1999	2.59E-01	5.43E-05	8.46E-03					2.68E-01
2002			8.73E-02	8.92E-03	2.39E-03			9.86E-02
2005 (draft)	3.04E-02	6.80E-04	8.33E-02	9.14E-03	2.30E-03	1.02E-02	7.21E-04	1.37E-01

FIPS = Federal Information Processing Standard

TABLE 3-4 — 2005 NATA St. Louis City Point Sources and Amounts (tons per year) of Arsenic Emissions

FACILITY_NAME	LOCATION_ADDRESS	ZIPCODE	2005_NATA TOTAL_EMISSIONS (tpy)
ANHEUSER-BUSCH INC, ST. LOUIS	1 BUSCH PLACE	63118	0.030344735
WASHINGTON UNIV MEDICAL SCHOOL-BOILER PLANT	500 S EUCLID	63116	0.000531074
ASTARIS LLC-CARONDELET PLANT	8201 IDAHO AVE	63111	3.25455E-05
DIAL CORP-DIAL CORP	6901 MCKISSOCK	63147	2.1636E-05
ST LOUIS UNIVERSITY-FACILITIES SVCS	3750 LINDELL RM 10	63108	1.8119E-05
METROPOLITAN ST. LOUIS SEWER DISTRICT, BISSEL PLANT	10 E GRAND	63147	0.000015704
MALLINCKRODT INC, N SECOND	3600 N SECOND ST	63147	1.48999E-05
PQ CORPORATION (THE), ST. LOUIS	4238 GERALDINE	63115	1.22934E-05
NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY-NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY	3200 SOUTH SECOND STREET	63118	1.03298E-05
ENERGY CENTER (THE)-ST LOUIS UNIV HEALTH SCIENCES CENTER	3628 RUTGER	63110	1.02619E-05
NESTLE PURINA PETCARE COMPANY-ST LOUIS	901 CHOUTEAU	63164	8.46476E-06
FOREST PARK HOSPITAL-TENET	6150 OAKLAND	63139	7.95238E-06
RHODIA INC-RHODIA INC	140 LAFAYETTE	63104	7.80523E-06
VETERANS ADMIN MEDICAL CENTER-JOHN COCHRANE DIV	915 N GRAND	63106	6.78571E-06
INTERSTATE BRANDS CORP-INTERSTATE BRANDS CORP	6301 N BROADWAY	63147	4.94405E-06
ST LOUIS CONNECT CARE-ST LOUIS CONNECT CARE	5535 DELMAR	63112	0.000004
BJC HEALTH SYSTEM-PAVILLION	#1 BARNES HOSPITAL PLAZA	63110	3.40576E-06
NATIONAL LINEN SERVICE-NATIONAL LINEN SERVICE	315 LYNCH	63118	2.7619E-06
HERMANN OAK LEATHER CO-HERMANN OAK LEATHER CO	4050 NORTH FIRST	63147	2.26414E-06
JW ALUMINUM, ST. LOUIS	6100 S BROADWAY	63111	1.90595E-06
SALUS CENTER-SALUS CENTER	3545 LAFAYETTE	63104	1.48492E-06

ST ALEXIUS HOSPITAL-ST ALEXIUS HOSPITAL	3933 S BROADWAY	63118	1.21429E-06
ST LOUIS POST DISPATCH-ST LOUIS POST DISPATCH	900 NORTH TUCKER BLVD	63101	1.19048E-06
ST ALEXIUS HOSPITAL-ST LOUIS	2639 MIAMI	63118	9.2619E-07
NATIONAL GRAPHICS-NATIONAL GRAPHICS	2711 MIAMI	63118	7.29286E-07
SIEGEL-ROBERT PLATING CO	8645 S. BROADWAY	63111	6.66667E-07
SWING-A-WAY MFG-SWING-A-WAY MFG	4100 BECK	63116	5.09905E-07
NIES/ARTCRAFT-NIES/ARTCRAFT	5900 BERTHOLD AVENUE	63110	4.28571E-07
ASSOCIATED EQUIPMENT-ASSOCIATED EQUIPMENT	5043 FARLIN	63115	0.0000004
KOCH MATERIALS CO-ST LOUIS (ELF ASPHALT)	6350 KNOX INDUSTRIAL	63139	3.09524E-07
ITALGRANI ELEVATOR-ITALGRANI ELEVATOR	7900 VAN BUREN	63111	1.66667E-07
RAINERI BUILDING MATERIALS-RAINERI BUILDING MATERIALS	6351 KNOX INDUSTRIAL DRIVE	63139	1.19048E-07
KELLER MFG-KELLER MFG	4324 FYLER	63116	0.000000102
CONNECTOR CASTINGS-CONNECTOR CASTINGS	1600 N. 22D STREET	63106	7.14286E-08
HILLCREST ABBEY CREMATORY-ST LOUIS	3211 SUBLETTE	63139	0.00000003
STERLING PROPERTIES, LACLEDE GAS BUILDING	720 OLIVE	63101	2.52381E-08
BI-STATE DEVELOPMENT AGENCY (BSDA)-MAIN REPAIR FACILITY	3330 SPRUCE	63102	7.14286E-09

TABLE 3-5 — The Number of Point Sources, Reporting Facilities, and Total Emissions of Arsenic Compounds for the Seven Surrounding Counties and St. Louis City According to the 1999, 2002, and 2005 National Emissions Inventories

County or City Name	1999			2002			2005		
	Number of Point Sources	Number of Facilities	Tons Per Year	Number of Point Sources	Number of Facilities	Tons Per Year	Number of Point Sources	Number of Facilities	Tons Per Year
Madison County, IL	267	93	3.02E-01	145	54	6.95E-02	133	51	6.31E-02
Monroe County, IL	6	6	9.27E-05	1	1	2.40E-07	5	4	2.53E-05
Randolph County, IL	30	18	7.89E-01	20	12	6.99E-01	26	14	6.54E-01
St. Clair County, IL	111	62	3.94E-02	76	41	2.40E-02	100	49	1.04E-01
Jefferson County, MO	7	5	7.80E-01	6	2	9.59E-01	6	2	1.12E+00
St. Charles County, MO	11	8	4.34E-01	8	1	7.35E-01	11	3	6.96E-01
St. Louis County, MO	11	9	2.83E-02	11	4	5.59E-01	20	6	6.86E-01
St. Louis City, MO	29	19	2.59E-01	0	0	0.00E+00	0	0	0.00E+00
Totals	472	220	2.63E+00	267	115	3.05E+00	301	129	3.32E+00

Definitions: IL = Illinois; MO = Missouri.

TABLE 3-6 — Greatest Number of Point Sources and Their North American Industry Classification System (NAICS) According to the 1999, 2002, and 2005 National Emissions Inventories (NEI)

County or City Name	Number of Point Sources	NAICS Code	NAICS Description
1999 NEI			
Madison County, IL	60	324110	Petroleum Refineries
Monroe County, IL			No dominant NAICS codes present in emissions data.
Randolph County, IL	5	5614	Business Support Services and NAICS code 922140 for Correctional Institutions
St. Clair County, IL	38	622110	General Medical and Surgical Hospitals
Jefferson County, MO	4	2211	Electric Power Generating, Transmission and Distribution
St. Charles County, MO	5	2211	Electric Power Generating, Transmission and Distribution
St. Louis County, MO	2	622110	General Medical and Surgical Hospitals
St. Louis City, MO	6	31	Manufacturing
2002 NEI			
Madison County, IL	28	221112	Fossil Fuel Electric Power Generation
Monroe County, IL	1	327320	Ready-Mix Concrete Manufacturing
Randolph County, IL	5	922140	Correctional Institutions
St. Clair County, IL	8	327320	Ready-Mix Concrete Manufacturing and NAICS code 622110 for General Medical and Surgical Hospitals
Jefferson County, MO	4	2211	Electric Power Generating, Transmission and Distribution
St. Charles County, MO	8	2211	Electric Power Generating, Transmission and Distribution
St. Louis County, MO	8	2211	Electric Power Generating, Transmission and Distribution
St. Louis City, MO			No emissions data provided.
2005 NEI			
Madison County, IL	28	221112	Fossil Fuel Electric Power Generation
Monroe County, IL	4	327320	Ready-Mix Concrete Manufacturing
Randolph County, IL	5	327320	Ready-Mix Concrete Manufacturing
St. Clair County, IL	31	327320	Ready-Mix Concrete Manufacturing
Jefferson County, MO	4	221112	Fossil Fuel Electric Power Generation
St. Charles County, MO	6	221112	Fossil Fuel Electric Power Generation
St. Louis County, MO	10	48811	Airport Operations
St. Louis City, MO			No arsenic sources present in emissions data.

Definitions: IL = Illinois; MO = Missouri.

TABLE 3-7 — Facilities Releasing the Largest Amounts of Arsenic Compounds in the Seven Surrounding Counties and St. Louis City According to the 1999, 2002, and 2005 National Emissions Inventories (NEI)

County or City Name	Facility Name	NAICS Code	Tons Per Year
1999 NEI			
Madison County, IL	Illinois Power Company – Wood River Power Station	2211	2.17E-01
Monroe County, IL	Schmitts Supermarket	4451	4.18E-05
Randolph County, IL	Illinois Power Company – Baldwin	2211	7.88E-01
St. Clair County, IL	Onyx Environmental Services	562	1.85E-02
Jefferson County, MO	AmerenUE – Rush Island Plant	2211	7.34E-01
St. Charles County, MO	AmerenUE – Sioux Plant	2211	4.21E-01
St. Louis County, MO	Chrysler Corporation – North Plant	336	1.37E-02
St. Louis City, MO	AmerenUE – Meramec Plant	2211	1.50E-01
2002 NEI			
Madison County, IL	Dynegy Midwest Generation, Incorporated	221112	4.22E-02
Monroe County, IL	Roessler Ready-Mix, Incorporated	327320	2.40E-07
Randolph County, IL	Dynegy Midwest Generation, Incorporated	221112	6.98E-01
St. Clair County, IL	Cerro Copper Products, Company	331423	8.98E-03
Jefferson County, MO	AmerenUE – Rush Island Plant	2211	9.42E-01
St. Charles County, MO	AmerenUE – Sioux Plant	2211	7.35E-01
St. Louis County, MO	AmerenUE – Meramec Plant	2211	5.59E-01
St. Louis City, MO	No emissions data provided.		
2005 NEI			
Madison County, IL	Dynegy Midwest Generation, Inc. – Wood River	221112	5.66E-02
Monroe County, IL	Schwend's Red E Mix	327320	2.00E-05
Randolph County, IL	Dynegy Midwest Generation, Incorporated	221112	6.53E-01
St. Clair County, IL	Big River Zinc Corporation	331419	9.40E-02
Jefferson County, MO	AmerenUE – Rush Island Plant	221112	1.11E+00
St. Charles County, MO	AmerenUE – Sioux Plant	221112	6.96E-01
St. Louis County, MO	AmerenUE – Meramec Plant	221112	6.81E-01
St. Louis City, MO	No arsenic sources present in emissions data.		

Definitions: IL = Illinois; MO = Missouri. NAICS = North American Industry Classification System.

4.0 PHASE I MEASUREMENT RESULTS AND DATA ANALYSES

As described in Section 2, the Phase I measurements featured 1-in-3 day 24-hour integrated PM_{10} sample collection throughout calendar year 2008 at four sites in the Missouri portion of the St. Louis metropolitan area. Two sites (Blair, Hall) are classified as urban/industrial and two sites are classified as suburban (Arnold, WashU). Ambient particulate matter collected on quartz fiber filters was extracted and analyzed by ICP-MS for elemental composition. Emphasis was placed on quantifying spatiotemporal patterns for PM_{10} arsenic. Additional air toxics metals were examined if the data were deemed of sufficiently high quality using metrics such as high extraction recoveries for representative NIST Standard Reference Materials, robust ICP-MS calibration data for the concentration range observed in the ambient samples, low field blank concentrations relative to ambient concentrations, and high correlation with concentration values reported by Eastern Research Group (ERG) for the Blair NATTS site. Based on these performance metrics, the antimony, arsenic, lead, and selenium data were deemed of high quality with the latter three elements being the focus of this section. Details about the measurement data quality are provided in Appendix C.

4.1 PM_{10} Arsenic

Figure 4-1 shows box plots[2] of the PM_{10} arsenic concentration distributions measured at the four sites. Blair exhibited the highest annual average arsenic concentration among the four sites, 1.3 ng/m^3, which is below the 2 ng/m^3 benchmark established in the CAP study. The urban/industrial sites (Blair, Hall) exhibited higher median arsenic concentrations compared to the suburban sites (Arnold, WashU), which suggests there are local emission sources impacting the urban/industrial sites. **Figure 4-2** shows scatter plots for arsenic measured at the urban/industrial sites (Figure 4-2a) and the suburban sites (Figure 4-2b). There is more day-to-day variability between the urban/industrial sites that are separated by only ~4 km than between the suburban sites that are separated by ~25 km. The agreement between the suburban site data is especially strong at concentrations below 1 ng/m^3. **Figure 4-3** shows scatter plots for the ranked concentration data. Figure 4-3a shows very little difference between the network-wide minimum and second minimum concentrations. The 3rd minimum concentration were only incrementally higher than the 2nd minimum (Figure 2-4b) with one outlier – 8/31/2008 when Arnold and WashU concentration values were much greater than Blair and Hall values. In contrast, the maximum concentration was often much higher than the 3rd minimum (Figure 4-3c). Again, this is evidence of significant local emission sources impacts on measured arsenic levels.

The patterns observed in Figures 4-2 and 4-3 motivate the splitting of the day-specific concentration values at each site into two components: a “baseline concentration” defined by the lowest concentration value among the four sites; and an “excess concentration” which is the difference between the observed concentration and the baseline concentration. It is postulated that the baseline concentration represents emission sources exerting influences on urban- and

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[2] All box plots in this report are formatted as follows: the interior black line is the median; the dashed red line is the arithmetic mean; boxes include concentrations from the 25th to 75th percentile, whiskers are 10th and 90th percentile concentrations; and circles are 5th and 95th percentile concentrations.

larger-spatial scales and would be the same throughout the metropolitan area while the excess concentration represents emissions sources exerting influences on neighborhood- and smaller-spatial scales that would vary from site to site. Using this approach, **Figure 4-4** shows the apportionment of arsenic to baseline and excess contributions. About 90% of the arsenic at WashU is assigned to the baseline (urban- and larger-scale sources) while 50% of the arsenic at Blair is assigned as local excess (neighborhood- and smaller-scale sources). The interpretation of the arsenic contributions assigned to baseline and excess components was further examined using surface winds and air mass back trajectories. **Figure 4-5** show the conditional probability function (CPF) plot[3] for baseline arsenic using NWS hourly surface winds from St. Louis Lambert International Airport. The CPF plot shows that while the prevailing surface winds in St. Louis are from the south and the northwest, surface winds from the east are more likely to correspond to a high arsenic baseline concentration. It is unlikely that these sources are in the St. Louis metropolitan area. Thus, quantitative transport bias analysis (QTBA)[4] was used to determine the geographic regions for air mass residence times corresponding to high baseline arsenic concentrations in St. Louis. **Figure 4-6** shows the QTBA results for baseline arsenic using 72-hour back trajectories generated using NOAA/HYSPLIT. High arsenic concentrations are coincident with air masses from the eastern United States and especially the Ohio River Valley. This is consistent with a major source of arsenic in the nationwide inventory being coal-fired power plants.

Figure 4-7 shows CPF plots for excess arsenic at Blair and Hall overlaid on an aerial map. In contrast to the baseline CPF plot, which shows a highest frequency of high arsenic for surface winds from the east, the CPF plots for excess arsenic at Blair and Hall show high frequencies of high arsenic for winds from the northeast and southeast, respectively. The bearings with highest frequency triangulate to the large circle between the two sites. Possible arsenic emission sources in this circle include a coal-fired industrial boiler and the incinerator at a municipal wastewater treatment plant. The smaller circle shows the location of coal piles near the Hall site which could also be a source of PM_{10} arsenic.

4.2 PM_{10} Selenium

The analyses presented in Section 4.1 for arsenic were repeated for selenium. **Figure 4-8** shows box plots of the PM_{10} lead concentration distributions measured at the four sites. Like arsenic, annual-average selenium is higher at the two urban/industrial sites than the two suburban sites. Whereas annual-average arsenic was much higher at the Blair site compared to the Hall site, annual-average selenium was nearly identical at these two sites. At all four sites most of the annual-average selenium is apportion to regional- and urban-scale sources (**Figure 4-9**). About 70% of the annual-average selenium at the two urban/industrial sites is apportioned to local sources. Conditional probability function plots for excess selenium at these two monitoring sites again triangulate to a spatial zone along the industrialized Mississippi Riverfront northeast of

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[3] The conditional probability function plots in this report show for each wind direction the fraction of hours from that bearing corresponding to a top 25th percentile daily-average concentration.

[4] Quantitative transport bias analysis plots show the average concentration at the receptor site (in this case, the St. Louis area-wide base concentration) corresponding to air mass trajectories passing through a given location on the map.

Blair and southeast of Hall (**Figure 4-10**). However, the precise locations of the putative local emission source(s) for selenium are not as clearly defined for selenium (Figure 4-10) as for arsenic (Figure 4-7). Several coal handling facilities along the riverfront are candidate emission sources for selenium, as well as the aforementioned coal-fired industrial boiler.

4.3 PM_{10} Lead

While arsenic and selenium exhibit similar spatial features, the patterns for lead are distinct. **Figure 4-11** shows box plots of the PM_{10} lead concentration distributions measured at the four sites. Annual-average PM_{10} lead is highest at the suburban Arnold and urban/industrial Blair sites, with lower and similar distributions at the Hall and WashU sites. The baseline/excess construct is not applicable to the lead data because there is a major lead emission source – the lead smelter in Herculaneum – that is spatially outside the four-site network yet does not have the defining characteristic of a regional-scale source that exerts equal influence on all sites in the network. Emissions from the smelter are still dispersing across the network and thus are more-strongly observed at Arnold than the other three sites to the north. Conditional probability function plots for total PM_{10} lead at all four sites point in the direction of the lead smelter. There also appears to be a local emission source of PM_{10} lead that affects the Blair site but not the Hall site. However, an excess lead time series cannot be developed for reasons mentioned above, and the surface winds analysis do not provide insights into the location of the lead emission source near the Blair site. PM_{10} lead patterns are examined in more detail in Section 5, with emphasis on impacts from the lead smelter.

4.4 Summary

One year of 1-in-3 day air toxics metals measurements at four sites in St. Louis has provided important insights into the spatial variability of PM_{10} arsenic. The Blair Street NATTS site is strongly influenced by both regional and local sources. Annual-average arsenic is about evenly apportioned between these two emission source scales. Air mass trajectory analyses implicate the eastern United States, and in particularly the Ohio River Valley, as a major source of arsenic transported to St. Louis. Surface winds analyses identified a spatial zone northeast of the Blair Street station and nominally along the industrial Mississippi Riverfront as a major source of local arsenic emissions. Annual-average arsenic across the four-site network was below four sites was below the 2 ng/m^3 health-based benchmark established for the St. Louis Community Air project. In the case of Blair Street, however, annual-average PM_{10} arsenic was within a factor of two of that benchmark. The data generated from this study – in particular the apportionment of PM_{10} arsenic into local and regional contributions – could be used in validating the NATA modeling.

PM_{10} selenium exhibits spatial patterns grossly similar to arsenic with a high regional contribution. Local contributions are estimated to be at most 30% of the annual-average selenium. PM_{10} lead in is strongly influenced by the lead smelter south of St. Louis with relatively high impacts at the suburban Arnold site.

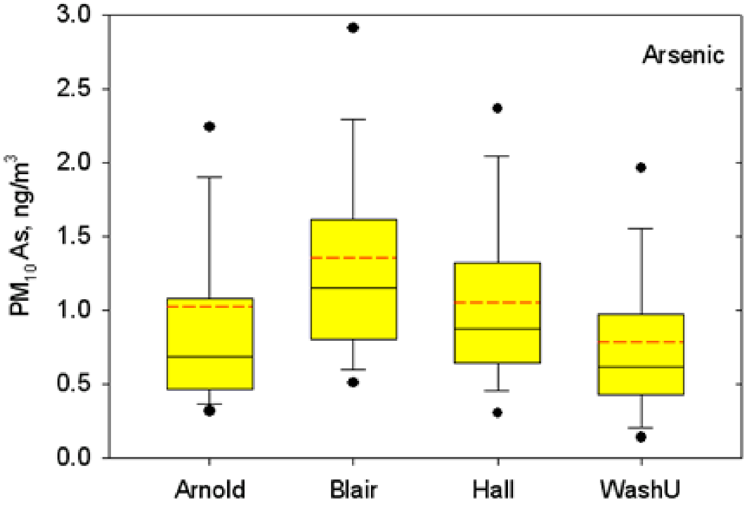

Figure 4-1. Concentration distributions for 24-hour integrated PM$_{10}$ arsenic, 1-in-3 day sampling during calendar year 2008.

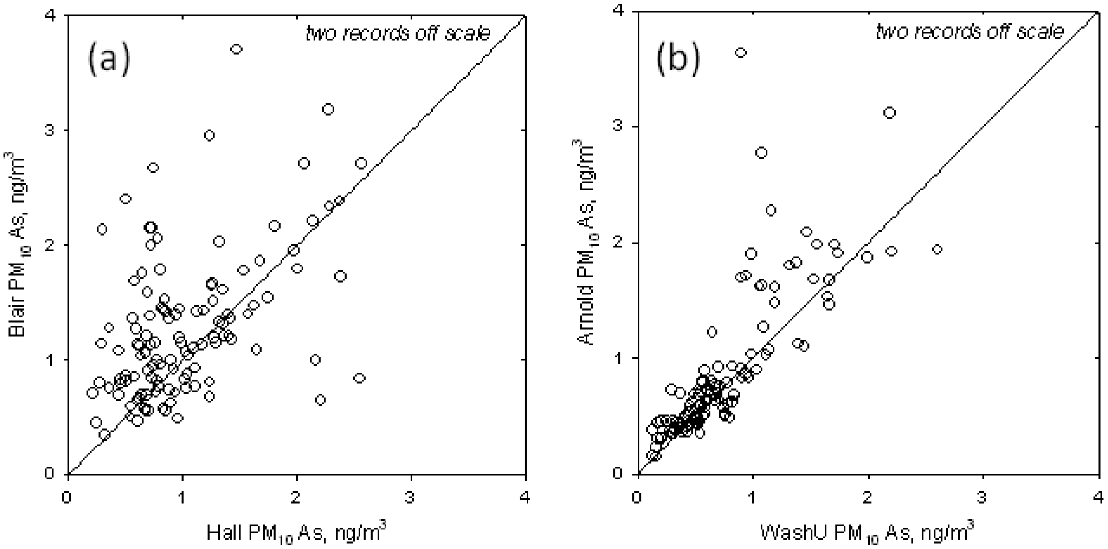

Figure 4-2. Scatter plots for 24-hour integrated PM$_{10}$ arsenic at: (a) the urban/industrial sites – Blair and Hall; and (b) the suburban sites – Arnold and WashU.

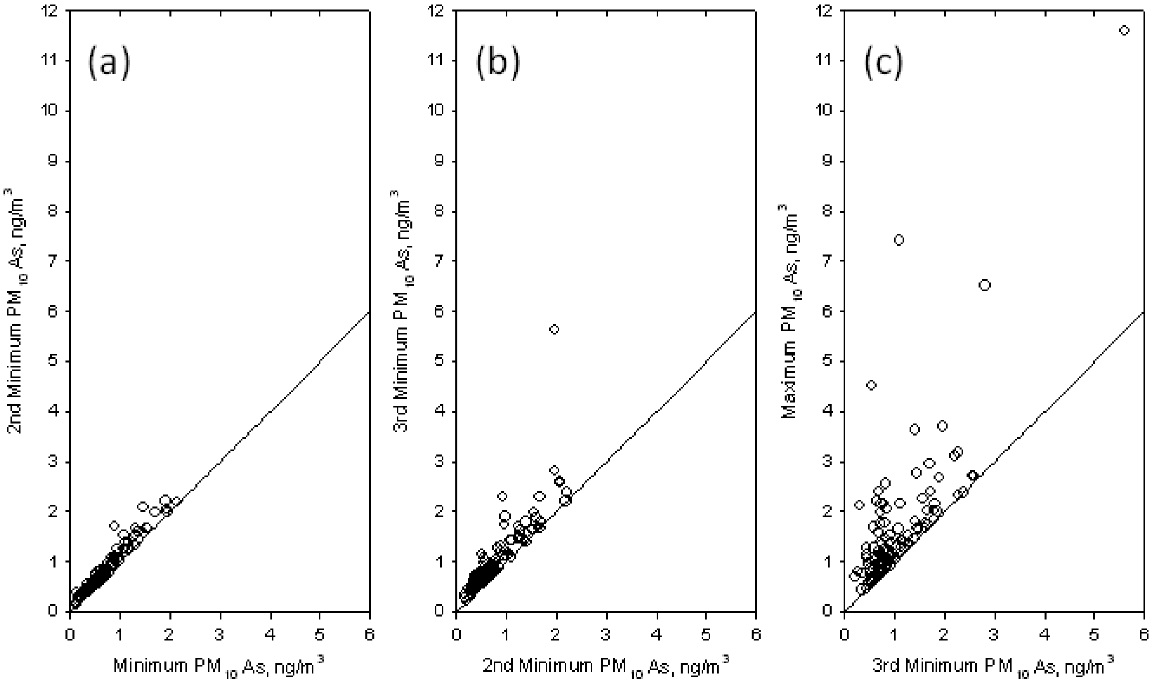

Figure 4-3. Scatter plots for 24-hour integrated PM_{10} arsenic comparing network-wide: (a) minimum to 2nd minimum; (b) 2nd minimum to 3rd minimum; and (c) maximum to 3rd minimum. Data only included for those days with all four sites having valid data (N = 114).

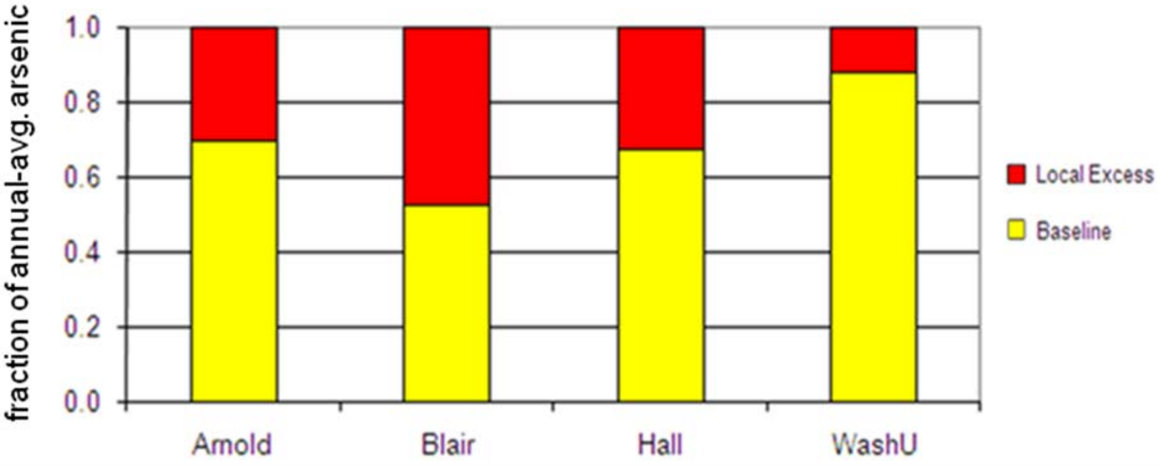

Figure 4-4. Apportionment of annual-average PM_{10} arsenic to baseline and local excess contributions.

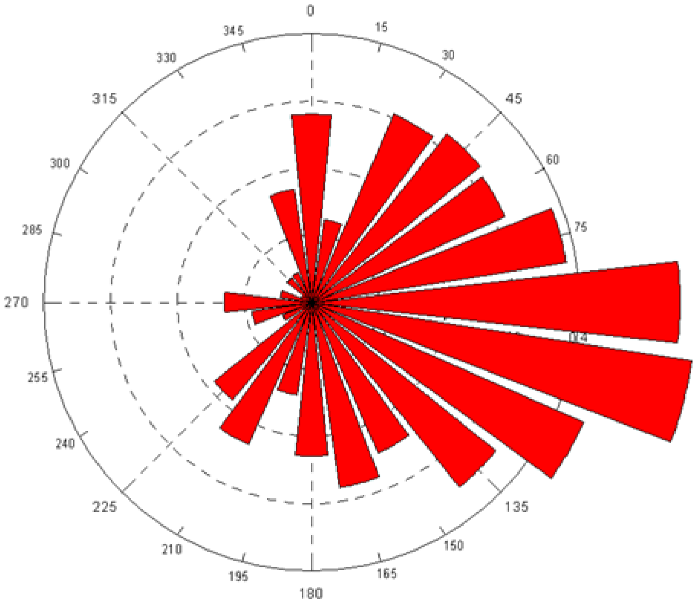

Figure 4-5. Conditional probability function (CPF) plot for the PM_{10} arsenic network-wide baseline concentration distribution using hourly surface winds from St. Louis Lambert International Airport.

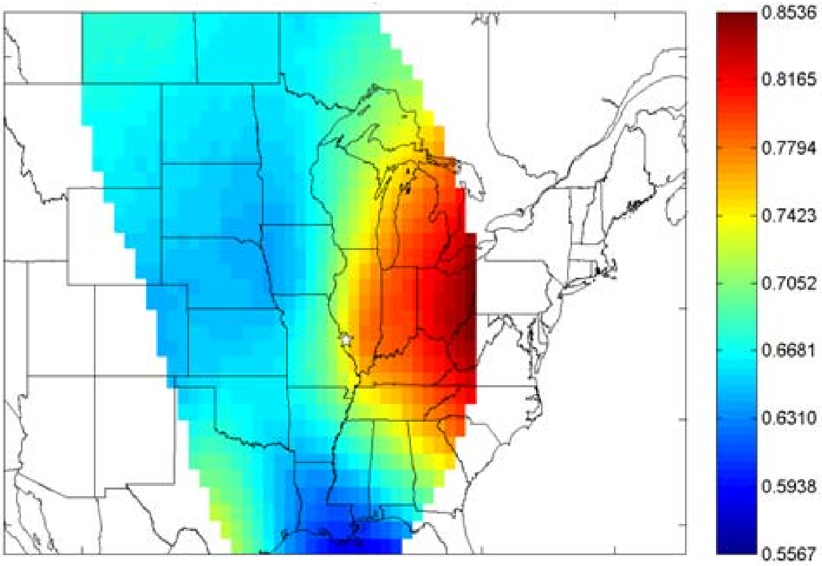

Figure 4-6. Quantitative transport bias analysis (QTBA) plot for the PM_{10} arsenic network-wide baseline concentration distribution using three-day air mass back trajectories form NOAA/HYSPLIT.

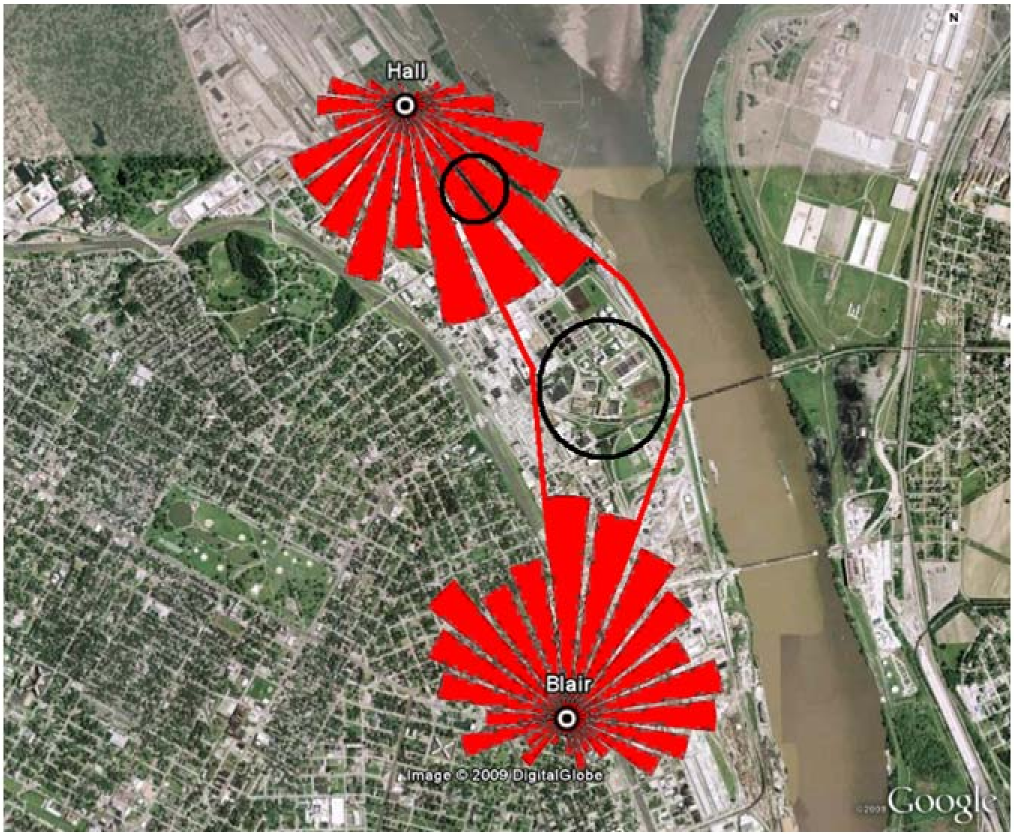

Figure 4-7. Conditional probability function (CPF) plots for the PM_{10} arsenic excess concentration distributions at Blair and Hall sites using hourly surface winds from St. Louis Lambert International Airport. The large circle shows the zone where triangulation of the CPF plots suggests local arsenic emission sources might be located; the small circle shows the location of a coal pile that might influence PM_{10} arsenic measured at the Hall site.

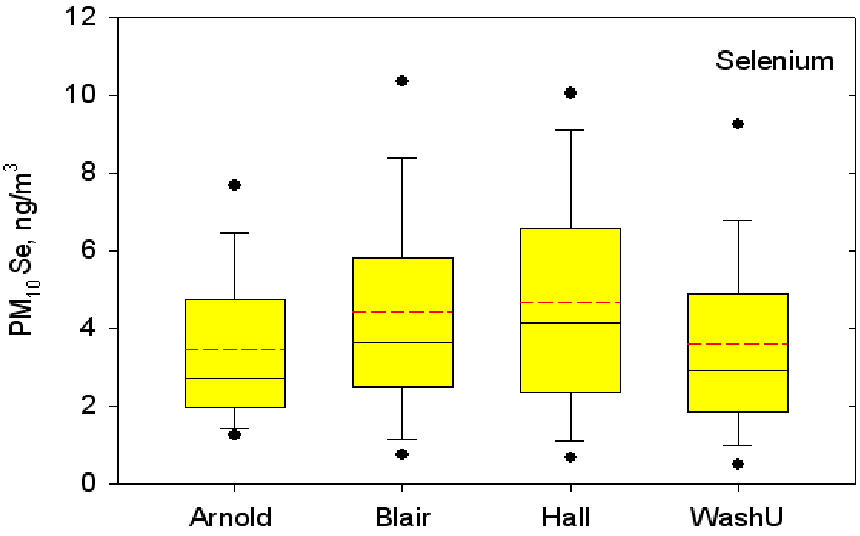

Figure 4-8. Concentration distributions for 24-hour integrated PM_{10} selenium, 1-in-3 day sampling during calendar year 2008.

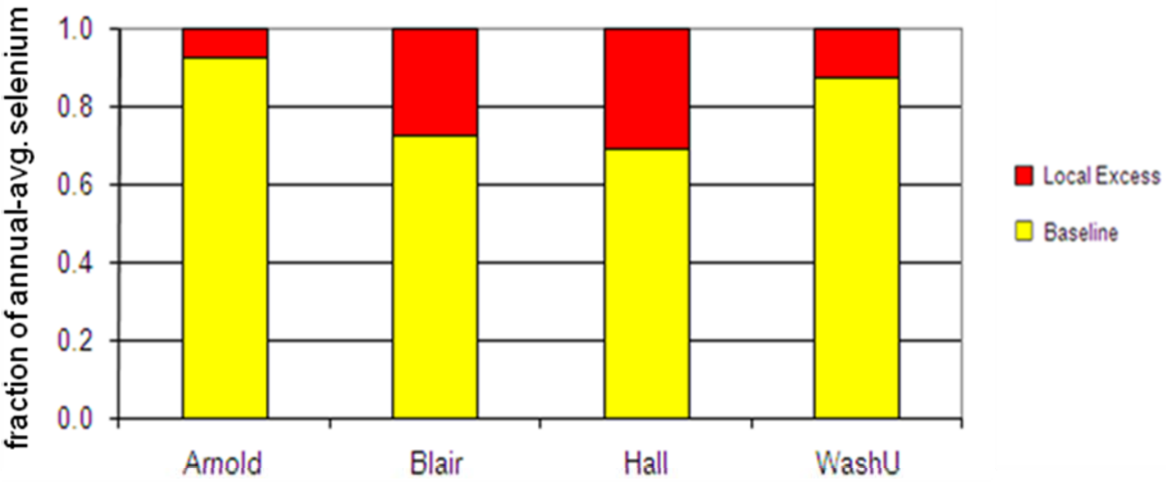

Figure 4-9. Apportionment of annual-average PM_{10} selenium to baseline and local excess contributions.

Figure 4-10. Conditional probability function (CPF) plots for the PM_{10} selenium excess concentration distributions at Blair and Hall sites using hourly surface winds from St. Louis Lambert International Airport.

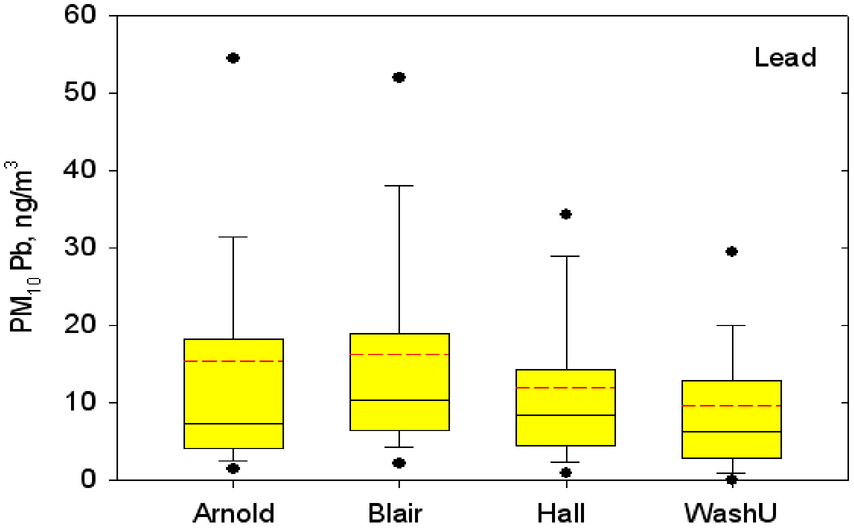

Figure 4-11. Concentration distributions for 24-hour integrated PM$_{10}$ lead, 1-in-3 day sampling during calendar year 2008.

5.0 PHASE II MEASUREMENT RESULTS AND DATA ANALYSES

Results presented in the previous section demonstrate that significant insights into the intraurban variability of PM_{10} arsenic and other air toxics metals were obtained from a four-site network of 24-hour integrated filter-based sampling. In particular, it was possible to estimate the relative contributions from regional- and urban-scale emissions sources compared to neighborhood- and finer-scale emission sources. High time resolution (i.e. sub-daily) measurements provide complementary data. Observed concentrations can be more-directly related to surface wind directions which can dramatically fluctuate over a 24-hour integrated sample collection period. Surface wind directions during plume impacts can be used to constrain the bearing of significant emission sources. In contrast, at least for short deployments it is challenging to apportion the observed concentrations to different spatial scales, especially resolving the urban- and large scales from the neighborhood- and finer scales.

This section summarizes key findings from the short-term (nominally one month) deployments of the Xact instrument to measure selected PM_{10} elements at two-hour time resolution. Xact performance was evaluated, with the results presented in Appendix D. That evaluation focused on arsenic, lead, and selenium and demonstrated these species are being robustly measured. One objective of this study was to perform receptor modeling on the Xact data set using factor analytic methods (e.g. PCA, PMF, UNMIX). Twenty-four elements were measured; presumably this could provide a rich data set for receptor modeling. However, as demonstrated in Appendix D, data quality is poor for certain elements and inadequately characterized for other elements. For example, the 2005 UATMP identified cadmium as an air toxic of concern for St. Louis. Cadmium concentration levels were high in the raw Xact data but it has been determined there is a spectral interference that leads to gross overestimation for cadmium for the Xact instrument as configured for this study. It was beyond the initial scope of this project to perform a detailed performance evaluation for the entire suite of measured analytes. However, given the issues identified by the preliminary performance evaluation, an extensive set of collocated, low-volume 18-hour integrated filter samples were collected and are being analyzed by both XRF (USEPA/ORD) and ICP-MS (WUSTL). The detailed performance evaluation will be completed by summer 2010, and the potential to perform receptor modeling on these data sets will be reevaluated at that time. Despite this limitation, substantial insights were obtained from the Xact deployments and are summarized in this section. Consistent with Section 4, emphasis is placed on arsenic, lead, and selenium.

Figure 5-1 shows the wind roses for each of the six Xact deployments. For most conditions, the surface wind direction is nearly homogeneous across the metropolitan area. The large differences in the wind rose patterns for Figure 5-1 likely reflect seasonal variations in surface winds more than spatial variations in surface winds. These differences, as well as the patterns for each deployment, define the opportunities and limitations for interpreting the data. The data can be used as a preliminary screening tool to identify local source impacts. However, if certain wind directions are not adequately represented (e.g. the northeast sector for the Blair deployment) then local sources at such bearings might be missed. This limitation could be resolved by longer deployments or a series of short deployments across the seasons.

Concentration values across six deployments should not be compared because they represent dramatically different transport conditions.

5.1 PM_{10} Arsenic

Figure 5-2 shows the wind direction dependence of 2-hour integrated arsenic concentration data collected at all six sites. Concentrations were lowest at the S. Broadway site with very low temporal variability and no 2-hour concentration values exceeding 2 ng/m^3. Arsenic concentrations were higher at Hall and Margaretta but with no distinct wind direction features. The conditional probability function plot for 24-hour integrated excess arsenic at Hall indicated relatively high concentrations for winds from the southeast (Figure 4-7) but this feature is not observed in the Hall station Xact data. Arnold and East St. Louis exhibit routinely higher concentrations for surface winds from the southeast. This might be indicative of local source emissions, but this is also a common direction for surface winds with synoptic transport from the eastern U.S., and thus the elevated arsenic levels for these bearings might arise from regional transport. Two concentration values at East St. Louis are off the scale in Figure 5-2. Both of these high concentration values were observed on 4/13/2009 and, as described later in this section, one of these two-hour average values exceeded 2 μg/m^3.

The most striking features were observed at the Blair Street site with three wind directions exhibiting high concentration excursions. High arsenic concentrations were observed for winds from the west/northwest, south/southeast, and from the north/northeast although in the latter case there were very few hours with winds from that direction (Figure 5-1). While high concentrations excursions for winds from the north/northeast are consistent with the conditional probability function plot for 24-hour integrated excess arsenic at the Blair site (Figure 4-7), this highlights one potential problem with short-term deployments to map out emissions sources – such periods might not include a high frequency of winds from every bearing and certain sources might be missed or not adequately resolved. Routinely higher concentrations were also observed for winds from the southeast and, like Arnold and East St. Louis, might be explained by regional transport. High arsenic concentrations for winds from the west/northwest were not clearly identified in the Blair excess arsenic conditional probability function plot (Figure 4-7) because these events were very short duration with typically no more than one two-hour excursion on any given day. Thus, the two-hour concentration high spikes would be damped out when averaged with low concentrations values throughout the remainder of the day. Data from this wind sector were examined in more detail. Figure 5-1 shows that there is a high frequency of winds from the northwest for the Blair deployment (this is a common wintertime wind direction in St. Louis), and this data set is particularly well-suited to pick up features from that wind direction sector. **Figure 5-3** shows the distributions of 2-hour integrated arsenic for winds from the west/northwest (270-330°N) further stratified by weekdays / weekends and daytime (8 AM – 6 PM) / nighttime (6 PM – 8 AM) work-shift hours. Arsenic concentration values were consistently higher during the weekday day-shift hours compared to weekday evenings and weekends. This temporal pattern is consistent with an industrial source operating primarily only on weekdays during daytime hours. This source was not picked up by the Hall and Margaretta deployments, which suggests it is likely a middle- or micro-scale source with respect to the Blair station location. Candidate sources include a small metalworking facility near the site with welding activities. Mercury and nickel excursions often occurred with the arsenic excursions for winds from the north/northwest, but more work is needed to determine the data quality for these elements given the possibility for spectral interferences as was clearly observed for cadmium.

April 13, 2009 Arsenic Spike. On April 13, 2009, a two- hour average arsenic concentration of 2,345 ng/m^3 was monitored from 10 AM to 12 noon, with a likely uncertainty of about 120 ng/m^3 (~5%). This data appears to be of reasonable quality. Periodic audits of thin film standards and flow rate indicate uncertainties of less than 5%. April 13th was about half way into the study period in which less than two percent drift in arsenic measurements was observed; calibration drift at that time was only about one percent. The concentration of arsenic was so high that it dominated the elemental XRF spectrum, and there is no possibility of a spectral interference problem. It also clearly indicated that the arsenic represented well over 90% of the measured elemental mass of deposit on the filter. However, the Xact is not sensitive to elements like C, N, O, Na, Mg, Al and Si.

The concentration exceeds the concentration that OSHA recommends should never be exceeded by any adult worker for more than 15 minutes. The arsenic exposure of the monitored population during this hit is equal to about 4% of the arsenic exposure they would receive if exposed to the one-in-a-million concentration (0.2 ng/m^3) for 70 years. The tailing off of the arsenic concentration after the peak measurement and the associated meteorology strongly suggests that these arsenic emissions were occurring well before the Xact's first measurement, and populations to the west and southwest of the source/monitor may have been exposed to similar high arsenic concentrations.

5.2 PM$_{10}$ Selenium

The wind direction dependence of 2-hour integrated selenium data was examined for the six Xact deployments. Most sites exhibited maximum selenium for surface winds from the south/southeast, which is consistent with long range transport. Figure 4-10 shows high excess selenium at Hall for surface winds from the southeast. High selenium for south/southeast winds was also observed in the Hall station Xact data, but the split between local and regional contributions cannot be determined. **Figure 5-4** shows the 2-hour integrated selenium measured at the Blair station. In addition to the high concentration excursions for winds from the south/southeast which are observed at many of the sites, high concentration excursions are also observed for winds from the north/northeast. This is generally consistent with filter-based measurements which exhibit high excess selenium at Blair for winds from the northeast.

5.3 PM$_{10}$ Lead

Figure 5-5 shows the wind direction dependence of 2-hour integrated lead concentration data collected at all six sites. Most sites exhibit sharp features for winds consistent with the bearing of the Doe Run Herculaneum lead smelter (dashed line in each plot). These features are much less distinct at Margaretta, perhaps due to the light and variable winds during that deployment (Figure 5-1). These results are consistent with the filter-based four-site network data which also featured highest lead values from the south. In contrast to arsenic and selenium, the southerly wind sector for high concentration values is much narrower for lead because the high concentration values are not dominated by transport on the scale of up to 50 km rather than hundreds of kilometers.

5.4 Summary

One-month deployments of the Xact instrument at six sites in St. Louis have demonstrated the potential for such measurements to identify local emission source bearings that could not otherwise be extracted from the 24-hour average data. The wind direction dependence of arsenic is consistent with a significant contribution from regional transport. Relatively higher arsenic was observed for surface winds from the southeast, and in many cases this corresponds to synoptic transport from the eastern United States. Local emission source impacts are clearly evident at the Blair NATTS station and include an intermittent emitter northwest of the site. Other features observed in the Blair data are consistent with the four-site filter-based network results, but the low frequency of wind directions from certain sectors precludes a detailed comparison. Most sites show a strong lead signature for winds from the south, consistent with the bearing of the Doe Run Herculaneum lead smelter. This observation is consistent with the results from the four-site filter-based network with the higher time resolution Xact measurements sharpening the relationship between wind direction and high concentration excursions. This data set provides preliminary information about the behavior of air toxics metals in St. Louis. A refined analysis would require longer duration deployments to more thoroughly capture the climatological surface winds patterns. An extended deployment at the Blair NATTS site is recommended both to place the NATTS data in context and because this site is clearly impacted by local emission sources of arsenic.

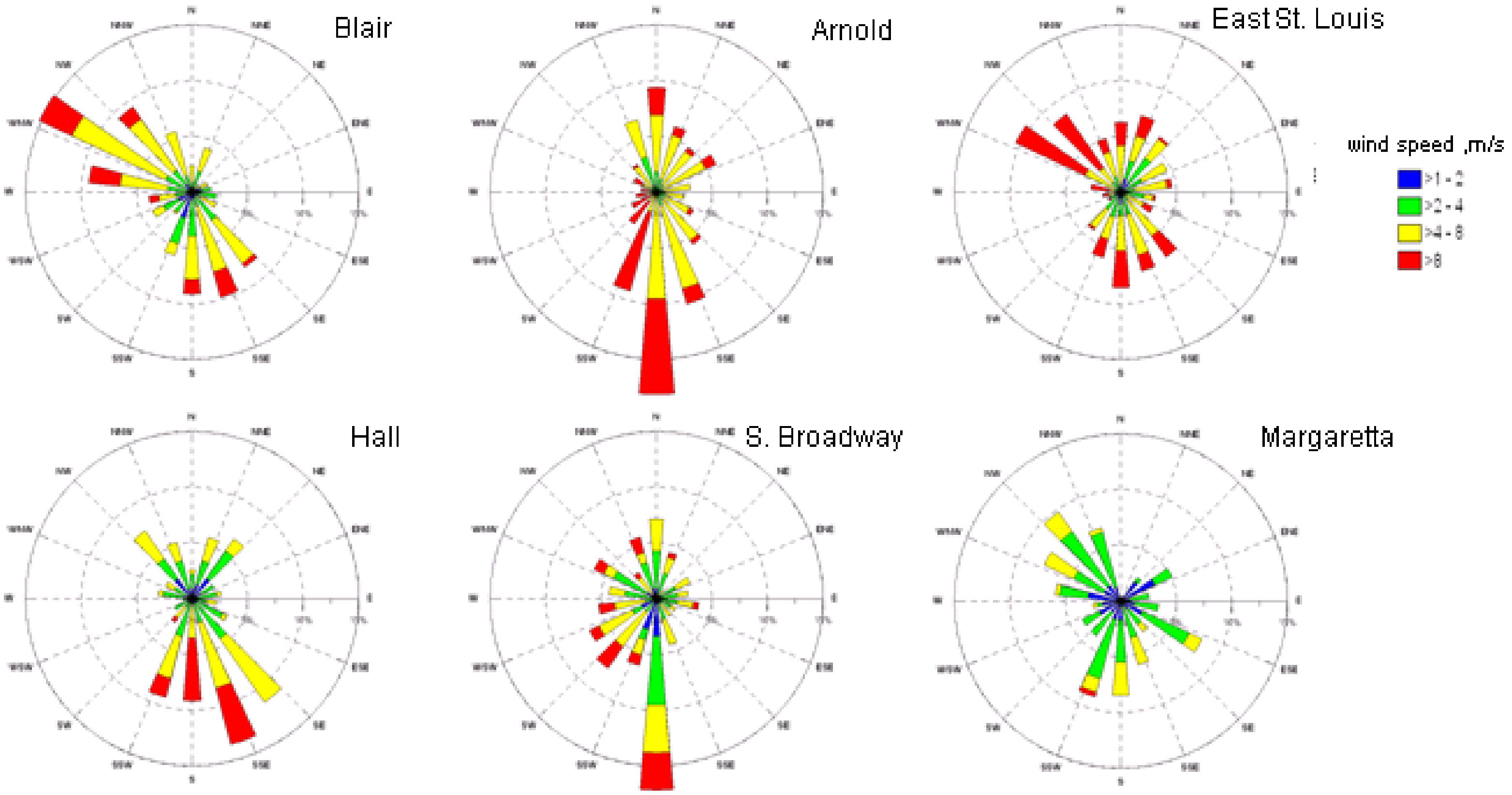

Figure 5-2. Wind roses for the six Xact deployments. 2-hour average winds measured on-site at 10 m for those records with valid Xact data. Wind speeds less than 1 m/s are excluded.

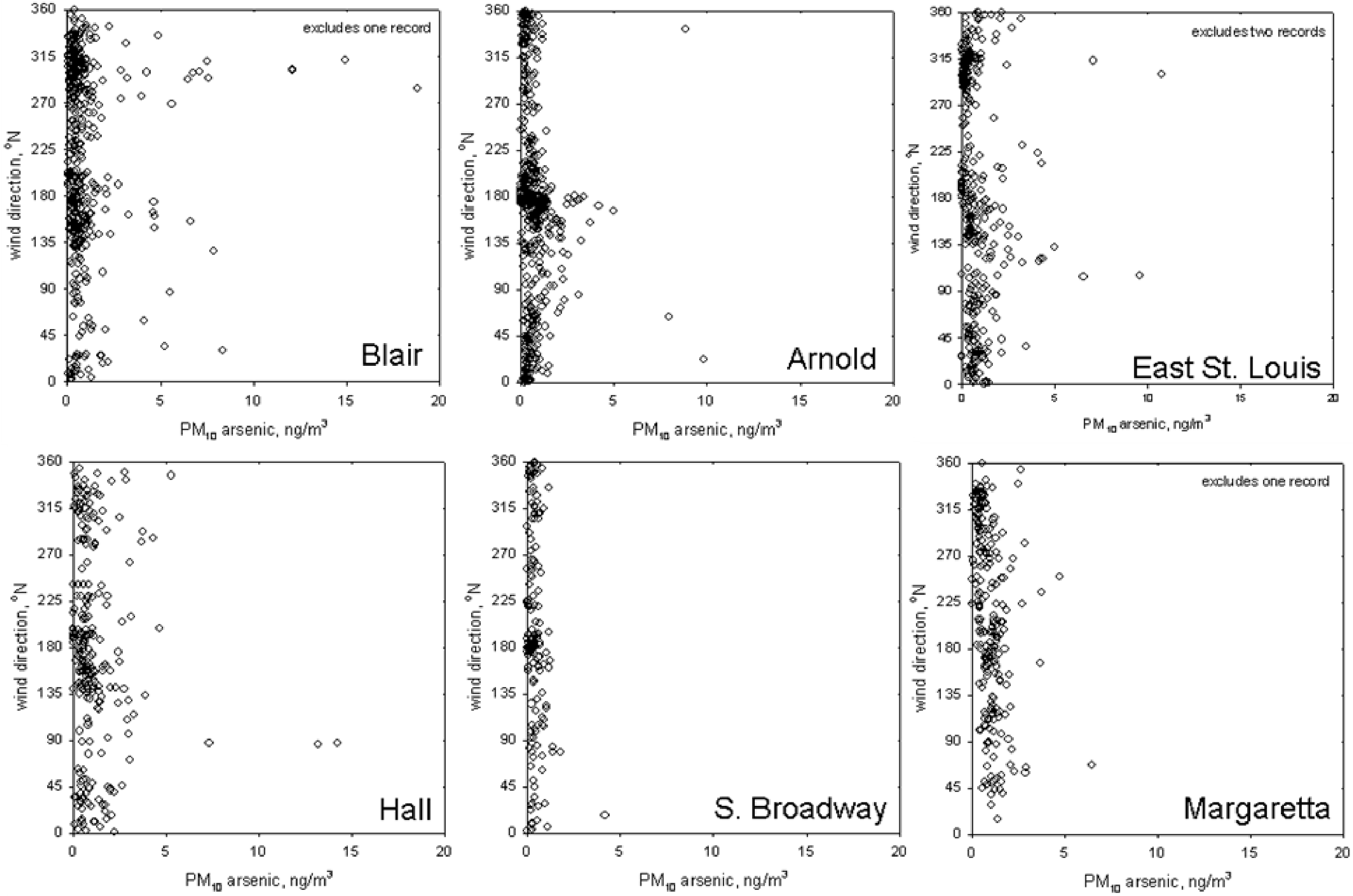

Figure 5-2. Two-hour integrated PM$_{10}$ arsenic and wind direction for the six Xact deployments. Two-hour intervals with wind speeds less than 0.5 mph were removed from the data set.

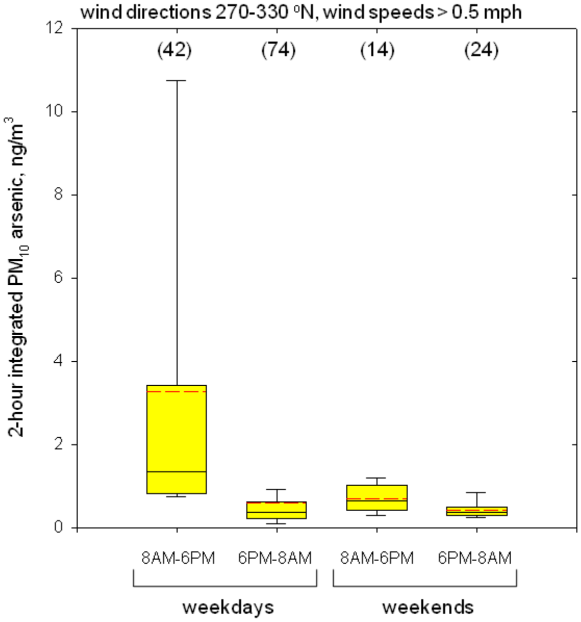

Figure 5-3. 2-hour integrated PM_{10} arsenic at the Blair site, 12/13/08-1/31/09, for winds from 270-330°N only. Values in parentheses are the number of hours in each group.

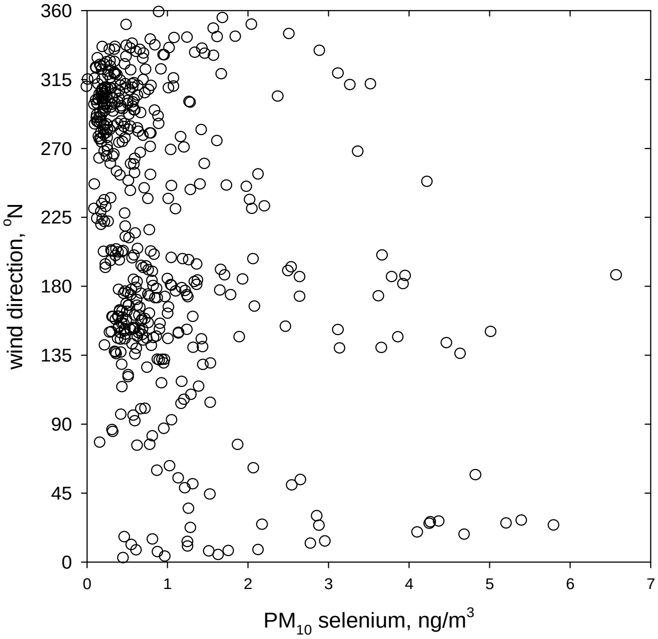

Figure 5-4. Two-hour integrated PM_{10} selenium and wind direction for the Xact deployment at the Blair Street station. Two-hour intervals with wind speeds less than 0.5 mph were removed from the data set.

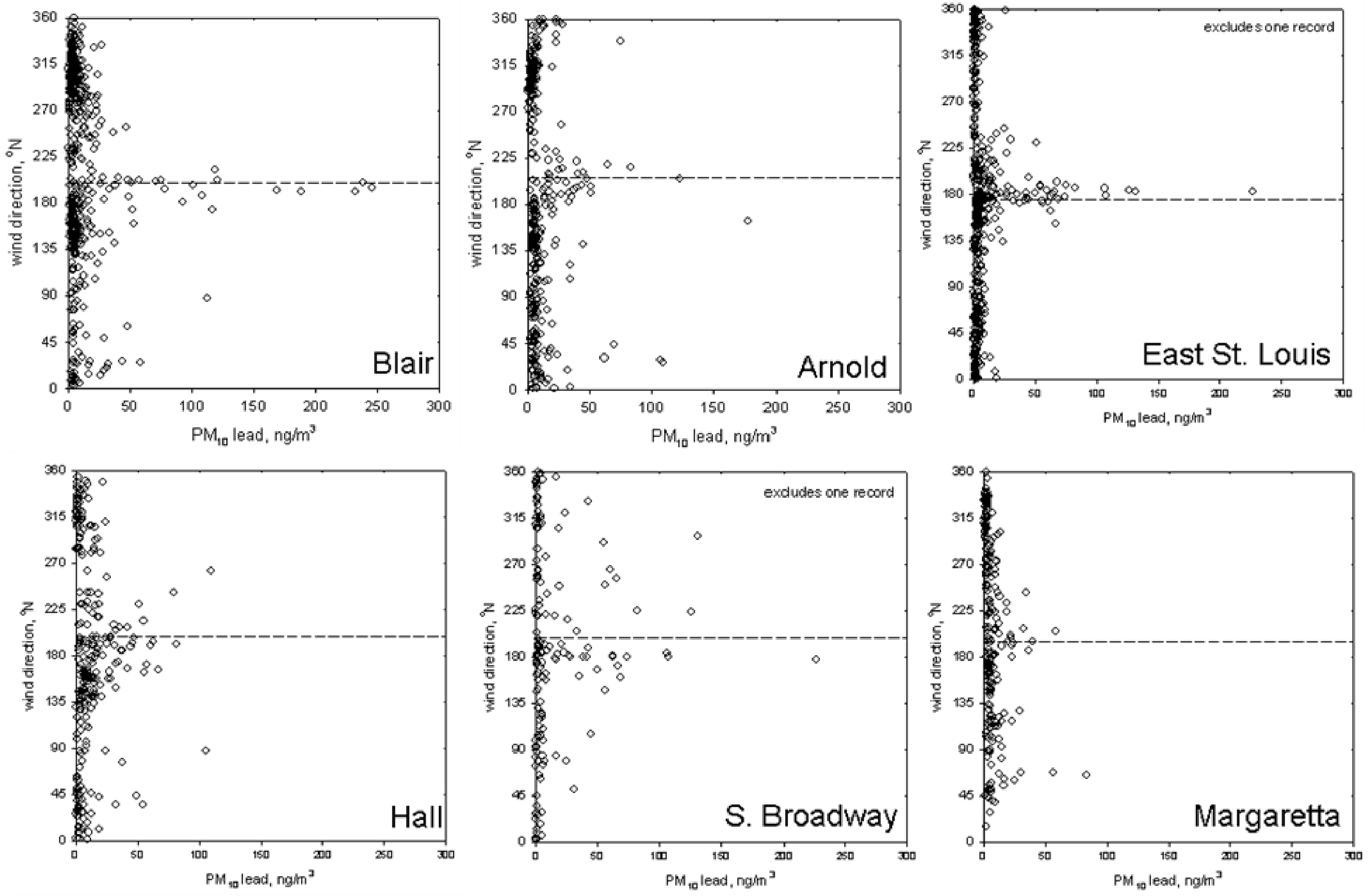

Figure 5-5. Two-hour integrated PM_{10} lead and wind direction for the six Xact deployments. Two-hour intervals with wind speeds less than 0.5 mph were removed from the data set. Dashed lines are the bearing of a primary lead smelter with source-to-receptor distances from 21 km (Arnold) to 50 km (Hall).

6.0 CONCLUSIONS AND RECOMMENDATIONS

Phase I

One year of every third day 24-hour integrated PM_{10} arsenic measurements at a four-site network in the greater St. Louis area has revealed significant spatial gradients over relatively short distances along the industrial Mississippi Riverfront north of the urban core. The annual average PM_{10} arsenic concentration was highest at the Blair Street (City of St. Louis) NATTS site and was twice that observed at two suburban sites. Despite this, annual average PM_{10} arsenic was 1.4 ng/m^3 at the Blair Street site, below the 2 ng/m^3 benchmark established in the St. Louis Community Air Project study for arsenic to be deemed a pollutant of concern. This decrease may be due to changes in source configurations during the intervening years, although that has not been documented.

Conditional probability plots on the Blair St site-specific excess mass concentration distributions, relative to an areawide baseline which was defined as the lowest concentration value observed across the four-site network on each sampling day, yielded consistent bearings for the location of the near-field emission source(s), with the location even further refined through triangulation of the site-specific bearings corresponding to high arsenic concentrations. Surface winds analysis of excess mass distributions for PM_{10} selenium also revealed features that were masked when analyzing the total concentration data due to the relatively high contributions from urban/regional scale emissions sources. Annual-average PM_{10} lead was highest (16.4 ng/m^3) at the Blair Street site and nearly identical (15.4 ng/m^3) at the suburban Arnold site ~25 km to the south. High PM_{10} lead at Arnold is consistent with the location of a large primary lead smelter ~20 km south of that site.

Phase II

Subsequent to the beginning of the 24-hour integrated measurements, high time resolution measurements were conducted using a Cooper Environmental Services Xact 620 ambient metals monitor. This study was the first sustained deployment of the Xact 620 in North America. After resolving some initial hardware problems, data capture was high and the calibration was stable even upon moving the instrument from site to site. Two-hour integrated measurements of PM_{10} arsenic and certain other air toxics metals at six sites in the greater St. Louis area exhibited temporal structure consistent with impacts from regional sources and in some cases also local sources. In the latter case, there can be high within-day variability due to changes in surface wind patterns and perhaps emission rates from sources. Arsenic at the Blair Street NATTS site exhibited high variability with plume impacts most notable from the west /northwest, not seen in the 24-hour samples; the temporal structure for these plumes was consistent with an industrial source operating during the daytime on weekdays. The high arsenic spike (2,345 ng/m^3, 2-hour average) in April 2009 at the East St. Louis site is indicative of a source of extreme emission rates, possibly under upset conditions. At most sites, PM_{10} lead plumes were observed for winds from the south. This is consistent with the location of a large primary lead smelter 20-50 km from the sites.

Relationship of Monitoring to Emission Inventories

While the agreement between the annual average ambient PM_{10} arsenic monitoring data in this study and the ASPEN computer air dispersion model estimates appear to support the argument that the 2005 to 2008 NATTS annual arithmetic mean PM_{10} arsenic concentrations were an accurate reflection of ambient air quality, there are some questions as to the comparisons. Point sources modeled in NATA are not reflected in the NEI, leading to some concern as to our understanding of the arsenic and other toxic metals inventory. Monitoring indicates that residents of census tract 29510126700 in St. Louis City have been exposed to ambient PM_{10} arsenic concentrations at elevated levels. Whether that exposure at one census tract is likely to be similar for a larger portion of the area does not appear to have been proven, and monitoring in several parts of the area indicate that concentrations are not as high. Spatial source apportionment of monitoring data to this point shows several emission sources are involved, further indicating that exposures in the area are in a range of concentrations.

The conclusions above provide rationale for the following recommendations:

1. The elevated arsenic levels monitored on April 13, 2009 at the East St. Louis site are a concern. The states of Missouri and Illinois should continue to work cooperatively to determine the source of these emissions and take corrective actions as appropriate.

2. This study indicates that highest levels of arsenic are not at an urban scale and are related principally to nearby sources, as opposed to information in the National Emissions Inventory. Improvement of the toxic metals inventory would allow a greater understanding of the potential ambient air quality so that it can be reconciled to monitored values. The current Air Quality Management Plan project is working to improve this inventory, and to the extent possible may be able to make use of this study results to do so.

While this study has provided information on and improvements to our understanding of toxic metals in an urban setting such as the St. Louis area, in many instances it points to more work which can be done. Further projects and analysis which could be conducted have been identified if resources can be found. Following are recommendations for additional study:

3. The four-site filter-based network provided significant insights into the spatio-temporal variability of PM_{10} arsenic, selenium, and lead. The high time resolution measurements were intended to further refine the determination of local emission sources by conducting measurements on shorter time scales which provide a stronger coupling between observed concentration and the associated wind direction. The success of this strategy was clearly demonstrated by the identification of an arsenic source near the Blair Street NATTS site and the primary lead smelter tens of kilometers away. In some cases, however, it was not possible to discern whether elevated concentrations of arsenic and especially selenium were from local sources or were regionally transported. The one-month deployments also reveal challenges with relatively short-term deployments to identify primary emissions sources and their impacts – it is possible that the frequency of winds from certain sectors is too small to determine the presence of emission sources from such sectors. Thus, deployments of sufficient length to obtain a representative number of observations from each wind direction are recommended.

Since the both the concentration and surface winds data are collected in near real time, the deployment length could be determined by routine examination of the data being collected.

4. Xact 620 performance was evaluated by comparing the Xact data to filter samples analyzed by XRF and ICP-MS. Very good performance was observed for several elements including arsenic, lead, and selenium, which were the focus of this study. However, the data quality remains to be determined for several of the 24 reported elements. Work should be done with this data and in subsequent deployments to further determine data quality for other elements.

5. Additional receptor modeling should be performed on these data after identifying the subset of elements that have sufficiently high quality to be included in such modeling.

APPENDIX A. PHASE I RESULTS

Table A-1. PM_{10} arsenic, lead, and selenium for the four-site high-volume sampler network.

	PM_{10} arsenic, ng/m^3				PM_{10} lead, ng/m^3				PM_{10} selenium, ng/m^3			
Date	Arnold	Blair	Hall	WashU	Arnold	Blair	Hall	WashU	Arnold	Blair	Hall	WashU
01/01/2008	0.36	0.59	0.55	0.43	3.83	4.53	2.29	12.69	0.52	0.20	0.21	0.25
01/04/2008	0.57	0.71	0.94	0.59	31.76	14.71	32.93	35.78	0.44	0.90	0.86	0.70
01/07/2008	0.39	0.55	0.68	0.32	12.89	8.23	12.83	19.26	0.51	0.72	0.76	0.65
01/10/2008	0.62	1.51	1.27	0.82	6.02	18.57	13.86	7.92	1.31	1.37	1.60	1.98
01/13/2008	0.34	1.19	0.97	0.55	3.51	13.40	6.06	6.73	0.57	0.24	0.31	0.48
01/16/2008	0.44	1.09	1.65	0.54	7.62	6.78	18.14	6.86	0.43	0.44	2.37	0.49
01/19/2008	0.36	1.03	0.63	0.39	2.96	2.25	2.06	2.48	0.12	0.12	0.13	0.15
01/22/2008	0.63	1.14	0.72	0.48	5.38	51.78	9.33	3.17	0.55	0.47	0.51	0.51
01/25/2008	0.48	1.15	1.29	0.52	7.93	21.54	18.67	4.78	0.66	1.09	2.13	0.95
01/28/2008	0.49	1.03	1.05	0.58	30.65	14.72	29.58	9.63	0.56	0.76	1.55	0.71
01/31/2008	0.68	1.36	0.89	0.84	5.35	18.86	8.32	12.66	2.67	3.60	4.06	3.73
02/03/2008	1.47	1.65	1.25	1.19	18.66	17.91	6.53	8.48	1.89	4.30	3.64	3.86
02/06/2008	0.31	1.06	0.44	0.21	1.47	9.20	3.00	2.79	0.39	0.68	0.20	0.32
02/09/2008	0.30	0.86	0.50	0.18	1.48	4.28	3.21	0.87	0.38	0.45	0.40	0.42
02/12/2008	0.68	1.58	0.70	0.68	3.39	4.46	2.60	4.72	1.25	1.72	1.30	1.48
02/15/2008	0.73	1.79	0.81	0.53	5.94	7.10	3.89	3.47	0.66	1.02	0.73	0.86
02/18/2008	0.14	0.79	0.28	0.17	0.57	9.90	1.33	1.44	0.39	0.22	0.19	0.21
02/21/2008	0.64	1.75	0.65	0.71	3.09	10.68	3.54	7.81	2.53	2.86	2.58	2.57
02/24/2008	0.74	1.00	0.90	0.68	8.73	14.68	9.79	7.91	1.38	1.57	1.61	1.36
02/27/2008	0.16	0.76	0.36	0.13	2.47	4.30	2.68	1.32	0.14	0.10	0.10	0.10
03/01/2008	0.51	0.84	2.55	0.77	29.23	90.46	75.64	19.74	0.48	0.54	2.35	0.45
03/04/2008	0.60	1.12	0.62	0.54	3.36	8.05	3.77	4.17	0.55	0.69	0.64	0.67
03/07/2008	0.59	2.15	0.74	0.54	7.19	18.84	10.04	6.26	0.95	4.27	0.76	0.85
03/10/2008	0.53	1.38	0.72	0.49	2.71	13.17	5.86	2.14	0.52	0.70	0.69	0.68
03/13/2008	0.80	1.15	0.98	0.57	3.79	15.72	10.03	3.42	0.62	0.74	0.64	0.55
03/16/2008	0.91	1.53	0.84	0.71	4.05	7.65	3.22	5.43	1.49	1.98	1.33	1.24
03/19/2008	0.41	1.68	0.58	0.45	3.89	27.17	5.17	3.61	0.74	0.68	0.65	0.73
03/22/2008	0.42	0.79	0.46	0.52	2.49	2.97	2.41	1.56	0.44	0.70	0.68	0.43
03/25/2008	0.79	1.07	1.03	0.78	7.14	11.93	23.72	19.70	0.76	0.90	0.88	0.78
03/28/2008	0.47	1.27	0.60	0.53	4.06	5.74	3.96	6.06	0.76	0.80	0.65	0.68
03/31/2008	0.50	1.15	0.77	0.45	25.28	5.85	6.10	8.80	0.58	0.67	0.78	0.50
04/03/2008	0.75	1.45	0.82	0.72	15.66	16.76	7.38	13.16	1.19	2.16	1.90	1.81
04/06/2008	0.89	1.20	1.27	1.04	30.24	7.87	9.30	10.99	1.85	1.85	1.99	1.65
04/09/2008	0.64	0.86	1.04	0.62	5.54	13.19	9.96	8.86	0.57	0.92	1.10	1.01
04/12/2008	0.38	0.47	0.61	0.13	2.62	6.22	2.74	2.44	0.39	0.16	0.14	0.14
04/15/2008	0.93	3.18	2.28	0.82	43.33	41.89	33.17	17.81	0.57	0.85	1.12	0.66
04/18/2008	0.39	0.72	0.77	0.40	17.98	9.38	13.80	9.40	0.67	0.72	1.36	0.70
04/21/2008	0.98	1.36	1.42	2.01	7.49	8.85	11.29	14.09	1.35	1.28	1.88	2.75
04/24/2008	0.99	1.21	1.36		30.69	9.04	15.74		1.33	1.55	2.65	
04/27/2008	2.77	1.44	0.96	1.06	6.22	12.03	5.74	9.04	0.69	2.42	0.80	0.71
04/30/2008	0.69	0.93	1.11	0.70	6.41	9.38	15.52	6.73	0.87	0.90	1.75	0.86
05/03/2008	0.70	2.40	0.50	0.37	2.39	15.70	4.58	2.19	0.41	0.35	0.29	0.33
05/06/2008	1.26	1.47	1.63	1.09	40.27	41.34	40.41	19.83	0.73	1.00	1.36	0.80
05/09/2008	1.90	2.67	0.75	0.99	6.48	18.56	8.15	6.20	1.72	2.35	1.54	1.41
05/12/2008	0.47	1.99	0.73	0.40	11.68	8.18	7.59	0.00	0.69	0.87	0.89	0.80
05/15/2008	0.68	0.85	0.57	0.49	4.14	9.38	6.06	3.05	1.03	1.65	1.00	0.92
05/18/2008	0.71	0.77	0.79	0.55	2.46	3.86	5.41	0.51	0.39	0.56	0.46	0.39
05/21/2008	0.89	0.82	0.46	0.58	2.95	7.39	3.72	0.57	0.45	0.51	0.51	0.37
05/24/2008	1.80	1.86	1.68	1.32	4.81	9.41	7.70	1.28	2.44	2.46	2.65	2.73
05/27/2008	1.53	2.03	1.32	1.65	30.06	19.98	11.06	20.00	0.77	2.27	0.92	0.97
05/30/2008	0.67	0.82	1.02	0.54	11.23	25.94	36.17	9.76	1.33	1.97	1.58	1.23
06/02/2008	0.90	1.31	1.35	0.89	6.45	19.13	18.52	5.00	0.86	1.07	1.40	0.93
06/05/2008	0.36	0.69	0.68	0.29	12.76	6.39	13.53	13.33	0.67	0.77	1.27	0.64
06/08/2008	0.34	0.50	0.54	0.32	8.26	4.31	12.59	7.72	0.56	0.77	0.86	0.50
06/11/2008	0.44	0.57	0.67	0.34	9.96	17.12	7.57	1.30	1.15	1.14	1.71	1.06
06/14/2008	0.59	0.74	0.89	0.46	4.14	5.11	10.50	0.85	0.60	1.22	1.87	0.62
06/17/2008	0.38	1.20	0.68	0.33	3.99	5.54	3.96	3.17	0.54	0.68	0.67	0.64
06/20/2008	1.21	0.91	0.70	0.65	8.25	9.60	7.84	4.70	1.14	1.58	1.81	1.26
06/23/2008	0.63	0.91	0.92	0.68	5.57	7.00	9.21	2.99	0.65	1.17	1.44	0.73
06/26/2008	0.43	0.69	0.64	0.51	8.66	9.57	12.85	14.26	0.47	0.91	0.86	0.83
06/29/2008	0.44	0.34	0.32	0.18	0.45	1.34	2.61	0.66	0.53	0.51	0.50	0.47

Table A-1. Continued.

	PM$_{10}$ arsenic, ng/m^3				PM$_{10}$ lead, ng/m^3				PM$_{10}$ selenium, ng/m^3			
Date	**Arnold**	**Blair**	**Hall**	**WashU**	**Arnold**	**Blair**	**Hall**	**WashU**	**Arnold**	**Blair**	**Hall**	**WashU**
07/02/2008	0.41	0.49	0.96	0.43	13.74	21.84	40.06	12.21	0.63	0.92	0.89	0.71
07/05/2008	1.92	2.38	2.38	2.20	56.46	39.62	32.48	25.93	1.45	1.50	2.25	1.35
07/08/2008	0.43	0.57	0.83	0.81	6.06	9.86	11.41	20.70	0.53	0.76	0.79	1.34
07/11/2008	0.45	0.55	0.70		18.86	32.18	30.34		0.78	1.02	1.05	
07/14/2008	0.45	0.95	0.75	0.31	2.95	11.92	6.35	0.71	0.65	0.63	0.70	0.61
07/17/2008	0.76	0.76	1.11	0.67	64.10	15.15	14.84	42.95	1.62	2.30	2.44	1.67
07/20/2008	0.49	0.65	2.21	0.53	8.26	8.65	9.00	2.40	0.72	1.23	1.20	1.32
07/23/2008	0.79	1.05	0.68	0.57	6.48	11.67	12.34	4.57	1.70	3.58	2.93	2.27
07/26/2008	0.63	1.00	0.78	0.59	5.12	5.37	4.83	3.97	0.74	1.05	1.16	0.93
07/29/2008	0.80	0.82	0.78	0.64	7.76	5.33	8.01	5.77	1.29	1.41	1.61	1.24
08/01/2008	0.83	1.73	2.39	0.97	11.69	19.36	14.69	15.64	1.40	1.62	2.18	1.40
08/04/2008	1.10	1.40	1.40	1.45	16.94	15.88	22.29	18.41	2.05	2.47	2.76	2.11
08/07/2008	0.76	1.39	0.94	0.63	7.39	10.24	5.49	9.33	1.00	1.07	1.03	1.01
08/10/2008	2.27	1.39	1.57	1.16	12.14	10.45	7.11	8.91	1.14	1.51	1.79	1.42
08/13/2008	1.12	1.79	2.01	1.40	5.97	24.65	17.03	14.20	1.89	2.21	2.68	1.82
08/16/2008	1.07	1.43	0.83	1.14	8.14	9.32	2.09	7.96	1.10	1.84	1.15	1.28
08/19/2008	1.68	2.34	2.29	1.54	11.69	58.32	26.09	18.38	1.74	1.39	1.78	1.28
08/22/2008	0.82	0.67	1.24		23.76	4.09	19.56		1.01	0.74	1.42	
08/25/2008	0.84	1.42	0.85		10.01	15.21	7.68		1.08	1.92	1.08	
08/28/2008	1.46	1.32	1.33	1.67	28.50	27.31	27.05	27.09	1.51	1.76	1.85	1.54
08/31/2008	11.59	1.96	1.97	5.62	8.86	43.05	7.66	8.91	2.69	2.66	2.96	2.71
09/03/2008	1.71	2.95	1.24	0.95	6.75	18.11	8.57	7.30	2.11	2.04	1.67	1.86
09/06/2008	1.87	1.61	1.36	2.00	3.89	9.59	5.80	3.18	0.78	1.21	1.21	0.73
09/09/2008	0.50	0.66	0.63	0.76	4.79	5.79	4.43	6.33	0.52	0.83	0.46	0.60
09/12/2008	1.62	1.66	1.27	1.06	30.07	11.50	4.91	8.79	1.35	1.10	1.33	1.18
09/15/2008	0.31	2.13	0.30	0.21	1.11	1.42	0.87	0.93	0.23	0.28	0.26	0.26
09/18/2008	1.98	3.70	1.48	1.56	27.58	40.26	16.46	15.42	1.13	1.29	2.09	1.11
09/21/2008	1.63	1.78	1.53	1.08	30.00	15.12	14.05	6.26	1.56	1.72	2.83	1.67
09/24/2008	1.93	2.70	2.06	2.60	32.79	57.58	13.41	17.75	1.84	2.24	2.57	1.80
09/27/2008	3.11	2.20	2.14	2.20	28.75	13.03	9.00	2.06	1.22	1.13	1.19	1.47
09/30/2008	0.49	0.81	0.50	0.80	1.64	34.48	0.86	0.00	0.45	0.51	0.54	0.51
10/03/2008	3.63	1.42	1.12	0.90	8.74	4.24	10.87	2.32	0.45	0.48	0.52	0.62
10/06/2008	1.61	3.82	3.83	1.20	38.30	52.05	32.68	7.92	1.31	1.85	2.51	1.09
10/09/2008	1.90			1.74	18.10			12.25	0.74			0.72
10/12/2008	2.08	2.71	2.57	1.47	6.01	6.81	7.39	3.69	1.03	0.99	1.54	0.88
10/15/2008	0.86	1.13	1.17	0.95	19.68	12.86	14.01	15.51	0.58	0.98	0.97	0.67
10/18/2008	7.42	1.10	1.09	0.89	4.04	19.88	10.54	3.21	0.64	0.87	0.62	0.52
10/21/2008	0.68	2.06	0.78	0.84	1.21	34.38	5.34	5.52	0.58	1.50	0.87	0.75
10/24/2008	0.73	0.69	0.45	0.30	11.50	5.47	4.82	1.67	0.52	0.28	0.36	0.38
10/27/2008	0.22	0.71	0.21	0.17	0.09	1.64	0.99	0.00	0.27	0.12	0.11	0.14
10/30/2008	1.69	2.16	1.81	0.90	78.28	100.03	51.61	59.47	1.34	0.92	1.48	1.06
11/02/2008	1.68	1.54	1.74	1.67	140.87	31.45	27.63	69.35	1.48	1.39	1.82	1.55
11/05/2008	1.03	1.17	1.43	0.99	25.37	5.10	17.95	9.97	1.05	1.01	1.64	1.07
11/08/2008	0.45	0.45	0.25	0.21	1.96	2.02	0.00	1.92	0.96	0.22	0.20	0.23
11/11/2008	0.82	1.20	1.40	0.91	5.53	5.65	3.92	3.90	1.15	1.62	2.18	1.41
11/14/2008	0.49	0.95	0.80	0.52	3.79	12.89	11.28	6.25	0.68	0.88	0.87	0.68
11/17/2008	0.46	1.14	0.30	0.21	1.37	6.94	0.20	2.38	0.30	0.31	0.30	0.32
11/20/2008	0.46	1.27	0.38	0.25	2.41	6.33	2.09	4.19	0.34	0.51	0.43	0.35
11/23/2008	1.02	0.99	2.17	1.12	154.04	32.05	34.52	22.10	1.05	0.88	1.94	1.05
11/26/2008	1.98	6.52	2.82	1.71	39.30	82.59	13.85	22.58	1.77	3.94	1.68	1.65
11/29/2008	1.82	1.43	1.18	1.38	4.59	7.64	6.67	7.24	2.14	1.90	1.83	1.98
12/02/2008	0.50	0.62	0.90	0.42	25.54	26.90	25.96	15.70	0.34	0.74	0.50	0.35
12/05/2008	0.35	1.13	0.61	0.29	10.79	11.81	20.49	17.94	0.37	0.32	0.49	0.29
12/08/2008	0.59	0.75	1.03	0.53	85.96	11.33	9.40	29.83	0.65	0.63	2.42	0.72
12/11/2008	0.60	2.15	0.71	0.79	6.77	6.50	3.37	4.93	0.64	1.10	0.74	0.80
12/14/2008	0.53	0.65	0.60	0.45	30.14	1.83	0.68	48.02	0.99	0.90	1.01	1.30
12/17/2008	0.58	1.36	0.57	0.75	12.25	10.11	6.20	5.85	0.96	1.05	0.96	0.91
12/20/2008	0.70	0.84	0.74	0.61	4.58	8.04	4.24	4.21	1.18	1.38	1.32	1.33
12/23/2008	0.58	0.55	0.85	0.55	9.80	4.45	10.11	4.03	0.52	0.52	0.62	0.53
12/26/2008	0.52	0.80	1.24	0.58	5.63	2.78	5.06	2.79	1.21	1.39	1.52	1.95
12/29/2008	0.44	4.51	0.55	0.37	5.83	23.89	9.59	3.43	0.57	0.38	0.38	0.33

APPENDIX B. PHASE II RESULTS

Table B-1a. PM$_{10}$ Arsenic by Xact 620: Blair Station, City of St. Louis (MO).

PM$_{10}$ Arsenic by Xact 620: Blair, City of St. Louis, MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
12/13/2008								0.30	0.29	0.39	0.51	0.49
12/14/2008	0.27	0.27	0.39	0.42	0.40	0.55	0.37	0.44	1.30	2.05	0.25	0.32
12/15/2008	0.19	0.57	0.49	0.44	0.58	0.63	1.45	3.16	1.19	0.69	0.40	0.05
12/16/2008	0.54	0.48	0.64	0.84	1.20	1.27	1.36	5.51	0.94	0.20	0.47	0.27
12/17/2008	1.04	1.87	0.16	0.44	0.33	0.43	0.66	1.25	1.11	0.73	0.48	4.69
12/18/2008	0.80	0.28	0.40	0.67	0.77	38.25	4.69	1.89	0.91	0.71	0.40	0.28
12/19/2008	0.92	0.33	0.66	0.41	3.95	0.28	0.26	0.60	0.14	0.15		
12/20/2008												
12/21/2008												
12/22/2008						1.42	0.80	0.79	1.02	0.53	0.51	0.41
12/23/2008	0.41	0.49	0.42	0.70	0.57	0.73	0.79	0.66	0.67	0.23	0.49	0.47
12/24/2008	0.56	0.51	0.47	0.35	0.50	0.46	0.19	0.21	0.52	0.44	0.34	0.28
12/25/2008	0.34	0.15	0.52	0.47	0.25	0.43	0.47	0.20	0.38	0.33	0.46	0.68
12/26/2008	0.88	0.93	0.89	0.61	1.24	1.24	1.08	0.97	0.82	0.41	0.30	0.28
12/27/2008	0.19	0.48	0.26	0.27	0.28	0.32	0.19	0.66	0.42	0.33	0.27	0.45
12/28/2008	0.15	0.25	0.48	0.36	0.14	0.09	0.11	0.36	0.34	1.10	0.36	0.16
12/29/2008	0.00	0.00	0.22	0.20	1.60	0.65	0.52	3.24	14.89	7.07	4.85	2.03
12/30/2008	4.10	0.10	0.32	0.26	0.45	1.04	0.80	5.60	1.10	0.66	0.08	0.14
12/31/2008	0.35	0.40	0.22	0.29	0.65	1.52	1.27	0.23	0.24	0.58		
01/01/2009												
01/02/2009												
01/03/2009												
01/04/2009												
01/05/2009									0.33	1.01	1.10	0.58
01/06/2009	0.49	0.82	2.29	0.89	1.29	1.37	1.30	1.32	0.41	0.76	0.78	0.19
01/07/2009	0.11	0.44	0.84	0.71	18.77	0.74	0.65	1.06	2.87	0.26	0.10	0.14
01/08/2009	0.05	0.18	0.38	0.92	12.10	12.10	7.59	6.49	0.78	0.67	0.97	1.37
01/09/2009	0.44	0.48	0.57	0.41	4.57	1.08	0.51	3.30	6.59	1.71	4.64	0.95
01/10/2009	0.93	0.79	0.75	1.03	1.01	0.90	0.72	0.49	0.39	0.34	0.39	0.35
01/11/2009	0.37	0.38	0.39	0.70	0.82	0.68	0.51	0.71	0.56	0.56	0.40	0.29
01/12/2009	0.23	0.11	0.49	0.36	0.19	0.33	0.70	0.65	1.08	0.72	0.70	0.91
01/13/2009	0.20	0.28	0.38	0.85	0.93	6.77	0.60	2.84	0.31	0.58	0.96	0.37
01/14/2009	0.21	0.26	0.32	0.47	0.31	0.16	0.45	0.74	0.54	0.31	0.50	0.40
01/15/2009	0.00	0.00				1.62	0.79	7.52	0.58	0.25	0.22	0.31
01/16/2009	0.37	0.24	0.05	0.51	1.07	0.87	1.13	0.58	0.58	0.44	0.34	0.62
01/17/2009	0.33	0.32	0.28	0.21	0.55	0.81	1.17	1.03	0.32	0.51	0.38	0.26
01/18/2009	0.31	0.24	0.29	0.30	0.25	0.41	0.92	1.19	1.20	7.86	0.89	0.14
01/19/2009	0.36	0.27	0.41	0.51	0.61	0.83	0.77	0.49	0.60	0.32	0.15	0.47
01/20/2009	0.43	0.32	0.45	0.87	2.25	1.02	0.79	0.52	0.92	0.76	1.83	0.50
01/21/2009	0.49	0.00	0.00	0.08	0.18	0.56	0.21	0.23	0.59	0.74	0.78	1.06
01/22/2009	0.81	0.83	0.66	0.26	2.18	2.01	1.54	1.38	1.31	1.03	1.47	1.67
01/23/2009	1.34	1.45	1.44	1.23	1.52	1.03	0.76	0.49	0.52	0.31		
01/24/2009												
01/25/2009												
01/26/2009						1.85	1.94	1.77	0.47	0.66	1.02	
01/27/2009						2.20	0.50	1.14	0.71	0.82	1.01	0.63
01/28/2009	0.00	0.52	0.43	0.55	0.66	0.44	0.48	0.35	0.53	0.12	0.48	0.55
01/29/2009	0.54	0.48	0.76	0.78	1.11	1.73	1.40	0.64	0.14	0.62	0.09	0.28
01/30/2009	0.23	0.15	0.24	0.26	4.27	0.35	0.54	0.96	8.32	5.24	0.40	0.48
01/31/2009	0.65	0.79	0.72	0.12	0.00	2.09	2.75	0.51	0.00	0.00		

Table B-1b. PM_{10} Lead by Xact 620: Blair Station, City of St. Louis (MO).

PM_{10} Lead by Xact 620: Blair, City of St. Louis, MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
12/13/2008								5.13	6.01	4.48	4.15	4.19
12/14/2008	3.02	3.65	2.55	2.26	2.36	1.72	1.99	2.06	2.25	1.85	1.92	2.01
12/15/2008	2.52	1.43	2.81	2.01	2.23	2.29	2.21	3.10	3.07	2.31	2.17	2.88
12/16/2008	6.84	6.27	3.85	3.69	5.10	4.10	4.17	111.95	3.27	4.93	18.01	11.13
12/17/2008	16.28	12.66	6.78	3.29	2.85	3.87	4.57	20.72	8.98	4.73	8.54	4.88
12/18/2008	28.78	3.55	4.10	13.50	36.87	19.48	25.84	20.97	11.68	7.67	6.24	6.01
12/19/2008	1.80	10.50	16.57	35.78	6.47	5.40	4.44	8.68	3.35	3.61		
12/20/2008												
12/21/2008												
12/22/2008						11.97	10.85	18.54	7.15	11.06	5.83	3.69
12/23/2008	4.97	5.62	5.28	7.16	6.92	4.86	4.17	5.70	4.62	3.60	1.19	1.97
12/24/2008	2.93	1.68	1.29	5.89	2.24	0.99	2.10	3.73	8.98	2.12	2.47	2.03
12/25/2008	1.96	4.25	2.16	1.83	2.58	2.29	5.90	3.79	4.69	5.17	3.32	4.18
12/26/2008	2.96	2.05	2.40	4.08	4.16	4.76	6.20	3.80	1.67	2.02	1.60	1.62
12/27/2008	0.97	0.62	0.70	1.28	0.91	0.48	1.62	0.43	5.42	1.79	0.58	0.43
12/28/2008	0.88	0.48	0.04	0.69	1.65	4.78	4.63	1.05	2.95	11.49	27.47	47.96
12/29/2008	50.12	56.39	20.29	17.86	6.49	26.18	3.77	5.87	16.64	11.38	9.17	14.08
12/30/2008	47.74	5.47	7.06	10.29	8.45	11.76	12.80	22.69	4.17	3.26	2.17	3.66
12/31/2008	2.27	2.11	1.70	1.69	3.22	5.05	8.88	5.14	2.28	5.14		
01/01/2009												
01/02/2009												
01/03/2009												
01/04/2009												
01/05/2009									6.95	4.34	8.54	4.04
01/06/2009	4.14	3.43	2.30	2.35	7.39	22.80	12.12	9.85	8.04	15.34	9.32	19.67
01/07/2009	16.29	6.34	3.53	6.27	18.53	3.80	4.29	6.83	22.67	2.76	1.36	0.74
01/08/2009	1.33	0.74	0.71	1.93	6.86	12.66	10.94	14.04	7.17	23.10	27.84	5.00
01/09/2009	7.01	6.52	7.28	9.77	15.38	7.71	8.49	15.48	17.38	4.95	4.91	3.29
01/10/2009	3.26	5.11	5.27	6.44	11.21	6.95	5.14	8.33	4.77	3.16	2.21	1.84
01/11/2009	1.55	2.26	1.95	2.39	5.40	6.41	3.11	7.59	4.88	2.79	2.88	2.62
01/12/2009	2.04	15.79	2.36	12.44	6.60	11.84	12.78	8.69	7.97	5.22	12.96	7.87
01/13/2009	1.27	1.36	2.13	1.39	2.07	5.25	3.13	2.47	2.78	12.16	8.02	7.14
01/14/2009	7.21	9.24	10.63	10.25	13.43	2.69	5.63	7.47	3.82	1.75	3.00	2.14
01/15/2009	0.14	0.00				4.16	3.90	5.31	2.24	3.43	3.32	4.02
01/16/2009	1.94	2.32	5.43	10.24	9.75	7.25	8.33	5.80	6.88	4.00	4.58	4.54
01/17/2009	4.40	3.48	3.26	3.46	6.20	16.92	7.23	11.62	7.49	1.04	2.03	1.16
01/18/2009	0.56	2.09	0.45	0.20	2.72	10.40	10.41	8.60	9.65	14.23	23.07	1.64
01/19/2009	4.61	3.42	4.22	2.20	2.46	5.26	4.59	3.31	4.22	3.36	3.85	5.17
01/20/2009	1.52	1.08	1.58	1.95	4.66	3.53	8.50	5.35	4.21	23.89	24.44	4.46
01/21/2009	18.79	118.48	120.68	238.15	70.20	28.67	51.95	16.43	18.33	12.14	21.42	22.84
01/22/2009	16.05	29.95	46.83	77.24	100.24	48.85	108.28	115.96	32.59	10.10	6.76	7.64
01/23/2009	10.74	19.23	17.61	10.63	10.09	7.60	8.04	10.93	4.02	2.51		
01/24/2009												
01/25/2009												
01/26/2009						58.30	28.41	43.30	5.32	3.77	3.46	
01/27/2009						30.97	16.22	25.54	6.71	11.35	8.72	9.25
01/28/2009	26.64	8.53	5.31	4.88	5.00	6.68	4.18	3.63	8.33	18.49	37.62	33.00
01/29/2009	40.47	22.56	6.43	12.11	9.74	8.90	12.67	5.87	22.48	1.59	12.18	14.61
01/30/2009	1.02	0.70	0.57	1.32	3.99	5.53	16.97	31.86	11.27	7.69	1.75	2.81
01/31/2009	5.34	53.06	4.26	26.08	74.71	92.63	231.79	245.23	168.57	187.84		

Table B-1c. PM_{10} Selenium by Xact 620: Blair Station, City of St. Louis (MO).

PM_{10} Selenium by Xact 620: Blair, City of St. Louis, MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
12/13/2008								0.36	0.39	0.41	0.52	0.62
12/14/2008	0.76	0.85	0.98	1.11	1.25	1.37	1.05	1.06	1.01	1.02	0.64	0.24
12/15/2008	0.25	0.21	0.30	0.23	0.22	0.20	0.20	0.29	0.54	0.85	0.49	2.13
12/16/2008	2.89	2.18	1.53	2.66	4.83	2.55	1.14	0.96	1.18	1.69	1.29	1.06
12/17/2008	1.17	0.89	1.08	1.28	0.73	0.57	0.55	1.58	2.07	1.88	1.54	1.32
12/18/2008	1.22	1.03	0.79	0.68	0.81	1.14	1.14	1.21	1.30	1.18	0.91	0.83
12/19/2008	0.40	0.81	0.71	0.52	0.48	0.10	0.13	0.19	0.20	0.42		
12/20/2008												
12/21/2008												
12/22/2008						0.30	0.27	0.44	0.91	1.45	0.97	0.65
12/23/2008	0.48	0.48	0.60	0.70	0.73	0.63	0.60	1.26	0.60	0.42	0.31	0.35
12/24/2008	0.43	0.37	0.58	0.33	0.79	0.13	0.25	0.22	0.26	0.31	0.27	0.27
12/25/2008	0.27	0.45	0.47	0.63	0.44	0.52	1.54	0.93	0.96	0.94	3.14	5.02
12/26/2008	3.87	3.12	2.47	1.90	1.43	0.78	0.59	0.69	0.83	0.52	0.55	0.58
12/27/2008	0.63	0.50	0.56	0.49	0.33	0.40	0.46	0.41	0.30	0.10	0.40	0.26
12/28/2008	0.22	0.42	0.19	0.22	0.18	0.22	0.18	0.09	0.13	0.21	0.37	0.39
12/29/2008	0.36	0.32	0.24	0.31	0.30	0.59	0.48	0.33	0.42	0.39	0.35	1.32
12/30/2008	0.88	0.87	0.58	0.62	0.66	1.66	2.07	1.05	0.43	0.45	0.23	0.30
12/31/2008	0.35	0.25	0.18	0.71	0.97	1.09	1.64	1.76	2.96	0.82		
01/01/2009												
01/02/2009												
01/03/2009												
01/04/2009												
01/05/2009									0.33	0.43	0.73	1.39
01/06/2009	3.66	4.64	4.47	3.63	2.03	1.62	1.21	0.80	0.59	0.55	0.46	0.25
01/07/2009	0.34	0.55	0.60	0.67	0.63	0.21	0.22	0.26	0.19	0.21	0.12	0.15
01/08/2009	0.25	0.23	0.21	0.31	0.51	0.59	0.67	0.53	0.35	0.52	0.88	1.33
01/09/2009	1.01	0.69	0.47	0.40	0.44	0.55	1.18	0.65	0.44	0.57	1.79	6.58
01/10/2009	3.67	1.29	3.12	3.27	3.53	2.38	1.08	1.02	0.70	0.48	0.36	0.41
01/11/2009	0.42	0.45	0.48	0.48	0.57	1.11	0.70	0.39	0.32	0.35	0.49	0.47
01/12/2009	0.62	1.29	0.60	0.39	0.42	0.48	0.71	0.75	0.50	0.82	0.52	0.58
01/13/2009	0.21	0.43	0.32	0.20	0.19	0.23	0.18	0.12	0.14	0.17	0.23	0.29
01/14/2009	0.46	0.66	1.37	0.20	0.79	0.09	0.36	0.64	0.38	0.12	0.17	0.19
01/15/2009	0.02	0.00				0.16	0.15	0.24	0.12	0.14	0.20	0.56
01/16/2009	0.62	0.95	0.30	0.68	2.09	1.44	0.91	0.45	0.40	0.41	0.46	0.61
01/17/2009	0.87	1.01	0.48	0.52	1.72	0.78	1.46	0.79	0.52	0.21	0.14	0.17
01/18/2009	0.16	0.13	0.16	0.24	0.22	0.18	0.26	0.21	0.33	0.75	0.63	0.29
01/19/2009	1.58	0.97	0.90	1.35	0.93	0.77	0.80	0.70	0.59	0.66	0.88	0.82
01/20/2009	1.03	0.57	0.79	1.62	1.85	0.57	0.48	0.54	0.41	0.34	0.38	0.55
01/21/2009	0.53	0.48	0.44	0.59	0.84	1.38	0.78	0.63	0.88	1.94	1.41	0.76
01/22/2009	0.72	0.49	0.60	0.68	1.27	3.79	3.96	2.65	1.25	0.77	1.34	2.65
01/23/2009	2.54	2.50	1.99	1.43	1.47	2.51	0.50	0.35	0.22	0.36		
01/24/2009												
01/25/2009												
01/26/2009						5.21	4.69	4.27	1.26	4.26	5.40	
01/27/2009						4.11	1.25	2.78	1.52	2.05	1.25	1.43
01/28/2009	2.89	1.68	0.73	0.58	0.85	0.43	2.21	0.61	1.23	0.68	1.20	0.74
01/29/2009	0.64	1.02	1.74	2.13	4.23	3.37	0.90	0.60	0.29	0.23	0.19	0.16
01/30/2009	0.18	0.15	0.18	0.17	0.13	0.10	4.37	5.80	2.86	1.27	1.06	0.32
01/31/2009	0.36	0.32	2.06	1.05	0.80	3.93	1.67	0.23	0.23	0.77		

Table B-2a. PM_{10} Arsenic by Xact 620: Arnold (MO).

PM_{10} Arsenic by Xact 620: Arnold, MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
02/03/2009									0.32	0.24	0.19	0.26
02/04/2009	0.17	0.41	0.41	0.46	0.24	0.23	0.39	1.13	0.78	0.39	4.17	0.65
02/05/2009	0.09	0.00	0.00			0.00	0.46	0.42	0.23	0.05	0.15	0.30
02/06/2009	0.16	0.31	0.18	0.59	1.21	0.64	0.52	0.49	0.27	0.65	0.41	0.65
02/07/2009	0.42	0.26	0.25	0.41	0.66	0.63	0.60	0.59	0.49	0.55	0.48	1.36
02/08/2009	0.86	0.61	0.33	0.34	0.50	1.07	0.94	1.77	1.00	0.99	1.13	0.85
02/09/2009	0.82	0.66	0.56	0.83	1.37	0.42	0.23	0.10	0.63	0.36	0.17	0.22
02/10/2009	0.04	0.21	0.13	0.38	0.37	0.29	0.06	0.09	0.00	0.00	0.14	0.40
02/11/2009	0.23	0.24	0.18	0.10	0.27	0.00	0.15	0.13	0.34	0.31	0.18	0.26
02/12/2009	0.18	0.18	0.18	0.11	0.02	0.20	0.09	0.21	0.60	0.42	0.49	0.88
02/13/2009	0.71	0.51	0.34	0.31	0.04	0.13	0.18	0.19	0.23	0.26	0.50	0.59
02/14/2009	0.41	0.23	0.04	0.20	0.31	0.13	0.41	0.42	0.32	0.79	1.04	0.87
02/15/2009	0.80	0.60	0.44	0.26	0.17	0.32	0.04	0.21	0.23	0.20	0.17	0.33
02/16/2009	0.22	0.29	0.35	0.32	1.14	0.55	0.51	0.25	0.03	0.37	0.40	0.18
02/17/2009	0.32	0.61	0.80	0.02	0.46	0.18	0.22	0.57	0.00	0.00		
02/18/2009												
02/19/2009									0.09	0.78	0.24	
02/20/2009					0.80	0.44	1.27	1.63	1.28	0.87	0.30	0.67
02/21/2009	0.51	0.60	0.78	0.27	0.11	0.19	0.66	0.21	0.88	0.06	0.32	0.23
02/22/2009	0.16	0.19	0.30	0.13	0.06	0.05	0.13	0.41	0.45	0.46	0.39	0.78
02/23/2009	0.47	0.97	0.74	0.60	0.62	0.78	0.63	0.55	0.69	0.53	0.97	0.88
02/24/2009	0.41	0.66	0.46	0.53	1.19	1.07	1.23	0.58	0.42	0.82	1.02	1.01
02/25/2009	0.78	0.69	0.86	0.88	1.05	0.88	0.96	1.14	1.37	1.67	1.30	0.98
02/26/2009	0.95	1.33	1.62	1.07	0.89	0.78	0.68	0.34	0.18	0.25	0.54	0.26
02/27/2009	0.38	0.08	0.08	0.10	0.04	0.10	0.20	0.15	0.40	0.36	0.12	0.19
02/28/2009	0.64	0.37	0.21	0.48	0.35	0.61	0.49	0.48	0.43	0.29	0.27	0.16
03/01/2009	0.14	0.10	0.18	0.14	0.20	0.12	0.12	0.17	0.21	0.60	0.33	0.21
03/02/2009	0.26	0.30	0.49	0.30	0.25	0.60	0.58	0.87	0.60	0.82	0.60	0.38
03/03/2009	0.18	0.24	0.12	0.12			0.68	0.58	0.73	1.01	0.97	0.67
03/04/2009			0.71	0.95	0.55	0.64	0.76	0.79	0.93	2.79	1.14	1.43
03/05/2009	1.33	0.83	1.13	1.57	0.99	1.00	0.64	0.72	0.80	0.79	0.54	0.45
03/06/2009	0.74	0.62	0.60	0.43	0.72	0.94	0.72	0.68	0.61	1.26	3.16	1.27
03/07/2009	0.69	0.78	0.65	0.99	1.00	0.62	0.38	0.21	0.39	0.73	1.19	0.72
03/08/2009	1.62	0.95	0.57	0.66	0.70	0.41	0.49					
03/09/2009												
03/10/2009												
03/11/2009							0.91	0.35	0.30	0.31	0.23	0.37
03/12/2009	0.59	0.45	0.25	0.39	0.33	0.87	0.52	0.73	0.55	0.77	0.35	0.50
03/13/2009	0.59	0.69	0.76	0.64	0.70	2.10	1.98	1.12	0.91	3.12	1.60	1.29
03/14/2009	0.59	1.42	1.17	1.13	2.34	1.57	1.18	1.33	2.24	1.02	2.20	3.26
03/15/2009	4.96	8.88	7.99	9.85	3.70	2.19	2.20	2.26	2.53	2.04		
03/16/2009												
03/17/2009												
03/18/2009									1.52	1.00	0.67	0.90
03/19/2009	0.74	0.74	0.64	0.52	0.71	0.39	0.42	0.44	0.35	0.86	0.83	1.14
03/20/2009	0.63	0.85	0.78	1.41	0.74	0.79	0.72	0.38	0.50	0.50	0.84	1.65
03/21/2009	0.99	0.78	1.09	0.95	1.15	3.00	1.02	0.88	1.27	1.59	1.04	0.81
03/22/2009	1.08	1.03	1.10	3.38	2.54	2.48	2.19	1.94	1.57	1.50	1.19	1.48
03/23/2009	2.15	2.11	1.89	1.95	1.41	0.31	0.55	2.87	0.31	1.08	1.33	1.29
03/24/2009	1.24	0.80	0.89	0.00	0.00	0.00	0.00	0.37	0.78	0.27	0.31	0.18
03/25/2009	0.33	0.41	0.59									

Table B-2b. PM_{10} Lead by Xact 620: Arnold (MO).

PM_{10} Lead by Xact 620: Arnold, MO. Concentrations reported in ng/m^3.

	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
02/03/2009									3.05	1.54	1.48	1.23
02/04/2009	1.42	0.59	0.68	1.00	1.71	1.58	4.41	1.08	0.68	4.04	4.75	4.87
02/05/2009	17.75	74.31	42.84			406.36	62.90	9.57	16.65	41.99	62.90	38.30
02/06/2009	107.54	106.84	226.22	35.64	50.51	66.77	16.39	6.19	44.83	9.00	1.99	1.17
02/07/2009	2.54	1.86	2.04	2.13	17.63	18.81	1.42	1.66	7.42	11.18	8.01	24.92
02/08/2009	8.29	2.95	2.33	2.44	3.00	5.42	5.19	7.48	4.95	5.55	6.60	4.72
02/09/2009	4.10	3.90	4.09	4.46	5.85	56.14	15.34	54.98	3.56	27.24	28.35	5.10
02/10/2009	0.34	0.03	0.35	8.39	3.77	3.35	22.67	9.57	65.93	131.72	43.05	0.60
02/11/2009	0.27	0.70	0.98	16.73	5.86	0.52	0.00	0.35	0.35	0.24	0.41	1.06
02/12/2009	1.96	1.20	1.14	1.49	1.43	0.84	1.62	1.26	1.63	1.29	1.84	4.23
02/13/2009	4.17	2.25	1.15	0.82	1.47	0.93	1.70	1.49	1.42	1.56	1.15	1.94
02/14/2009	2.41	2.17	1.88	1.83	1.13	1.29	1.13	1.21	1.84	3.07	5.26	5.91
02/15/2009	3.91	2.61	3.32	19.40	26.36	5.65	2.24	1.51	1.64	2.26	1.98	2.00
02/16/2009	2.45	2.34	2.33	2.84	3.21	2.57	2.32	24.58	21.39	2.18	2.42	3.50
02/17/2009	31.79	4.38	6.23	69.26	33.07	56.91	60.70	15.49	126.36	82.69		
02/18/2009												
02/19/2009									5.23	1.56	2.50	
02/20/2009					22.56	2.74	9.07	9.92	4.17	3.84	2.52	5.00
02/21/2009	2.31	3.18	5.28	1.36	0.93	4.15	2.82	1.76	1.23	1.18	1.16	2.02
02/22/2009	1.29	1.18	0.80	0.81	0.99	1.28	1.18	0.99	1.05	1.64	7.05	2.39
02/23/2009	2.31	2.82	2.66	7.28	3.39	2.55	3.14	4.34	4.81	2.32	3.10	5.16
02/24/2009	4.30	3.45	3.06	2.65	2.73	2.76	3.42	13.24	3.66	4.81	6.44	4.36
02/25/2009	3.95	4.13	4.03	4.57	11.83	13.08	5.21	12.54	12.37	11.93	8.59	5.30
02/26/2009	5.67	4.57	3.73	4.22	5.06	8.39	4.45	13.05	6.56	3.57	1.96	3.21
02/27/2009	2.38	1.62	1.39	1.46	1.48	1.19	1.71	1.87	3.44	2.27	1.65	1.31
02/28/2009	2.24	1.43	1.07	0.70	1.51	2.04	3.29	2.42	2.67	2.27	1.19	1.29
03/01/2009	1.43	2.22	2.40	1.60	2.00	2.93	4.54	3.09	2.18	1.30	2.38	2.57
03/02/2009	2.68	2.20	5.25	5.43	2.03	2.83	5.21	5.46	5.71	4.71	2.29	1.87
03/03/2009	2.40	2.69	2.84	4.18			2.15	2.64	3.43	2.91	4.29	4.07
03/04/2009			3.40	4.43	6.27	19.06	12.88	6.19	9.39	7.89	7.35	10.19
03/05/2009	6.55	6.31	6.59	6.64	6.33	4.52	4.71	2.85	2.56	3.24	2.34	2.01
03/06/2009	1.51	1.93	2.86	2.94	6.48	2.14	2.58	2.46	2.50	6.55	10.34	4.14
03/07/2009	3.39	7.21	13.44	5.50	3.99	11.39	51.26	31.00	15.21	27.24	9.96	5.09
03/08/2009	2.75	8.58	5.45	1.28	5.22	4.86	2.37					
03/09/2009												
03/10/2009												
03/11/2009							0.89	0.97	1.46	1.40	1.59	1.44
03/12/2009	2.10	3.35	2.88	1.56	2.83	6.76	7.62	6.78	6.50	4.74	3.98	3.24
03/13/2009	2.30	2.28	3.26	2.43	5.85	6.39	9.75	8.20	4.94	4.86	9.07	9.33
03/14/2009	7.98	17.68	7.15	5.64	7.13	5.13	4.34	5.54	4.81	6.66	6.29	14.50
03/15/2009	13.33	13.02	9.65	13.50	9.99	6.22	5.88	8.17	4.50	4.84		
03/16/2009												
03/17/2009												
03/18/2009									5.25	9.61	4.64	2.62
03/19/2009	3.31	3.45	2.88	3.39	4.93	3.37	1.27	1.09	1.13	1.35	1.92	1.77
03/20/2009	4.71	6.98	4.87	8.32	4.15	4.95	2.48	2.43	2.11	2.90	1.79	6.14
03/21/2009	8.90	4.64	2.00	2.32	14.42	4.32	9.03	4.55	4.88	4.94	3.73	3.39
03/22/2009	4.36	5.04	3.86	4.48	4.07	16.23	18.10	2.81	3.93	5.17	3.32	4.65
03/23/2009	4.83	4.96	4.84	4.48	9.48	44.71	19.43	27.52	22.69	3.70	3.51	2.11
03/24/2009	3.20	3.55	3.12	64.96	59.96	68.38	75.67	54.13	14.76	15.07	3.75	1.20
03/25/2009	1.04	0.78	0.07									

Table B-2c. PM$_{10}$ Selenium by Xact 620: Arnold (MO).

PM$_{10}$ Selenium by Xact 620: Arnold, MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
02/03/2009									0.25	0.28	0.31	0.37
02/04/2009	0.27	0.15	0.20	0.31	0.37	0.26	0.22	0.20	0.16	0.23	0.30	0.46
02/05/2009	0.49	0.88	0.53			0.31	0.47	0.75	0.87	0.71	1.04	1.15
02/06/2009	1.08	1.06	0.96	1.15	1.49	1.26	0.86	0.79	0.86	0.95	0.70	0.63
02/07/2009	0.64	0.68	0.66	0.62	0.57	0.65	0.67	0.65	0.66	0.62	0.59	0.65
02/08/2009	0.89	0.90	0.78	0.92	1.18	1.53	1.23	1.14	1.47	1.72	1.58	1.35
02/09/2009	1.60	1.81	2.02	2.50	2.36	1.20	0.70	0.41	0.62	0.86	0.65	0.43
02/10/2009	0.11	0.10	0.15	0.51	0.48	0.41	0.43	0.48	0.53	0.48	0.65	0.26
02/11/2009	0.13	0.19	0.63	0.64	0.18	0.07	0.06	0.28	0.55	0.97	0.34	1.18
02/12/2009	0.89	0.55	0.51	0.51	0.47	0.36	0.33	0.29	0.74	0.50	0.51	0.77
02/13/2009	0.86	0.56	0.38	0.39	0.54	0.42	0.94	0.91	1.20	1.02	1.32	2.24
02/14/2009	1.50	1.07	0.61	0.34	0.29	0.34	0.38	0.35	0.44	0.75	0.86	0.72
02/15/2009	0.84	0.78	0.61	0.68	0.88	0.83	0.58	0.37	0.32	0.46	0.39	0.39
02/16/2009	0.42	0.43	0.48	0.49	0.66	1.23	0.76	0.75	0.62	0.59	0.58	0.92
02/17/2009	1.25	1.01	1.04	1.25	1.62	0.86	2.32	1.17	0.95	0.99		
02/18/2009												
02/19/2009									2.61	2.51	0.37	
02/20/2009					0.86	0.67	0.76	0.84	0.49	0.68	1.39	1.22
02/21/2009	0.87	1.00	1.07	0.45	0.24	1.11	1.69	1.14	0.41	0.23	0.27	0.29
02/22/2009	0.27	0.25	0.22	0.18	0.18	0.19	0.58	2.31	1.73	0.24	0.32	0.69
02/23/2009	0.69	0.74	0.65	0.65	0.69	0.63	0.97	1.41	1.75	0.50	0.50	0.62
02/24/2009	0.65	0.77	0.89	1.12	2.68	2.34	2.57	1.40	1.80	2.83	2.64	2.48
02/25/2009	2.16	2.09	2.01	1.99	1.79	1.53	1.16	1.06	1.26	2.02	2.38	2.51
02/26/2009	2.86	2.77	2.67	2.22	1.69	1.58	1.27	1.19	1.09	0.98	0.58	0.91
02/27/2009	2.85	1.01	0.39	0.29	0.23	0.39	0.65	0.67	0.36	0.56	0.56	0.41
02/28/2009	0.52	0.37	0.39	0.29	0.38	0.48	0.60	0.88	0.73	0.54	0.30	0.30
03/01/2009	0.32	0.46	0.40	0.34	0.42	0.36	0.31	0.35	0.31	0.31	0.35	0.53
03/02/2009	0.79	0.83	0.52	0.54	0.51	0.57	0.58	0.64	0.52	0.65	0.61	0.44
03/03/2009	0.50	0.52	0.61	0.71			0.84	1.14	1.81	1.48	1.25	1.39
03/04/2009			1.51	1.50	1.61	1.35	1.22	1.55	1.05	2.80	1.64	1.96
03/05/2009	1.80	1.38	1.44	1.35	1.24	1.07	1.01	0.89	0.83	1.01	0.89	0.81
03/06/2009	0.88	0.98	0.96	0.92	0.79	0.80	0.74	0.68	1.99	2.01	1.92	1.23
03/07/2009	0.99	0.91	1.00	1.76	1.08	0.76	0.56	0.55	0.56	0.58	1.13	1.32
03/08/2009	0.97	1.19	1.11	0.68	0.65	0.37	0.20					
03/09/2009												
03/10/2009												
03/11/2009							0.20	0.21	0.25	0.23	0.28	0.26
03/12/2009	0.86	0.44	0.47	0.38	0.54	0.86	0.73	0.38	0.57	0.71	0.68	0.94
03/13/2009	0.65	0.73	1.20	0.78	1.09	1.07	0.92	1.14	1.00	0.76	0.94	1.07
03/14/2009	1.18	1.55	1.54	1.48	2.73	3.89	3.46	3.23	3.87	3.25	3.76	4.79
03/15/2009	5.37	5.06	4.85	4.88	5.76	6.77	6.19	5.27	4.04	3.38		
03/16/2009												
03/17/2009												
03/18/2009									2.41	1.68	1.42	1.15
03/19/2009	1.47	1.27	0.86	0.85	0.67	0.61	0.54	0.49	0.43	0.47	0.37	0.32
03/20/2009	0.41	0.63	0.51	0.89	1.43	2.23	1.50	0.99	0.98	1.19	0.75	0.61
03/21/2009	0.73	1.03	1.49	1.61	1.73	1.04	1.24	0.92	0.95	0.83	0.86	1.08
03/22/2009	1.20	1.23	0.98	1.12	1.16	1.15	0.98	1.09	0.97	0.99	1.13	1.36
03/23/2009	1.63	1.34	1.34	1.48	1.82	1.94	1.06	0.86	1.09	0.94	1.08	0.93
03/24/2009	0.87	0.92	0.97	0.88	0.86	0.78	0.66	0.98	0.72	1.08	0.23	0.34
03/25/2009	0.35	0.34	0.24									

Table B-3a. PM_{10} Arsenic by Xact 620: East St. Louis (IL).

PM_{10} Arsenic by Xact 620: East St. Louis, IL. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
03/25/2009									0.08	0.31	0.20	2.16
03/26/2009	0.76	1.28	0.38	0.54	0.33	0.28	0.84	0.88	0.42	0.50	0.33	0.34
03/27/2009	0.23	0.40	0.54	0.23	0.65	0.88	0.60	0.23	0.57	0.79	0.61	1.25
03/28/2009	0.66	1.12	0.72	0.72	0.88	0.82	0.91	1.30	0.92	1.21	0.37	0.51
03/29/2009	0.12	0.17	0.12	0.06	0.14	0.22	0.15	0.25	0.52	0.54	0.85	0.87
03/30/2009	1.75	0.65	0.91	0.90	0.89	0.23	0.63	0.77	0.32	0.57	0.42	0.50
03/31/2009	0.63	0.42	0.48	0.62	0.78	0.72	0.34	0.07	0.14	0.08	0.32	0.24
04/01/2009	0.09	0.28	1.08	2.24	4.28	1.06			0.22	0.30	0.28	0.38
04/02/2009	0.64	0.59	1.35	1.92	2.47	2.15	1.47	1.12	0.75	0.31	0.25	0.46
04/03/2009	0.32	0.36	0.42	0.37	0.39	0.41	0.29	0.45	0.19	0.20	0.32	0.80
04/04/2009	1.35	2.51	3.28	3.48	3.27	6.55	2.61	4.13	4.34	2.28	0.89	1.15
04/05/2009	1.54	2.08	2.07	1.50	1.23	0.99	1.20	0.42	0.18	0.22	0.11	0.03
04/06/2009	0.08	0.00	0.06	0.13	0.16	0.12	0.15	0.06	0.19	0.12	0.07	0.12
04/07/2009	0.10	0.09	0.06	0.20	0.21	0.13	0.25	0.17	0.18	0.35	0.35	0.55
04/08/2009	0.22	0.94	0.63	1.92	1.71	0.80	0.24	0.32	0.14	0.17	0.28	0.39
04/09/2009	0.50	0.57	1.31	0.00	0.40	0.71	0.67	0.83	0.24	0.39	0.39	0.43
04/10/2009	0.36	0.51	0.54	0.44	0.35	1.47	0.96	0.91	0.87	1.78	0.57	2.71
04/11/2009	0.63	3.17	2.07	1.29	0.87	0.50	0.42	0.29	0.59	0.67	0.79	0.74
04/12/2009	1.18	0.98	1.38	1.69	1.32	1.15	0.72	0.86	1.66	0.90	0.64	0.71
04/13/2009	0.98	0.71	0.65	0.58	0.76	2,345.00	173.38	10.73	2.44	0.54	0.34	0.27
04/14/2009	0.32	0.28	0.28	0.29	0.43	0.78	0.88	0.88	0.69	0.70	0.85	0.81
04/15/2009	0.97	1.03	1.03	1.88	0.95	0.79	0.89	0.61	0.51	0.48	0.63	0.79
04/16/2009	0.71	0.65	0.71	0.99	0.61	0.44	1.11	1.87	1.77	0.87	1.17	0.00
04/17/2009	0.00	1.25	1.59	1.46	3.06	1.56	1.25	1.21	1.10	1.75	9.57	4.25
04/18/2009	2.12	1.82	2.18	0.25	4.09	2.55	1.79	1.00	5.00	1.75	1.23	1.34
04/19/2009	1.37	0.98	1.36	1.15	0.68	0.40	0.12	0.26	0.42	0.35	0.40	0.44
04/20/2009	0.18	0.17	0.31	0.16	0.17	0.14	0.24	0.24	0.37	0.19	0.07	0.07
04/21/2009	0.28	0.11	0.10	0.09			0.03	0.04	0.12	0.80	0.29	0.10
04/22/2009	0.24	0.50	0.17	0.16	0.20	0.79	0.30	0.37	0.32	0.67	1.16	1.38
04/23/2009	1.87	4.02	7.06	1.75	1.60	0.90	0.71	0.90	0.81	0.73	2.25	0.71
04/24/2009	0.00	0.00	0.50	0.24	0.00	0.00	0.50	0.00	0.06	0.17	0.55	0.27
04/25/2009	0.65	0.32	0.05	0.00	0.00	0.00	0.08	1.29	0.00	0.00	0.46	0.38
04/26/2009	0.23	0.46	0.40	0.40	0.12	0.61	0.44	0.31	0.51	0.51	0.50	0.28
04/27/2009	0.28	0.94	0.29	0.00	0.19	0.17	0.18	0.22	0.47	1.41	0.31	1.90
04/28/2009	38.33	8.78	0.00	0.00	0.00	1.08	0.00	1.83	0.27	1.98	0.74	0.36
04/29/2009	0.49	0.59	0.61	1.21	0.43	0.25	0.30	0.92	1.27	0.63	0.60	0.35
04/30/2009	0.24	0.59	0.95	0.75	0.02	0.36	0.58	0.35	0.64	0.76	0.40	1.98
05/01/2009	1.11	0.86	0.53	0.00	2.06	0.27	0.35	0.43	0.99	0.04	0.37	0.20
05/02/2009	0.58	0.96	0.98	1.44	0.07	0.31	0.18	0.46	0.71	0.52	1.29	2.17
05/03/2009	15.30	12.08	4.50	1.76	1.50	0.51	0.97	0.87	0.55	1.12	2.29	3.40
05/04/2009	4.21	1.68	1.37	1.10	0.93	1.37	0.74	0.79	1.26	1.21	4.71	4.94
05/05/2009	2.74	1.94	2.25	1.15	0.34	0.61	0.58	0.61	2.38	1.11	1.11	0.84
05/06/2009	1.09	1.00	1.46									

Table B-3b. PM_{10} Lead by Xact 620: East St. Louis (IL).

PM_{10} Lead by Xact 620: East St. Louis, IL. Concentrations reported in ng/m^3.

	Start of two-hour sampling period, CST										
Date	00	02	04	06	08	10	12	14	16	18	20
03/25/2009									2.25	5.23	22.32
03/26/2009	6.58	25.64	6.18	31.93	3.37	2.41	7.38	7.22	7.83	6.45	5.58
03/27/2009	3.60	4.58	4.99	27.62	33.90	12.36	9.89	10.19	7.51	13.64	3.41
03/28/2009	5.60	4.42	3.44	2.80	2.88	3.21	5.75	6.34	6.56	6.41	1.34
03/29/2009	0.08	0.00	1.05	2.98	2.86	2.26	1.94	2.50	2.93	4.99	16.30
03/30/2009	14.57	114.31	13.34	10.09	8.24	44.44	4.29	3.84	5.23	3.98	3.69
03/31/2009	4.50	4.09	3.84	4.29	3.07	6.14	7.25	4.31	1.68	1.83	2.58
04/01/2009	16.75	16.41	50.56	42.81	24.15	12.75			3.58	3.01	3.81
04/02/2009	2.52	3.71	3.92	12.91	12.83	7.99	7.98	8.11	6.65	7.58	4.57
04/03/2009	7.38	4.48	2.90	3.91	4.52	3.26	3.59	3.90	3.76	8.47	69.50
04/04/2009	23.69	22.62	22.00	16.95	5.71	7.78	9.44	6.08	5.22	5.66	5.53
04/05/2009	9.57	8.18	8.04	7.04	4.24	7.43	31.07	3.30	4.23	1.25	1.31
04/06/2009	1.29	1.65	1.97	2.57	2.70	2.91	2.96	2.42	1.65	1.30	1.44
04/07/2009	1.26	1.18	1.55	3.22	3.37	3.01	2.96	2.67	2.07	3.98	5.02
04/08/2009	64.59	39.14	27.33	40.58	26.51	7.96	6.94	5.43	3.06	3.40	7.60
04/09/2009	22.50	19.40	22.12	33.53	5.81	8.52	9.39	6.50	6.29	2.95	2.41
04/10/2009	1.66	1.57	1.81	3.11	15.67	3.99	11.80	12.08	5.66	7.39	2.94
04/11/2009	2.81	12.95	3.98	20.89	11.90	3.01	3.22	5.18	3.20	5.05	7.04
04/12/2009	4.98	5.91	5.12	5.70	5.49	5.51	5.27	4.57	3.14	7.19	4.55
04/13/2009	2.19	2.65	2.37	5.27	3.34	14.58	15.93	4.27	3.99	3.00	2.94
04/14/2009	1.88	2.12	2.95	3.84	3.90	6.68	6.83	7.23	6.74	5.86	5.10
04/15/2009	5.17	5.16	8.92	74.27	10.62	8.93	8.69	6.18	4.68	5.68	10.98
04/16/2009	5.98	4.52	7.93	6.97	4.80	4.45	3.90	7.31	12.50	8.05	14.77
04/17/2009	108.66	23.35	22.83	18.15	6.34	6.92	5.53	4.70	4.33	7.80	15.71
04/18/2009	22.93	22.74	16.84	177.59	25.10	9.83	6.61	4.90	6.93	3.68	2.91
04/19/2009	6.18	9.21	5.38	2.79	2.84	1.68	5.37	7.95	3.01	5.09	3.94
04/20/2009	2.01	1.71	1.09	2.11	5.13	4.18	3.87	4.49	2.83	2.51	1.74
04/21/2009	0.67	1.23	1.52	2.50			3.97	3.89	2.57	3.58	2.54
04/22/2009	2.95	3.20	16.09	82.42	47.28	7.33	4.26	3.84	4.89	9.64	20.98
04/23/2009	19.26	13.15	18.98	8.93	9.83	6.66	7.03	7.78	5.78	4.24	19.83
04/24/2009	44.67	122.25	4.33	6.59	32.44	26.89	14.44	20.01	20.85	4.61	4.69
04/25/2009	3.72	4.48	13.35	37.21	50.97	33.04	12.64	18.42	39.58	35.14	4.21
04/26/2009	5.71	3.65	4.81	4.55	12.30	16.76	6.97	5.04	11.41	4.82	3.81
04/27/2009	3.09	3.57	3.32	28.67	2.69	3.81	2.44	3.12	2.08	1.75	15.90
04/28/2009	59.74	20.40	1.05	2.40	5.59	13.28	46.55	17.64	31.79	7.79	2.24
04/29/2009	2.58	2.36	24.45	3.62	7.00	10.10	3.53	4.03	3.25	4.72	6.65
04/30/2009	1.62	1.63	5.18	19.40	21.88	12.38	10.10	7.78	1.71	1.18	25.81
05/01/2009	22.79	57.33	139.66	144.02	15.42	4.00	9.87	9.89	7.02	4.17	3.63
05/02/2009	5.09	4.92	3.70	12.07	26.37	4.75	8.29	7.70	6.00	6.17	16.87
05/03/2009	13.54	15.17	20.07	9.46	2.66	4.25	3.91	4.57	6.35	6.65	6.18
05/04/2009	6.46	5.18	6.40	11.70	25.16	11.06	6.60	6.67	7.03	23.68	29.76
05/05/2009	48.17	32.97	21.24	57.38	69.46	18.52	15.39	21.26	18.74	14.13	6.51
05/06/2009	34.16	10.78	13.50								

Table B-3c. PM_{10} Selenium by Xact 620: East St. Louis (IL).

PM_{10} Selenium by Xact 620: East St. Louis, IL. Concentrations reported in ng/m^3.

	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
03/25/2009									1.54	1.54	0.82	0.85
03/26/2009	0.73	0.78	0.89	1.04	0.67	0.51	0.54	0.63	0.64	0.82	1.00	0.82
03/27/2009	0.75	0.72	1.15	1.67	1.28	1.21	1.23	1.10	1.32	1.23	1.08	1.31
03/28/2009	1.52	1.42	1.38	0.97	1.30	1.79	2.10	2.12	1.45	1.04	0.20	0.17
03/29/2009	0.06	0.03	0.11	0.15	0.30	0.40	0.33	0.35	0.39	0.41	0.43	0.44
03/30/2009	0.66	0.53	0.61	0.75	0.69	0.66	0.85	0.65	0.60	0.62	0.75	0.97
03/31/2009	0.67	0.48	0.60	0.69	0.90	1.07	0.42	0.34	0.40	0.35	0.37	0.42
04/01/2009	0.56	0.50	0.47	0.61	0.51	0.53			0.86	0.57	0.57	0.40
04/02/2009	0.87	1.10	2.01	2.24	1.68	1.58	1.53	2.10	3.05	2.50	1.64	0.76
04/03/2009	0.74	0.69	0.46	0.52	0.51	0.40	0.37	0.39	0.38	0.45	0.50	0.66
04/04/2009	0.70	0.65	0.85	0.78	0.51	0.62	0.72	0.73	0.96	1.11	1.08	1.32
04/05/2009	1.37	1.36	1.35	1.36	1.40	1.83	2.09	1.29	1.57	0.63	0.22	0.23
04/06/2009	0.26	0.23	0.19	0.32	0.33	0.31	0.24	0.24	0.25	0.21	0.25	0.26
04/07/2009	0.32	0.35	0.38	0.37	0.39	0.31	0.27	0.24	0.27	0.24	0.31	0.65
04/08/2009	0.66	0.59	0.72	0.98	0.74	0.83	0.61	0.49	0.43	0.37	0.41	0.41
04/09/2009	0.61	0.74	0.68	0.87	0.80	0.69	0.62	0.76	0.93	0.83	1.05	1.45
04/10/2009	1.31	1.62	1.39	1.12	1.71	1.57	1.64	2.13	1.62	1.33	0.94	1.12
04/11/2009	0.86	0.81	0.72	0.93	0.90	0.58	0.43	0.47	0.51	0.62	0.71	0.78
04/12/2009	0.87	0.92	1.24	1.57	1.74	1.59	1.02	0.93	1.19	1.34	1.39	1.55
04/13/2009	1.73	1.68	1.59	1.63	1.46	0.62	1.94	2.30	0.76	0.61	0.60	0.56
04/14/2009	0.70	0.72	0.63	0.58	0.73	0.86	0.86	0.80	0.80	0.77	0.96	0.95
04/15/2009	1.04	1.10	1.09	1.45	1.12	0.83	0.65	0.55	0.75	1.04	0.97	1.00
04/16/2009	1.05	1.18	1.18	1.07	1.30	0.85	0.70	1.08	1.76	1.70	1.41	1.34
04/17/2009	1.30	1.73	2.78	3.35	3.96	3.15	2.41	1.97	1.71	1.73	2.21	2.02
04/18/2009	2.19	2.15	2.50	2.37	3.00	1.76	1.11	1.04	0.98	1.09	0.99	0.96
04/19/2009	0.98	1.18	1.19	0.77	0.48	0.22	0.55	0.70	0.23	0.96	1.13	0.68
04/20/2009	0.54	0.40	0.44	0.66	0.80	0.56	0.42	0.49	0.39	0.38	0.33	0.26
04/21/2009	0.28	0.37	0.36	0.37			0.27	0.27	0.29	0.17	0.36	0.42
04/22/2009	0.44	0.58	0.78	0.64	0.94	1.01	0.56	0.64	0.75	0.79	0.94	1.06
04/23/2009	1.06	1.04	1.22	1.31	1.41	1.67	1.31	1.41	1.76	1.26	0.88	1.53
04/24/2009	2.95	0.69	0.93	0.62	0.88	0.64	0.47	0.34	0.44	0.82	1.01	1.07
04/25/2009	1.11	1.00	0.84	0.76	0.64	0.64	0.77	0.64	0.50	0.65	0.77	0.90
04/26/2009	1.03	1.20	1.23	1.24	1.10	1.03	0.94	0.72	0.65	0.68	0.77	0.76
04/27/2009	0.75	0.78	0.89	0.97	1.01	0.85	0.87	0.96	0.56	0.67	0.57	0.68
04/28/2009	1.02	0.67	0.26	0.46	1.04	0.77	1.02	1.05	0.77	0.96	1.22	1.19
04/29/2009	1.15	0.84	0.85	0.63	0.84	1.05	1.34	1.49	1.07	1.20	1.64	0.80
04/30/2009	0.72	1.01	1.15	1.54	0.59	0.30	0.31	0.29	0.20	0.27	0.42	0.46
05/01/2009	0.67	0.71	0.51	0.54	1.32	1.26	0.64	0.44	0.53	1.23	1.07	0.89
05/02/2009	0.88	1.08	0.97	0.88	0.83	0.73	0.75	0.77	0.82	1.06	1.25	1.44
05/03/2009	1.75	1.59	1.91	1.81	1.06	1.04	1.02	1.07	1.23	1.59	1.69	1.73
05/04/2009	1.51	1.30	1.35	1.77	1.58	1.51	1.07	1.09	1.33	1.48	1.55	1.67
05/05/2009	1.65	1.67	1.73	2.42	2.09	1.56	1.47	1.32	1.69	1.80	1.80	2.17
05/06/2009	3.91	3.86	3.02									

Table B-4a. PM$_{10}$ Arsenic by Xact 620: Hall Station, City of St. Louis (MO).

PM$_{10}$ Arsenic by Xact 620: Hall, City of St. Louis. MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
05/06/2009								1.18	0.00	0.00	0.24	0.83
05/07/2009	0.72	0.65	1.81	3.00	0.66		0.78	0.01	0.48	0.81	0.89	0.82
05/08/2009	0.13	1.04	1.76	1.76	1.07	0.50	0.45	0.53	0.40	0.40	1.10	3.10
05/09/2009	0.79	0.30	0.19	0.09	0.23	0.41	0.07	1.42	1.09	0.35	0.77	1.58
05/10/2009	1.28	1.10	1.53	1.41	0.83	0.54	0.60	0.72	0.64	0.47	0.90	1.18
05/11/2009	0.72	0.72	0.57	0.54	0.46	1.35	0.40	0.36	0.38	0.34	5.26	4.25
05/12/2009	2.47	3.74	3.66	0.75	0.61	1.09	0.82	0.93	0.56	0.54	0.46	1.81
05/13/2009	0.98	0.70	1.73	0.82	0.08	0.25	0.32	0.00	0.37	0.29	0.39	0.04
05/14/2009	0.24	0.50	0.61	0.47			0.53	0.67	0.52	0.67	2.44	1.04
05/15/2009	0.54	0.30	0.30	0.69	0.52	0.34	0.00	0.00	0.43	1.33	0.37	0.48
05/16/2009	0.00	0.29	0.24	0.33	0.28	0.38	0.13	0.12	0.07	0.28	1.13	2.05
05/17/2009	0.60	0.67	0.28	0.42	0.04	0.83	0.47	0.43	0.40	2.01	14.21	13.19
05/18/2009	0.77	1.56	1.05	0.64	0.37	0.58	0.65	0.72	0.31	0.61	0.49	0.82
05/19/2009	1.45	1.00	0.90	0.00	0.57	0.34	0.59	0.94	0.82	0.43	0.55	1.60
05/20/2009	1.96	2.93	3.86	1.96	0.65	1.05	2.43	0.99	0.84	1.12	0.98	0.55
05/21/2009	0.67	0.88	1.10	1.98	0.82	0.66	0.80	0.55	0.37	0.00	1.35	2.87
05/22/2009	1.70	1.76	2.59	7.30	2.45	1.18	1.27	1.01	0.72	0.34	0.25	1.49
05/23/2009	0.96	2.08	2.72	2.64	1.35	0.74	0.70	0.73	0.64	1.47	1.17	1.44
05/24/2009	1.32	2.85	2.75	2.20	1.55	1.69	1.83	1.39	2.28	1.38	3.22	2.94
05/25/2009	0.53	0.82	2.21	1.83	3.00	0.77	0.31	0.27	0.24	1.39	0.24	0.87
05/26/2009	0.47	0.20	0.29	0.44	0.35	0.23	0.28	0.39	0.25	0.00	0.00	0.00
05/27/2009	0.54	1.32	1.38	1.52	0.70	0.67	0.78	0.55	0.61	0.28	0.39	0.39
05/28/2009	1.22	0.50	0.24	0.40	0.26	0.29	0.12	0.12	0.08	0.20	0.61	0.55
05/29/2009	0.86	0.62	1.15	0.87	0.42	0.34	0.66	0.47	0.48	0.70	0.99	1.39
05/30/2009	1.07	2.18	2.85	0.77	0.91	0.34	0.62	0.74	0.72	0.46	0.52	0.48
05/31/2009	0.77	0.62	0.53	0.58	0.66	0.52	0.64	1.65	0.73	0.32	4.62	1.02
06/01/2009	0.87	1.11	1.06	0.52	0.80	0.72	1.15	0.61	0.35	0.30	0.14	1.02
06/02/2009	0.65	0.00	0.54	0.74	0.67	0.72	0.45	0.07	0.87	0.25	0.52	0.17
06/03/2009	0.67	0.82	0.83	0.77	0.86	0.64						

Table B-4b. PM$_{10}$ Lead by Xact 620: Hall Station, City of St. Louis (MO).

PM$_{10}$ Selenium by Xact 620: Margaretta, City of St. Louis. MO. Concentrations reported in ng/m^3.

	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
07/09/2009									1.14	0.69	1.35	2.03
07/09/2009	1.94	2.12	2.33			2.91	2.98	2.67	2.95	2.40	2.03	2.00
07/10/2009	2.71	3.60	2.90	2.60	2.14	2.05	1.86	1.95	2.09	2.59	2.47	2.78
07/11/2009	3.36	2.36	2.02	1.89	2.08	1.62	2.06	2.14	2.78	2.05	2.00	1.89
07/12/2009	2.03	1.80	1.81	1.44	1.25	1.42	0.54	0.25	0.43	0.31	0.30	0.35
07/13/2009	0.45	0.84	1.29	2.21	1.45	1.40	1.69	1.79	1.77	1.78	1.83	1.84
07/14/2009	2.00	2.23	2.63	3.14	3.09	1.96	1.62	1.60	1.70	1.69	2.05	2.14
07/15/2009	1.88	1.70	1.62	0.54	0.71	1.63	2.03	1.65	1.25	1.10	1.10	1.24
07/16/2009	1.18	1.17	1.08	1.12	1.96	0.93	0.97	1.20	1.14	1.13	0.88	0.82
07/17/2009	0.81	0.74	0.65	0.50	0.40	0.33	0.29	0.30	0.33	0.31	0.35	0.36
07/18/2009	0.39	0.40	0.37	0.38	0.26	0.28	0.21	0.20	0.21	0.22	0.25	0.28
07/19/2009	0.35	0.35	0.41	0.42	0.47	0.43	0.41	0.43	0.52	0.58	0.83	0.72
07/20/2009	0.73	0.92	1.24	1.34	1.13	1.05	1.29	0.98	1.17	0.93	0.87	0.96
07/21/2009	1.08	1.27	1.14	1.25	0.82	0.71	0.76	1.02	0.70	0.78	0.72	0.75
07/22/2009	0.95	0.99	1.19	1.74	1.55			0.68	0.68	0.67	0.73	0.70
07/23/2009	0.57	0.67	0.71	0.85	0.71	0.61	0.56	1.19	0.66	0.64	1.29	0.97
07/24/2009	0.85	0.76	0.79	1.09	0.97	0.87	1.69	0.89	0.64	0.69	0.69	0.57
07/25/2009	0.56	0.67	0.85	0.80	1.00	0.87	0.75	0.72	0.55	0.42	0.43	0.44
07/26/2009	0.54	0.71	0.86	0.78	0.48	0.39	0.23	0.26	0.28	0.30	0.35	0.37
07/27/2009	0.47	0.44	0.44	0.46	0.37	0.49	0.86	0.40	0.34	0.34	0.49	0.72
07/28/2009	1.18	1.14	1.83	1.36	1.08	1.10	1.06	0.57	0.41	0.58	0.62	0.60
07/29/2009	0.63	0.67	0.88	0.89	1.21	0.97	0.65					

Table B-4c. PM$_{10}$ Selenium by Xact 620: Hall Station, City of St. Louis (MO).

PM$_{10}$ Selenium by Xact 620: Hall, City of St. Louis. MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
05/06/2009								0.54	0.95	1.34	1.97	2.02
05/07/2009	1.27	1.22	0.95	0.55	0.64		1.02	1.27	1.50	0.85	1.00	1.10
05/08/2009	1.54	1.29	1.00	0.87	0.84	0.67	0.44	0.42	2.35	1.86	2.37	0.75
05/09/2009	0.79	1.04	0.86	0.52	0.34	0.33	0.39	0.33	0.30	0.46	0.52	0.56
05/10/2009	0.79	0.98	1.15	0.96	0.74	0.71	0.78	0.96	1.40	0.68	0.73	0.53
05/11/2009	0.58	0.65	0.72	0.82	0.72	0.61	0.64	0.94	1.00	1.30	1.41	1.20
05/12/2009	1.05	1.16	1.17	2.64	2.01	1.95	1.13	1.42	1.38	1.55	1.85	2.55
05/13/2009	2.67	1.94	1.80	1.45	1.18	1.14	0.82	0.54	0.96	1.31	1.84	1.31
05/14/2009	0.85	1.01	0.96	0.93			0.66	0.65	0.79	1.15	1.57	1.58
05/15/2009	1.44	1.90	2.36	1.97	1.24	0.82	0.76	0.95	1.31	0.75	0.48	0.59
05/16/2009	0.54	0.38	0.26	0.55	1.06	0.85	0.40	0.27	0.35	0.41	0.45	0.46
05/17/2009	0.48	0.46	0.47	0.58	0.39	0.34	0.36	0.37	0.33	0.43	0.51	0.64
05/18/2009	0.68	0.82	0.71	0.47	0.48	0.62	1.07	1.51	1.22	1.62	3.11	2.83
05/19/2009	1.25	1.61	3.04	3.68	1.57	1.36	1.30	0.88	1.12	1.98	3.25	3.91
05/20/2009	3.24	5.46	4.36	2.92	1.90	1.20	0.70	0.69	1.21	2.06	1.76	1.05
05/21/2009	4.14	4.57	3.26	2.96	1.74	0.50	0.63	0.88	0.96	1.78	3.75	4.62
05/22/2009	4.05	3.02	3.07	2.89	2.64	1.17	1.01	0.92	1.04	1.56	1.99	1.66
05/23/2009	2.85	3.50	3.07	2.13	1.60	0.91	1.18	1.13	0.98	1.85	3.01	4.10
05/24/2009	2.32	2.89	3.84	3.99	3.95	4.05	3.43	2.64	2.25	1.92	1.68	1.93
05/25/2009	1.21	1.80	2.58	1.97	1.48	1.19	0.55	0.38	0.60	0.64	0.91	1.19
05/26/2009	0.90	1.24	0.97	0.95	0.90	1.10	0.79	0.77	0.69	0.78	1.21	2.11
05/27/2009	1.23	0.87	0.64	1.10	2.83	2.78	1.26	2.34	1.27	0.41	0.46	0.62
05/28/2009	1.11	0.94	0.82	0.51	0.58	0.15	0.45	0.50	0.49	0.54	0.61	0.78
05/29/2009	1.06	1.09	1.12	0.95	0.88	0.95	0.91	0.88	0.96	1.05	1.25	1.03
05/30/2009	2.23	2.31	2.02	1.29	1.44	1.21	0.94	0.86	1.19	1.75	1.77	1.54
05/31/2009	1.20	1.12	0.88	0.95	0.72	0.50	0.80	0.55	0.80	2.86	3.13	1.62
06/01/2009	1.57	1.49	2.36	1.91	2.50	2.29	1.03	0.80	0.88	0.95	1.06	1.09
06/02/2009	1.06	1.07	1.12	1.98	2.23	1.87	0.70	0.69	0.82	1.20	0.62	1.29
06/03/2009	1.01	0.80	1.53	1.87	1.26	1.21						

Table B-5a. PM_{10} Arsenic by Xact 620: South Broadway Station, City of St. Louis (MO).

PM_{10} Arsenic by Xact 620: South Broadway, City of St. Louis. MO. Concentrations reported in ng/m^3.

	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
06/04/2009								0.56	0.35	0.28	0.95	1.16
06/05/2009	1.67	2.19	2.15	1.19	0.45	0.55	0.43	0.40	0.33	1.45	1.05	1.21
06/06/2009	1.64	2.44	2.92	1.92	0.12	0.69	1.48	0.68	0.92	1.33	3.82	1.63
06/07/2009	1.64	1.36	1.09	0.85	1.01	0.90	1.93	0.94	0.70	0.84	0.96	0.89
06/08/2009	0.72	0.64	0.79	0.63	0.47	0.52	0.63	0.81	1.18	0.93	0.42	0.13
06/09/2009	0.20	0.17	0.22	0.14							2.53	0.82
06/10/2009	1.07	1.72				0.70	0.65	0.68	0.46	0.33	0.35	0.86
06/11/2009	0.79	1.55	1.13	1.14	0.72	0.83	0.13	0.00	0.41	0.23	0.27	0.73
06/12/2009	0.65	1.15	1.43	1.19	1.31	0.73	0.41	0.42	0.60	0.80	0.59	12.36
06/13/2009	2.64	4.91	2.82	1.40	0.85	1.43	1.01	0.73	0.57	0.43	3.13	1.47
06/14/2009	1.46	1.67	1.43	1.48	1.56	0.83	0.55	0.74	1.10	0.97	1.35	6.61
06/15/2009	5.00	3.42	3.81	3.80	2.28	7.96	1.87	0.48	0.28	0.33	0.42	0.83
06/16/2009	0.96	0.51	0.50	0.30	0.42	0.16	0.37	0.18	0.09	0.31	1.72	2.05
06/17/2009	3.35	2.78	2.39	1.81	0.70	0.54	0.44	0.41	0.25	0.86	2.33	1.28
06/18/2009	0.98	1.21	1.17	0.82	0.44	0.59	0.51	0.55	0.21	0.64	1.37	0.66
06/19/2009	0.67	0.98	1.23	0.80	0.56	0.39	0.41	0.34	0.13	0.28	0.65	0.73
06/20/2009	0.63	0.58	0.33	0.30	0.23	0.38	0.50	0.28	0.33	0.23	1.34	2.77
06/21/2009	0.86	0.94	0.91	0.85	0.61	0.82	0.46	0.38	0.56	0.19	0.35	0.35
06/22/2009	0.45	0.47	1.03	0.56	0.38	0.45	0.50	0.44	0.52	0.37	0.36	1.02
06/23/2009	1.65	2.51	3.05	2.08	0.42	0.63	0.39	0.67	0.60	0.64	0.95	0.60
06/24/2009	0.00	1.84	0.34	0.39	0.89	0.85	0.59	0.41	0.27	0.59	0.62	1.00
06/25/2009	1.56	2.39	2.02	1.63	1.24			0.12	0.19	0.15	0.19	2.36
06/26/2009	0.57	0.98	2.26	1.11	0.94	0.97	0.48	0.36	0.47	0.25	0.84	1.16
06/27/2009	1.07	0.92	1.82	0.98	0.85	0.67	0.26	0.60	0.36	0.77	0.81	1.33
06/28/2009	0.30	0.29	0.41	0.31	0.23	0.47	0.11	0.07	0.23	0.76	0.60	0.33
06/29/2009	0.32	0.23	0.22	0.34	0.28	0.50	0.28	0.17	0.31	0.18	0.15	0.55
06/30/2009	0.21	0.32	0.54	1.60	0.45	0.28	0.05	0.36	0.04	0.07	0.04	0.29
07/01/2009	0.07	0.09	0.32	0.38	0.81	0.55	0.41	0.46	0.26	0.69	0.50	0.47
07/02/2009	0.21	0.40	0.64	0.52	0.42	0.31	0.64	0.54	0.36	0.31	0.47	1.49
07/03/2009	0.86	0.68	1.00	0.75	0.43	0.34	0.56	0.51	0.62	1.68	7.17	16.62
07/04/2009	1.22	1.60	3.80	2.07	0.63	0.47	0.93	1.24	2.07	3.23	4.70	6.85
07/05/2009	1.85	1.25	0.36	0.56	0.72	0.82	0.99	0.76	1.03	2.67	2.53	4.76
07/06/2009	7.33	7.13	6.97	3.56	1.73	0.78	0.36	0.27	0.39	0.85	0.70	1.47
07/07/2009	1.85	2.25	4.17	2.43	0.68	0.45	0.50	2.22	0.82	0.49	1.24	1.64
07/08/2009	2.32	3.09	2.84									

Table B-5b. PM$_{10}$ Lead by Xact 620: South Broadway Station, City of St. Louis (MO).

PM$_{10}$ Lead by Xact 620: South Broadway, City of St. Louis. MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
06/04/2009								4.88	5.39	2.16	4.42	4.47
06/05/2009	4.35	3.64	4.21	4.97	9.01	8.40	4.32	3.68	3.12	4.98	4.80	4.91
06/06/2009	19.42	76.05	150.65	99.43	93.61	4.64	5.68	5.25	5.96	4.67	6.11	5.06
06/07/2009	4.46	4.60	4.63	7.85	16.89	12.51	16.01	7.55	5.31	4.78	6.90	3.58
06/08/2009	16.41	15.84	41.73	19.52	2.38	3.48	17.45	33.57	2.50	5.59	4.27	1.97
06/09/2009	1.47	0.93	1.20	2.06							4.39	4.81
06/10/2009	6.33	24.61				16.83	8.12	38.40	49.13	14.72	2.31	1.64
06/11/2009	2.07	2.07	29.39	50.01	86.17	26.60	2.46	2.53	2.22	2.23	2.43	8.71
06/12/2009	3.32	4.98	5.93	5.54	14.59	9.52	7.22	6.69	4.55	4.78	3.90	9.75
06/13/2009	51.11	9.00	5.13	42.37	135.96	34.35	6.94	4.45	3.74	3.53	3.92	7.39
06/14/2009	9.71	22.28	25.95	23.45	18.69	9.65	6.12	5.64	4.69	6.57	7.46	22.54
06/15/2009	13.69	8.87	33.28	10.47	7.08	16.10	5.17	3.51	3.15	3.27	4.73	5.06
06/16/2009	6.05	3.43	2.53	29.24	23.96	85.22	64.92	1.45	1.25	1.42	3.16	32.04
06/17/2009	5.25	9.39	19.87	81.60	3.82	7.56	2.92	2.69	2.89	5.29	13.32	17.60
06/18/2009	4.96	14.49	77.58	11.14	3.61	3.09	5.90	7.01	2.34	9.46	34.70	8.97
06/19/2009	6.85	32.86	7.79	22.25	2.44	2.69	2.45	4.69	3.12	1.96	4.56	5.13
06/20/2009	0.88	0.93	1.14	1.17	1.45	1.70	1.88	2.93	2.44	1.93	7.76	8.06
06/21/2009	8.23	9.18	4.38	25.23	8.85	2.80	2.25	1.61	8.76	10.96	1.47	2.27
06/22/2009	10.20	12.97	23.52	2.14	4.21	3.10	3.21	3.88	5.04	3.48	2.60	3.22
06/23/2009	3.13	4.92	4.72	31.63	9.53	13.69	10.82	8.33	4.25	6.25	11.42	13.39
06/24/2009	1.63	4.38	3.06	5.23	12.73	38.20	20.33	8.87	52.20	78.96	24.37	26.52
06/25/2009	40.06	63.10	51.90	52.06	35.85			4.78	2.84	2.43	3.25	4.27
06/26/2009	3.51	2.75	14.73	4.19	9.16	6.14	5.74	4.45	3.19	5.95	16.54	7.64
06/27/2009	7.13	3.42	16.71	4.23	4.18	22.98	38.74	7.67	6.12	8.74	10.21	17.64
06/28/2009	1.59	1.18	1.33	1.80	1.96	2.46	2.71	2.08	1.68	2.08	3.03	2.01
06/29/2009	3.52	2.13	2.66	2.31	3.59	5.00	6.72	17.14	5.39	2.03	2.14	0.99
06/30/2009	1.66	1.73	1.80	27.71	7.34	7.58	10.15	5.75	4.51	3.19	2.42	2.09
07/01/2009	2.96	2.49	2.49	8.23	12.91	6.12	10.80	6.58	2.74	2.56	4.18	3.77
07/02/2009	2.90	3.08	4.30	14.61	5.76	5.82	8.09	3.83	3.69	3.14	6.57	4.04
07/03/2009	2.66	2.85	3.91	4.36	3.07	5.14	6.18	5.53	7.22	10.67	15.55	14.45
07/04/2009	7.32	7.66	7.09	5.18	3.03	2.88	5.52	11.73	12.91	9.17	57.13	52.71
07/05/2009	11.55	6.78	2.71	1.62	2.28	3.01	5.70	5.72	5.40	12.68	20.25	19.08
07/06/2009	17.22	14.10	14.24	12.86	9.05	6.50	4.90	3.09	2.73	2.44	6.03	8.34
07/07/2009	7.12	6.17	398.66	377.63	9.01	4.30	4.81	18.90	9.76	3.76	24.31	16.02
07/08/2009	9.05	6.78	11.34									

Table B-5c. PM$_{10}$ Selenium by Xact 620: South Broadway Station, City of St. Louis (MO).

PM$_{10}$ Selenium by Xact 620: South Broadway, City of St. Louis. MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
06/04/2009								0.71	0.51	0.56	0.52	0.63
06/05/2009	0.73	0.84	0.87	0.81	0.81	0.64	0.69	0.72	0.69	1.01	1.96	2.80
06/06/2009	2.77	2.44	2.13	2.13	3.00	1.01	0.89	0.92	1.17	1.61	2.09	2.39
06/07/2009	2.85	3.32	3.44	3.67	3.36	2.56	2.53	2.31	2.25	2.85	3.15	3.18
06/08/2009	3.85	4.28	3.94	1.76	0.40	0.96	2.81	2.65	1.25	0.94	0.92	0.99
06/09/2009	0.95	0.90	0.86	0.93							2.39	2.02
06/10/2009	2.02	1.96				2.44	2.31	1.46	1.10	1.00	0.30	0.38
06/11/2009	0.53	0.46	0.64	0.99	1.18	0.50	0.79	0.33	0.75	0.64	0.93	1.27
06/12/2009	1.40	1.95	2.21	1.92	1.76	1.20	1.23	1.22	1.07	1.34	1.68	2.08
06/13/2009	1.99	2.33	2.19	2.15	2.05	2.02	1.18	1.09	1.23	0.93	1.01	1.94
06/14/2009	2.56	2.42	2.28	2.21	2.42	1.94	1.78	1.82	2.05	1.95	2.41	2.88
06/15/2009	3.07	2.86	3.04	3.12	1.76	1.02	1.15	0.69	0.67	1.03	0.94	1.53
06/16/2009	1.87	0.46	0.36	0.50	0.70	0.38	0.53	1.32	0.80	0.36	0.48	1.55
06/17/2009	1.21	1.52	1.27	1.04	0.59	1.21	1.45	2.19	2.12	2.19	2.90	2.64
06/18/2009	2.70	3.10	1.98	1.11	2.14	1.09	1.05	0.88	0.86	1.32	2.12	1.57
06/19/2009	1.28	1.25	1.29	1.19	0.93	0.93	0.80	0.81	0.71	0.63	0.63	0.58
06/20/2009	0.43	0.55	0.56	0.81	1.54	2.08	2.14	1.16	0.96	0.51	0.87	1.34
06/21/2009	1.13	1.14	1.21	1.64	1.17	1.95	1.37	0.96	0.92	1.03	0.93	1.20
06/22/2009	3.00	3.16	1.67	1.29	0.99	1.00	1.06	0.95	1.60	2.63	1.18	1.78
06/23/2009	2.01	1.64	1.49	1.89	2.14	1.62	1.56	1.92	1.72	1.69	2.08	1.35
06/24/2009	0.52	0.84	0.66	0.81	2.12	2.83	2.17	1.39	2.08	3.58	3.03	4.08
06/25/2009	4.98	3.58	3.20	2.89	2.46			0.89	2.52	1.57	0.86	1.21
06/26/2009	0.94	1.01	1.42	1.44	2.08	2.05	1.85	1.74	2.29	1.68	2.16	2.11
06/27/2009	1.95	1.88	2.08	2.49	2.93	2.76	1.92	2.17	1.53	1.46	2.41	1.38
06/28/2009	0.46	0.71	1.23	1.61	1.34	0.76	0.53	0.51	0.50	0.42	0.58	0.58
06/29/2009	0.65	0.65	0.67	0.80	0.66	0.74	0.79	0.93	0.87	0.57	0.56	0.61
06/30/2009	0.76	0.95	1.11	0.81	0.61	0.61	0.67	0.67	0.61	0.54	0.71	0.75
07/01/2009	0.66	0.61	0.63	0.65	0.56	0.49	0.49	0.49	0.54	0.73	0.71	0.63
07/02/2009	0.59	0.59	0.68	0.72	0.55	0.47	0.58	0.53	0.51	0.46	0.65	0.80
07/03/2009	0.87	0.91	0.91	1.16	0.91	0.75	1.08	1.36	1.53	0.89	1.13	1.53
07/04/2009	1.75	1.99	2.14	1.87	1.12	1.05	1.45	1.97	2.54	2.86	3.77	4.56
07/05/2009	1.70	1.51	0.46	0.80	0.98	1.18	1.26	1.12	1.45	1.52	1.68	1.74
07/06/2009	1.94	2.10	2.23	2.05	1.49	1.16	0.78	1.03	1.09	0.94	1.25	1.35
07/07/2009	2.35	1.17	1.22	1.05	1.25	1.32	1.40	2.31	2.13	1.95	4.78	4.60
07/08/2009	5.01	2.11	2.13									

Table B-6a. PM$_{10}$ Arsenic by Xact 620: Margaretta Station, City of St. Louis (MO).

PM$_{10}$ Arsenic by Xact 620: Margaretta, City of St. Louis. MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
07/09/2009									0.00	0.06	0.43	0.68
07/09/2009	0.66	0.77	1.18			1.05	1.17	0.81	0.68	2.25	6.41	1.40
07/10/2009	1.18	1.47	1.39	1.48	1.40	1.06	1.10	1.09	1.27	1.20	1.32	1.97
07/11/2009	3.64	1.74	1.27	1.32	1.31	1.25	1.02	1.14	1.67	0.99	1.02	1.49
07/12/2009	1.57	1.22	2.86	0.87	0.68	0.94	0.48	0.45	0.31	0.41	1.06	1.77
07/13/2009	3.33	2.63	2.42	2.87	1.54	1.11	1.83	1.14	0.49	0.79	1.29	2.04
07/14/2009	1.37	1.31	1.95	1.79	1.40	0.95	0.89	1.08	1.05	1.02	1.02	1.19
07/15/2009	1.10	0.94	1.15	0.73	0.81	1.25	1.12	1.14	0.97	1.12	2.84	3.70
07/16/2009	4.69	2.45	2.11	1.34	0.86	0.38	0.41	0.48	0.16	0.47	0.45	0.51
07/17/2009	0.44	0.50	0.62	0.34	0.14	0.13	0.20	0.30	0.31	0.19	0.21	0.17
07/18/2009	0.31	0.04	0.23	0.26	0.39	0.20	0.24	0.63	0.72	0.46	0.90	1.65
07/19/2009	1.08	2.19	1.46	1.05	0.91	0.53	0.28	0.50	0.56	0.52	0.94	1.57
07/20/2009	1.15	1.12	2.08	1.52	1.10	1.08	0.81	0.58	0.81	0.66	0.53	0.70
07/21/2009	0.83	1.19	0.84	0.76	0.73	0.95	0.76	0.81	1.50	1.41	0.86	0.90
07/22/2009	0.77	1.00	1.38	1.24	1.08			0.48	0.73	0.48	0.49	0.75
07/23/2009	1.31	1.60	1.67	1.26	0.75	0.41	0.38	0.38	0.42	0.73	23.69	1.33
07/24/2009	0.97	2.10	3.12	2.05	1.13	0.40	0.31	0.41	0.50	1.07	1.71	1.59
07/25/2009	1.66	0.49	0.82	0.43	0.59	0.25	0.26	0.31	0.25	0.30	0.46	0.33
07/26/2009	0.59	0.60	0.91	0.81	0.26	0.30	0.34	0.14	0.23	0.47	0.38	0.42
07/27/2009	1.05	1.67	2.68	1.86	0.52	0.26	0.36	0.32	0.09	0.00	0.28	0.43
07/28/2009	0.63	0.85	1.24	1.31	0.72	0.75	0.67	0.38	0.49	0.52	0.55	0.92
07/29/2009	1.19	0.77	0.82	0.52	0.64	0.25	0.38					

Table B-6b. PM_{10} Lead by Xact 620: Margaretta Station, City of St. Louis (MO).

PM_{10} Lead by Xact 620: Margaretta, City of St. Louis. MO. Concentrations reported in ng/m^3.												
	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
07/09/2009									9.43	9.78	11.40	9.70
07/09/2009	3.11	9.05	6.41			9.77	13.33	7.02	6.25	17.10	56.49	4.45
07/10/2009	5.53	7.07	15.30	24.19	32.38	21.90	23.63	14.68	4.34	20.32	23.36	5.13
07/11/2009	5.18	3.80	12.47	11.59	7.18	4.02	8.38	10.21	7.48	5.22	5.93	4.23
07/12/2009	4.59	3.99	25.72	5.42	2.60	2.15	2.19	2.96	1.07	0.64	0.85	1.11
07/13/2009	3.15	3.13	3.88	83.92	8.15	5.15	5.14	5.15	4.34	4.49	5.96	6.42
07/14/2009	4.95	11.02	14.51	11.18	6.77	5.45	4.72	4.89	4.67	4.46	5.35	3.98
07/15/2009	3.20	36.52	59.19	15.37	13.17	7.65	12.60	14.32	3.87	3.66	6.82	5.40
07/16/2009	2.53	3.19	3.11	16.55	12.13	7.85	4.03	2.08	34.62	40.28	5.37	3.27
07/17/2009	1.61	2.01	3.30	3.09	7.98	2.70	2.37	1.92	1.28	2.51	1.47	1.42
07/18/2009	1.30	3.54	3.36	3.00	3.47	2.35	2.67	2.82	2.23	3.58	4.93	6.91
07/19/2009	3.79	4.30	3.81	5.56	10.52	3.85	2.38	2.12	2.65	2.76	2.49	7.14
07/20/2009	9.97	11.46	31.02	23.13	16.60	12.54	11.92	5.78	8.03	3.88	5.68	4.51
07/21/2009	4.72	3.28	4.03	5.59	8.31	6.62	5.41	4.81	5.19	4.34	5.15	3.84
07/22/2009	5.13	5.01	2.79	3.82	4.81			3.09	2.12	3.53	3.57	5.61
07/23/2009	2.95	3.09	3.18	4.38	3.39	5.30	2.78	3.04	4.16	6.31	29.53	4.34
07/24/2009	3.75	27.55	22.70	6.95	4.18	4.40	4.90	5.27	3.32	6.77	22.26	9.10
07/25/2009	5.55	3.35	2.70	2.29	2.83	3.65	2.10	1.92	2.53	1.37	10.13	18.84
07/26/2009	2.60	2.16	2.05	4.43	2.13	1.69	1.27	1.08	0.92	1.36	3.61	28.86
07/27/2009	13.44	3.29	5.43	10.39	6.96	3.08	4.08	7.39	4.64	9.25	5.34	4.06
07/28/2009	3.85	4.59	9.83	19.44	10.31	5.36	6.73	9.93	2.36	1.99	1.78	1.99
07/29/2009	1.75	1.73	2.36	8.63	2.91	3.34	2.84					

Table B-6c. PM_{10} Selenium by Xact 620: Margaretta Station, City of St. Louis (MO).

PM_{10} Selenium by Xact 620: Margaretta, City of St. Louis. MO. Concentrations reported in ng/m^3.

	Start of two-hour sampling period, CST											
Date	00	02	04	06	08	10	12	14	16	18	20	22
07/09/2009									1.14	0.69	1.35	2.03
07/09/2009	1.94	2.12	2.33			2.91	2.98	2.67	2.95	2.40	2.03	2.00
07/10/2009	2.71	3.60	2.90	2.60	2.14	2.05	1.86	1.95	2.09	2.59	2.47	2.78
07/11/2009	3.36	2.36	2.02	1.89	2.08	1.62	2.06	2.14	2.78	2.05	2.00	1.89
07/12/2009	2.03	1.80	1.81	1.44	1.25	1.42	0.54	0.25	0.43	0.31	0.30	0.35
07/13/2009	0.45	0.84	1.29	2.21	1.45	1.40	1.69	1.79	1.77	1.78	1.83	1.84
07/14/2009	2.00	2.23	2.63	3.14	3.09	1.96	1.62	1.60	1.70	1.69	2.05	2.14
07/15/2009	1.88	1.70	1.62	0.54	0.71	1.63	2.03	1.65	1.25	1.10	1.10	1.24
07/16/2009	1.18	1.17	1.08	1.12	1.96	0.93	0.97	1.20	1.14	1.13	0.88	0.82
07/17/2009	0.81	0.74	0.65	0.50	0.40	0.33	0.29	0.30	0.33	0.31	0.35	0.36
07/18/2009	0.39	0.40	0.37	0.38	0.26	0.28	0.21	0.20	0.21	0.22	0.25	0.28
07/19/2009	0.35	0.35	0.41	0.42	0.47	0.43	0.41	0.43	0.52	0.58	0.83	0.72
07/20/2009	0.73	0.92	1.24	1.34	1.13	1.05	1.29	0.98	1.17	0.93	0.87	0.96
07/21/2009	1.08	1.27	1.14	1.25	0.82	0.71	0.76	1.02	0.70	0.78	0.72	0.75
07/22/2009	0.95	0.99	1.19	1.74	1.55			0.68	0.68	0.67	0.73	0.70
07/23/2009	0.57	0.67	0.71	0.85	0.71	0.61	0.56	1.19	0.66	0.64	1.29	0.97
07/24/2009	0.85	0.76	0.79	1.09	0.97	0.87	1.69	0.89	0.64	0.69	0.69	0.57
07/25/2009	0.56	0.67	0.85	0.80	1.00	0.87	0.75	0.72	0.55	0.42	0.43	0.44
07/26/2009	0.54	0.71	0.86	0.78	0.48	0.39	0.23	0.26	0.28	0.30	0.35	0.37
07/27/2009	0.47	0.44	0.44	0.46	0.37	0.49	0.86	0.40	0.34	0.34	0.49	0.72
07/28/2009	1.18	1.14	1.83	1.36	1.08	1.10	1.06	0.57	0.41	0.58	0.62	0.60
07/29/2009	0.63	0.67	0.88	0.89	1.21	0.97	0.65					

APPENDIX C. OVERVIEW OF QUALITY CONTROL/QUALITY ASSURANCE

PHASE I

Ambient Sampling. 24-hour integrated PM_{10} sampling was conducted at 1-in-3 day frequency at four sites in the St. Louis area as described earlier in this report. Quality Assurance activities included performance audits performed by the independently-reporting MDNR Air Quality Assurance Unit (AQAU). Meteorological monitoring was conducted by St. Louis City at the Blair Street site and by ESP/MDNR at the Arnold site. Meteorological data was obtained for the St. Louis Lambert International Airport NWS station.

Elemental Analysis of Arsenic and Selected Other Air Toxics Metals. Elemental analysis of the Phase I PM_{10} filter samples was performed at WUSTL for arsenic and other selected elements using ICP-MS. Laboratory quality assurance followed best practices including suitable frequencies of multi-point calibrations, single-point check samples, and replicate analyses. Recoveries were evaluated using a NIST SRM (i.e., urban dust). Field blanks were collected each month. Performance evaluation included comparisons to the 1-in-6 day NATTS samples collected at the Blair Street site and analyzed by ERG. Quality assurance protocols are described in detail later in this appendix.

PHASE II

Ambient Sampling. Ambient PM_{10} samples were collected and analyzed at two-hour time resolution using the CES Xact. The sampling and analysis instrument system was installed in a trailer that could be moved between sampling locations, though at certain locations, a pre-existing shelter was used to house the Xact. On-site wind speed and direction was collected. Six deployments of approximately one-month in duration were conducted.

Data Quality Objectives and Criteria for Measurement Data

The project Data Quality Objectives (DQOs) were based on testing the following hypotheses:

1. 24-hour integrated PM_{10} arsenic data collected every third day for one year at the defined four network sites can be used to characterize arsenic climatology and identify potential emission source locations.

2. 4-hour integrated PM_{10} arsenic data collected for one month each at six carefully selected locations can be used to refine the emission source locations and possibly estimate the emission source strengths.

Special Training Requirements/Certification

Personnel assigned to the air monitoring and laboratory activities for this project had the experience and training requirements appropriate to their responsibilities. ESP/MDNR Air Quality Monitoring Section staff has extensive experience in implementing and conducting field air monitoring both for routine monitoring and special studies. They had overall responsibility for field activities and they supervised the installation and recovery of filter media from samplers. Washington University (EECE/WUSTL) staff has extensive experience in analytical laboratory operations. All laboratory staff assigned to this project were trained in procedures specific to this project and supervised by more senior staff. ESP/MDNR Air Quality Assurance Section staff has extensive experience in conducting field audits of air monitoring activities both for routine monitoring and special studies.

Documentation and Records

The following table lists the major documentation and records that were generated during this project and identifies which organization has the primary responsibility for generating the reports and maintaining original records. Paper records will be maintained for at least five years and electronic data records will be retained indefinitely.

Category	Record/Document Types	Primary Responsible Organization
Management, Organization, and Procedures	Quality Assurance Project Plan (QAPP) Field SOPs Laboratory SOPs	APCP/MDNR ESP/MDNR EECE/WUSTL
Site Information	Site documentation	ESP/MDNR
Field Data	Field notebooks Data Sheets, Sample Mailers Field quality control records	ESP/MDNR ESP/MDNR, EECE/WUSTL ESP/MDNR
Laboratory Data	Laboratory notebooks Analytical data Laboratory quality control records Reduced data (e.g, airborne concentrations of target analytes)	EECE/WUSTL EECE/WUSTL EECE/WUSTL EECE/WUSTL
Quality Assurance Data	Field audit logs/data sheets Laboratory audit logs/data sheets Audit reports	ESP/MDNR EECE/WUSTL ESP/MDNR, EECE/WUSTL
Data Management and Reporting	Data Reports Progress Reports Technical Reports	EECE/WUSTL, APCP/MDNR APCP/MDNR APCP/MDNR, EECE/WUSTL

MEASUREMENT/DATA ACQUISITION

Sampling Process Design

Phase I sampling was conducted at four locations in the St. Louis area on an every third day schedule to provide the maximum amount of information consistent with the scope of the project. Sampling was done on the national schedule to allow analysis along with other data being collected on that schedule, including NATTS (every sixth day) and $PM_{2.5}$ STN (every third day) sampling. Phase II sampling was conducted for approximately one month at each site to ideally cover a period with sufficient variation in meteorological conditions to help with source attribution. Collocation of a Phase I sampler with the NATTS sampler at Blair Street provided estimate of sample analysis comparability and precision. Phase II sampling at Blair Street provided information on comparability between phase I and phase II measurements (see Appendix D).

In addition to ambient particulate matter samples, Phase I included a monthly field blank at each monitoring site. Field blank filters were taken to the field and then sent to the laboratory and analyzed in the same manner as the exposed filters. Filter installation and recovery and delivery to the laboratory were performed under the supervision of ESP by St. Louis City Air Pollution Control personnel at the Blair Street and Hall Street sites, by EECE/WUSTL staff at the Washington University site, and by a contractor at the Arnold site.

Sampling Methods

Phase I samples were collected onto 8”×10” quartz fiber filter sheets (Whatman®, P/N QMA) using PM_{10} HiVol samplers (Graseby Andersen GMW Model 1200) operated at 1.13 m^3/min. Procedures, including sampler flow calibration, flow checks, sample filter installation and sampler setup, and post-sampling sample retrieval and data recording followed those in the AQMS/ESP/MDNR Standard Operating Procedures Manual (MDNR, 2007), primarily those in Section 1140. These procedures were generally consistent with those used for NATTS particulate metals sampling (Eastern Research Group, 2007).

Phase II methodology was developed after staff gained experience with the Cooper Xact instrument. The methodology changed quite a few times due to numerous improvements during the months the instrument was in the field. An SOP was not formally developed until after sampling was completed since the vendor continued to provide upgrades to the instrument software. However, throughout the sampling period, staff followed the procedures recommended by the manufacturer. Several different sampling times were investigated. First, the instrument was programmed for a 4-hour sampling time, which frequently caused the filter tape to be overloaded and the recommend flow could not be obtained. Next a 1-hour sampling time was used which worked properly to collect a sample resulted in too many arsenic concentration values being below the detection limit (56% > MDL at Blair). When 3-hour sampling was tried, tape overloading occurred again on days with high ambient particulate matter mass concentrations. Two-hour sampling proved to be the optimum, since the tape did not overload and an acceptable percentage of records being above the manufacturer-specified detection limit was achieved (86% > MDL at Blair).

Sample Handling and Custody

Phase I Filters were folded in half with the deposit side facing inwards and mailed to Washington University with no special handling (i.e., no cold shipping) while at the laboratory the filters were stored in freezers. Each sample was also sent with a field data sheet that included sampler operating parameters and confirmation of who recovered and shipped or delivered the filter. The filter numbers served as the sample numbers, and the field data sheets served as a chain of custody record. Portions of each filter that were not analyzed were retained in the laboratory for the duration of the project for potential re-analysis. Sample extracts were maintained for at least three months after the initial analysis.

Analytical Methods

Phase I samples were analyzed by EECE/WUSTL using ICP-MS. The sample digestion methodology generally followed EPA Method IO-3.1 (Selection, Preparation and Extraction of Filter Material; IO methods are in US EPA, 1999), except a "hot-block" digestion protocol was used. Sample analysis methodology generally followed Method IO-3.5 (Determination of Metals in Ambient Particulate Matter Using Inductively Coupled Plasma / Mass Spectrometry), optimized for arsenic analysis. Quality Control (QC) measures for ICP/MS analysis followed Table 8 in Method IO-3.5.

For chemical analysis, a filter strip of 1"×8" was sectioned from each filter and placed in 70 mL polypropylene vials (Capitol Vial, Inc., Auburn, AL, P/N 03EDM33) with 16 mL of the extraction solution (16% nitric acid and 4% hydrochloric acid). Digestions were performed using a MODBlock^{TM} (CPI, Santa Rosa, CA) operated at 95°C for 90 minutes with additional extraction solution added as needed to keep the liquid level above the filter strip. Samples were subsequently diluted with 10 mL deionized water (DI) and allowed to cool for 30 minutes. The digests were rinsed from the vials with DI water and diluted to 50 mL in volumetric flasks. After being transferred to Griffin beakers, approximately 12 mL was filtered using nylon syringes with Acrodisk$^{®}$ 25 mm syringe filters (0.45µm nylon membrane, Pall Corporation, P/N 4438) into 15 mL polystyrene conical tubes.

Extracts were analyzed using an Agilent 7500ce Inductively Coupled Plasma/Mass Spectrometer (ICP/MS). ICP/MS analyses were performed using the three quantitative modes with carrier gases Ar/He, Ar/H_2, and Ar only. Arsenic quantification can be confounded by an isobaric polyatomic ion interference from argon chloride, with the chlorine originating from complex sample matrices or from the sample digestion reagents. However, the ICP-MS instrument used in this work was equipped with an Octopole Reaction System (ORS), also known as a collision cell, which efficiently suppresses this interference. Nine calibration standards over the range 0.1 – 1,000 ppb were prepared by diluting concentrated stock solutions (CPI International) with reagent water (5% nitric acid and 1.25% hydrochloric acid in DI water). A subset of the calibration data was used for each element, including only those concentration values which bracketed and spanned the concentration ranges for the ambient samples. All standards were run with every analysis batch. Quality control measures included field blanks collected every month, method blanks (analysis of clean filters never leaving the laboratory), reagent blanks run with each batch of samples digested, calibration verification solutions prepared using NIST-traceable multi-element standards purchased from a source separate from the calibration standards, check standards run every ten samples, and internal standards.

Quality Control

See discussion later in this section for acceptable flow rates and flowmeter calibration for the PM_{10} samplers.

Table 8 in Method IO-3.5 presents the QC procedures, frequencies and criteria (action levels) for the laboratory analysis QC requirements. For attended operations, corrective actions were taken whenever an action level threshold was breached, and no further sample analysis was conducted until the respective QC criterion can be met. For unattended operations (e.g. overnight using an autosampler), conformance to the QC criteria were reviewed appropriate portions of the sample batch were reanalyzed if the QC criteria were not met.

Action levels and corrective actions for Phase II were developed after staff gained experience with the Xact instrument. The most common action level that was violated was flow excursions outside ±5% of the setpoint flowrate. Corrective actions were taken when this criteria was exceeded.

Instrument/Equipment Maintenance and Calibration Requirements

PM_{10} sampler maintenance, calibration, operational verification, and (monthly) flow checks followed procedures described in the AQMS/ESP/MDNR Standard Operating Procedures Manual, primarily those in Section 1140. Flow calibration was performed using an orifice transfer standard; the transfer standard is calibrated annually using a primary standard flowmeter. Flow calibration was performed at installation and was required any time the indicated sampler flow deviated by more than 7% from the flow measured by a transfer standard during either a flow check or audit. No such deviations were observed.

Phase II instrument maintenance and flow calibration procedures were based on materials from the instrument vendor, the vendor’s recommendations, and instrument laboratory testing.

Inspection/Acceptance Requirements for Supplies and Consumables

Filter physical inspection/acceptance procedures are described in the AQMS/ESP/MDNR Standard Operating Procedures Manual. Unexposed filters were also analyzed in the EECE/WUSTL laboratory. They were determined to be acceptable if the average laboratory blank concentrations of target analytes (As, Pb, Se) measured on three unexposed filters was within ± 50% of average blank concentrations measured on field blank NATTS samples from Blair Street. This criterion was met for the three target analytes.

Data Management

Record keeping was also addressed earlier in this appendix. See the chart that identifies which entity involved in this project has primary responsibility for generating and maintaining original records. Field data sheets were sent or delivered to the laboratory along with filters, and sampler operating parameters were entered into an electronic data base along with laboratory analytical data. This data base was backed up periodically with redundant storage. Reduced data was provided to MDNR.

The Phase II instrument system included a computer for data acquisition and storage. Data backup to another computer was done frequently.

ASSESSMENT AND OVERSIGHT

Performance Audits

Performance audits consist of evaluation of analysis results for samples to test the proficiency of a monitoring system. The Air Quality Assurance Unit of ESP/MDNR conducted quarterly audits of each Phase I sampling site and sampler. The first audit at each site included a systems audit to evaluate monitor siting, personnel qualification, and compliance with this QAPP and SOPs. The audits included evaluation of each sampler's flowmeter using a transfer standard flowmeter with calibration independently traceable to a primary standard. Audit reports were provided to the Air Quality Monitoring Section of ESP/MDNR and to APCP/MDNR.

Sampler flow more than ± 10% different from the design flow rate and/or sampler flowmeter indication more than ± 7% different than actual flow (determined by the transfer standard) would be cause for appropriate corrective action, such as sampler repair, flowmeter recalibration, data adjustment, or data invalidation. No corrective actions were required.

Laboratory QA measures for sample extraction and sample analysis are described in Methods IO-3.1 and IO-3.5, respectively.

Phase II monitoring included routine audits of sampler flowrate and challenging the instrument with standards of known concentration of target certain analytes. The Missouri Air Quality Monitoring Section performed regular flow and standard quality control (QC) checks on the Cooper Xact 620. The quality control (QC) checks where based off of the $PM_{2.5}$ FRM QC checks, since the Xact had a flow of 16.7 liters per minute the same as a $PM_{2.5}$ FRM. The standards QC check where based on the manufacturer's recommendation. A set of standards came with the Xact for calibrations and QC checks from Cooper Environmental Services lab. The Xact passed all QC flow checks. The standards QC checks were the most important of the checks. Due to the problems with the Xact in the first part of the sampling period full QC checks were started later. The results are summarized in the table below; note that some of the checks were outside the six site deployments conducted for this study.

Date:	Element:	QC Conc. Ng:	Sampler Conc. Ng:	% Diff.:
3/2/2009	As	35236	35412	0.50
4/1/2009	As	35236	34859	-1.07
5/14/2009	As	35236	34643	-1.68
7/9/2009	As	35236	34339	-2.55
10/14/2009	As	35236	34024	-3.44
11/11/2009	As	35236	34030	-3.42
3/2/2009	Fe	34063	33775	-0.85
4/1/2009	Fe	34063	34001	-0.18
5/14/2009	Fe	34063	34074	0.03
7/9/2009	Fe	34063	33957	-0.31
8/20/2009	Fe	34063	33736	-0.96
9/2/2009	Fe	34063	33679	-1.13
10/14/2009	Fe	34063	33926	-0.40
11/11/2009	Fe	34063	33701	-1.06
3/2/2009	Pb	31523	31440	-0.26
4/1/2009	Pb	31523	31508	-0.05
5/14/2009	Pb	31523	31439	-0.27
7/9/2009	Pb	31523	31075	-1.42
8/20/2009	Pb	31523	30898	-1.98
9/2/2009	Pb	31523	30749	-2.46
10/14/2009	Pb	31523	31237	-0.91
11/11/2009	Pb	31523	31131	-1.24
8/20/2009	Zn	11649	11487	-1.39
9/2/2009	Zn	11649	11548	-0.87
10/14/2009	Zn	11649	11578	-0.61
11/11/2009	Zn	11649	11584	-0.56

The Missouri Air Quality Assurance Unit (AQAU) performed independent flow and standards audits on the Cooper Xact 620. Due to the nature of this project the number of audits was limited to the end of the project, but the audits that were done demonstrated acceptable performance. AQAU will continue to perform audits on the Xact at its present location.

Date:	Element:	Audit Conc. Ng:	Sampler Conc. Ng:	% Diff.
8/7/2009	As	7507	8167	8.8
8/7/2009	Pb	13221	12035	-9.0
8/7/2009	Pb	4034	3166	-21.5
10/14/2009	As	7507	8096	7.8
10/14/2009	Pb	13221	12036	-9.0
10/14/2009	Pb	4034	3229	-20.0

DATA VALIDATION AND USABILITY

Data Validation and Verification Methods

Phase I field data was verified and validated in accordance with the AQMS/ESP/MDNR Standard Operating Procedures Manual, primarily Section 1140.

Phase I laboratory data was verified and validated in accordance with laboratory SOPs.

Phase II data validation and verification procedures were developed after the instrument system was received and operated for a period of time to gain experience.

Reconciliation with Data Quality Objectives

Once data were verified and validated, the data were reviewed by EECE/WUSTL and APCP/MDNR to determine whether they were acceptable. Completeness was also evaluated to determine whether the completeness goal for this project was met.

Steps for evaluation of data quality included:

1. *Estimating precision and accuracy and calculating completeness on a quarterly basis.* Arsenic data precision, accuracy, completeness was sufficiently high to meet the DQOs, although for the Phase II Xact measurements the distribution of winds for most of the deployments prevented an assessment of potential emission sources from every wind sector.

2. *Determining whether quality goals were met.* The quality goals were generally met, although the Xact data quality for many elements outside of the target analytes (arsenic, lead, and selenium) was not adequately characterized to support source apportionment analyses. For the arsenic target analyte, Appendix D shows that collocated Xact data collected after this project was completed exhibits high imprecision at low concentrations (below 2 ng/m^3) which are still well above the manufacturer's reported MDL.

DATA QUALITY OBJECTIVES AND ASSESSMENTS

Detection Limits, Accuracy, and Precision Goals

The detection limit (MDL) goal was to meet or outperform the reported NATTS PM$_{10}$ arsenic MDL of ~0.02 – 0.03 ng/m^3. Virtually all of the Blair Street NATTS PM$_{10}$ arsenic data collected prior to this study was at least an order of magnitude greater than this MDL. The arsenic MDL for this study, derived from the analysis of seven strips taken from a clen filter, was 0.02 ng/m^3. Importantly, the grand average field blank for arsenic was 0.1 ng/m^3 expressed as an effective ambient PM$_{10}$ arsenic concentration. This value is much greater than the arsenic analytical MDL and constrains the practical quantifiable limit. MDL values for lead and selenium were 0.3 and 0.04 ng/m^3, respectively.

Accuracy was assessed on the basis of analytical instrument response to continuing calibration verification standards (CCVS, "check samples") and other QC measures as presented in Table 8 of Method IO-3.5. Criteria (action levels) are also provided in Table 8 of Method IO-3.5 (for example, the CCVS criterion is 90-100% recovery) Corrective actions were and samples were reanalyzed when one or more of these criteria were not met.

Precision was assessed by comparison of results at Blair Street to those for the NATTS PM_{10} metals analysis at the same site. Precision for collocated samples at Blair Street (collected on different samplers but analyzed in the same laboratory) in recent years has been about 12%. The precision goal for this project is less than 20%, considering that the sample extraction and analysis are being performed by different analytical laboratories. The observed precision was for arsenic was 32% but this was significantly inflated by a bias between the data sets with an ordinary least squares regression of the WUSTL data on the ERG NATTS data having slope 1.17. The collocated precision for selenium was 24% but this was significantly inflated by a bias (regression slope 1.27) and Appendix D demonstrates excellent agreement between the EECE/WUSTL measurements and the Xact data. The collocate precision for lead was 16% which meets the goal; note that in this case there was virtually no bias between the EECE/WUSTL and ERG/NATTS data (regression slope 1.01).

The detection limit (MDL) for the Phase II system was specified to be no greater than 0.1 ng/m^3 for a four-hour sample, and, according to the instrument vendor, may be lower by about an order of magnitude. Accuracy will be assessed on the basis of instrument response to calibration or other standards. Precision will be assessed by comparison of results to those of Phase I and other The accuracy of the Xact measurements was initially based on four standards – arsenic, iron, lead, and zinc – as described above. These standards were run at four different dates over the sampling period with average percent differences less than 2% for all four elements. A more detailed examination of accuracy is in progress with preliminary results presented in Appendix D.

Data Representativeness Goals

Sites selected for Phase I were intended to be neighborhood scale, i.e., representative of an area of the order of 0.5 to 4 square kilometers. Some of the Phase II sites were selected to represent a smaller area, i.e., to be more specifically source-oriented. The results from this study, especially the Phase II data, will be used to retrospectively re-evaluate the spatial representativeness of the monitoring sites for PM_{10} arsenic.

Data Comparability Goals

Appendix D presents preliminary comparisons between the HiVol/ICP-MS and Xact data for arsenic, lead, and selenium.

Data Completeness Goals

Overall Phase I data completeness was greater than 97% at each of the four sites.

Phase II Xact data completeness for 2-hour sampling at Blair starting 12/13/2009 (after the major instrument repair) was 78%. Data completeness for the remaining five deployments exceeded 80%.

APPENDIX D. Xact 620 PERFORMANCE EVALUATION

Xact performance for measuring arsenic and certain other air toxics metals was to be evaluated by collocated Xact and PM_{10} HiVol sampling at three sites (Arnold, Blair, Hall) during the measurements overlap periods for Phase I and Phase II. As previously described, due to Xact hardware issues at the start of Phase II, valid Xact data was collected starting only in mid-December 2008 and thus there were only two weeks of overlap with the Phase I HiVol PM_{10} measurements conducted during calendar year 2008. HiVol PM_{10} measurements beyond the Phase I period were maintained during the Xact deployments at Blair (through 1/31/09) and at Arnold (2/3/09 – 3/25/09). Comparisons were made only for those days with 100% data completeness for the Xact (twelve valid 2-hour samples).

Figure D-1 compares the 24-hour average Xact element concentrations to the 24-hour integrated element concentrations from HiVol sampling followed by extraction and ICP-MS. Regression statistics are reported in **Table D-1**. The arsenic comparison excludes one sample (ICP-MS = 4.3 ng/m^3, Xact = 2.9 ng/m^3). These relationships are placed in context using preliminary results from the collocated Xact study conducted in Herculaneum, MO, in summer/fall 2009. The collocated measurements used a one-hour time base whereas this study used a two-hour time base so caution must be used when inferring measurement precision from the collocated study. The arsenic collocated precision was 0.3 ng/m^3 for mean concentrations (average of the two Xact units, N = 274) in the range 0.2 – 1.5 ng/m^3; this range was selected based on the concentration range shown in Figure D-1a). Thus, the scatter in Figure D-1a might be explained by the relatively high imprecision for the Xact data in this concentration range. The reduced major axis regression assumes both the HiVol/ICP-MS and Xact data have comparable uncertainties and the arsenic RMA regression statistics in Table D-1a are likely not representative. Therefore, the regressions were also performed using an iterative Deming method with record-specific uncertainties 15% for the HiVol/ICP-MS data and either 0.3 ng/m^3 or 40% for the Xact data (the collocated precision divided by the mean concentration over the 274 records). In all cases, the 95% confidence intervals on the regression parameters are large. Thus, while Figure D-1a demonstrates the HiVol/ICP-MS and Xact arsenic data are reasonably well correlated, a more detailed performance evaluation is needed (see below).

Both lead and selenium are highly correlated with regression intercepts statistically indistinguishable from zero. Collocated precision for Xact selenium was 0.11 ng/m^3 (12%) for concentration values over the range 0.4-2 ng/m^3 (N = 353). The regression slope of 0.99 ± 0.02 for lead is strongly influenced by the lone high concentration value at ~60 ng/m^3 and the slope is 0.89 ± 0.22 (R^2 = 0.82) with this record removed. Collocated precision for Xact lead was 2.4 ng/m^3 (34%) for concentration values over the range 1-20 ng/m^3 (N = 278) which might explain some of the scatter in Figure D-1c.

In summary, Xact arsenic is reasonably well correlated with HiVol/ICP-MS arsenic but a quantitative comparison is hindered by the high Xact imprecision for the concentration range available for comparison. Good agreement is obtained between Xact and HiVol/ICP-MS lead although Xact imprecision at low concentration values (below 20 ng/m^3) might contribute to

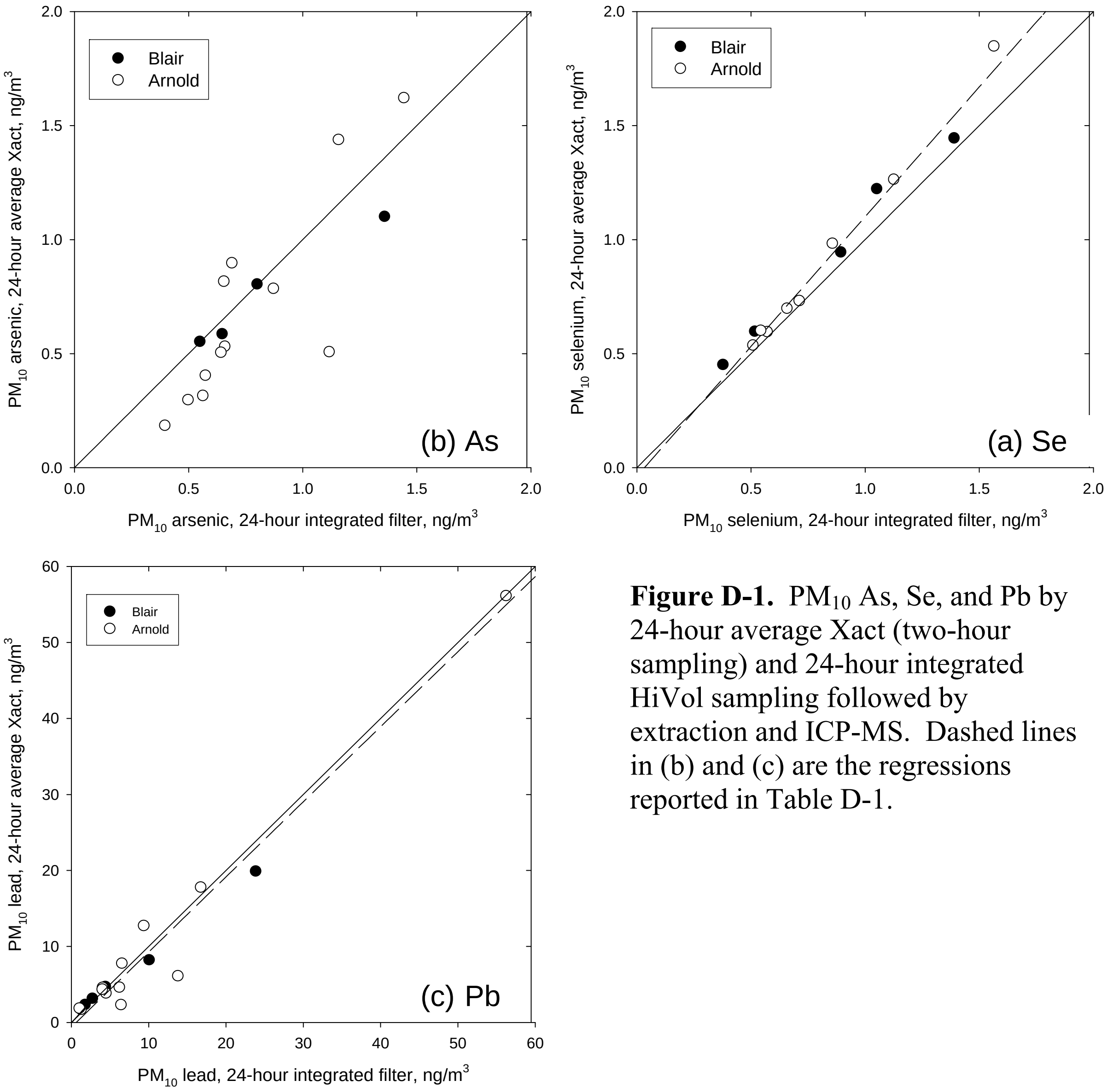

Figure D-1. PM$_{10}$ As, Se, and Pb by 24-hour average Xact (two-hour sampling) and 24-hour integrated HiVol sampling followed by extraction and ICP-MS. Dashed lines in (b) and (c) are the regressions reported in Table D-1.

Table D-1. Regression statistics for 24-hour average Xact species concentration regressed on 24-hour average HiVol/ICP-MS species concentration.

Element	Slope	Intercept	R^2	Comments[1]
As	1.28 ± 0.40	-0.3 ± 0.3	0.70	RMA
	1.19 ± 0.76	-0.2 ± 0.6		Deming[2]
	1.14 ± 0.73	-0.3 ± 0.4		Deming[3]
Se	1.15 ± 0.10	-0.0 ± 0.1	0.98	RMA
Pb	0.99 ± 0.02	-0.6 ± 1.7	0.96	RMA

(1) RMA = reduced major axis regression

(2) Iterative Deming regression with uncertainties of 15% (HiVol/ICP-MS) and 0.3 ng/m^3 (Xact).

(3) Iterative Deming regression with uncertainties 15% (HiVol/ICP-MS) and 40% (Xact).

increased scatter in this concentration range. Selenium is highly correlated and is consistent with the high Xact precision for the observed concentration range. As described below, more work is planned to compare the Xact arsenic to filter-based measurements at higher concentration values.

One goal of this study was to perform source apportionment on the Xact high time resolution data. It is clear from the above analysis for As, Pb, and Se that a detailed element-by-element evaluation of Xact performance – including estimates of measurement uncertainty – is needed before source apportionment can be pursued with confidence in the input data. This assessment is outside the scope of the current study, but samples were collected and a preliminary analysis has been performed towards meeting this goal as described in the remainder of this section. The filter extraction protocol used in the NATTS program and in the Phase I study is not suitable for most elements because the recoveries are low. Therefore, the approach is to collect PM_{10} filter samples for laboratory analysis by both XRF and ICP-MS. 18-hour integrated low-volume PM_{10} samples were collected on Teflon filters using a Federal Reference Method (FRM) monitor during the last four of the Xact deployments (East St. Louis, Hall, South Broadway, and Margaretta). More than fifty samples were collected for analysis by both XRF and ICP-MS.

To date, laboratory XRF analysis has been performed on twelve samples by USEPA/ORD. These results are shown in **Figure D-2** (regression statistics will be generated after all of the sampled have been analyzed). For most elements the measurements are highly correlated. In some cases there is excellent quantitative agreement (e.g. potassium) while in other cases there is a bias between the measurements (e.g. manganese). In the latter case, there might be calibration issues but it is not yet known whether the problems are with the Xact or laboratory XRF instrument. Some species including arsenic and selenium show poor agreement because the laboratory XRF measurements are near the detection limit. The Xact versus HiVol/ICP-MS comparisons in Figure D-1 show that the Xact data quality for selenium is quite high and the data quality for arsenic is better than reflected in Figure D-2 when the Xact is compared to a more robust offline measurement. After all of the remaining samples have been analyzed by laboratory XRF, the entire filter set will be extracted and analyzed by ICP-MS. The resulting data quality assessment (including the collocated precision estimates from the Herculaneum study) will be used to inform the source apportionment modeling.

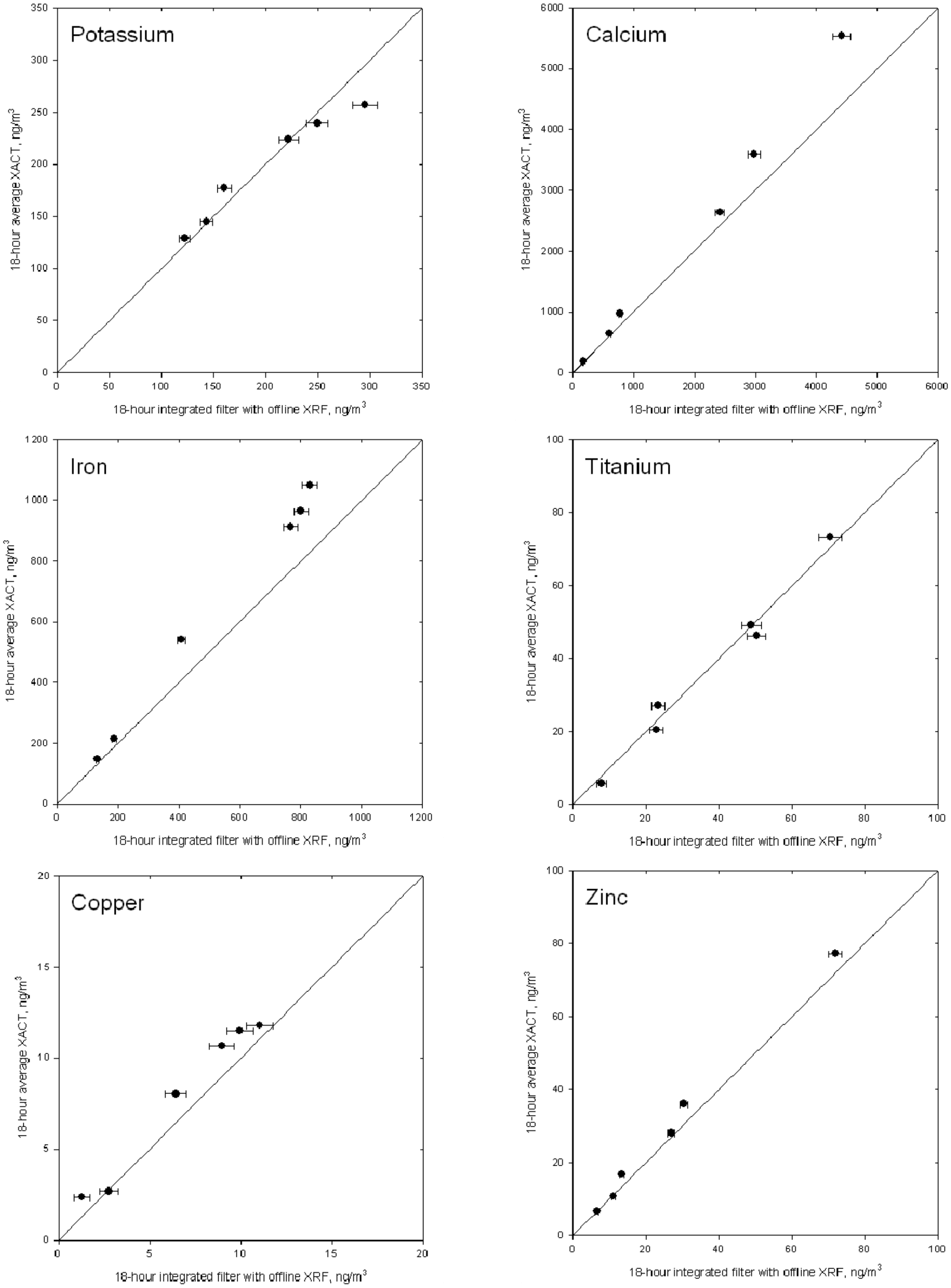

Figure D-2. PM_{10} elements 18-hour average Xact (two-hour sampling) and 18-hour integrated low-volume PM_{10} sampling onto Teflon filters with laboratory analysis by XRF.

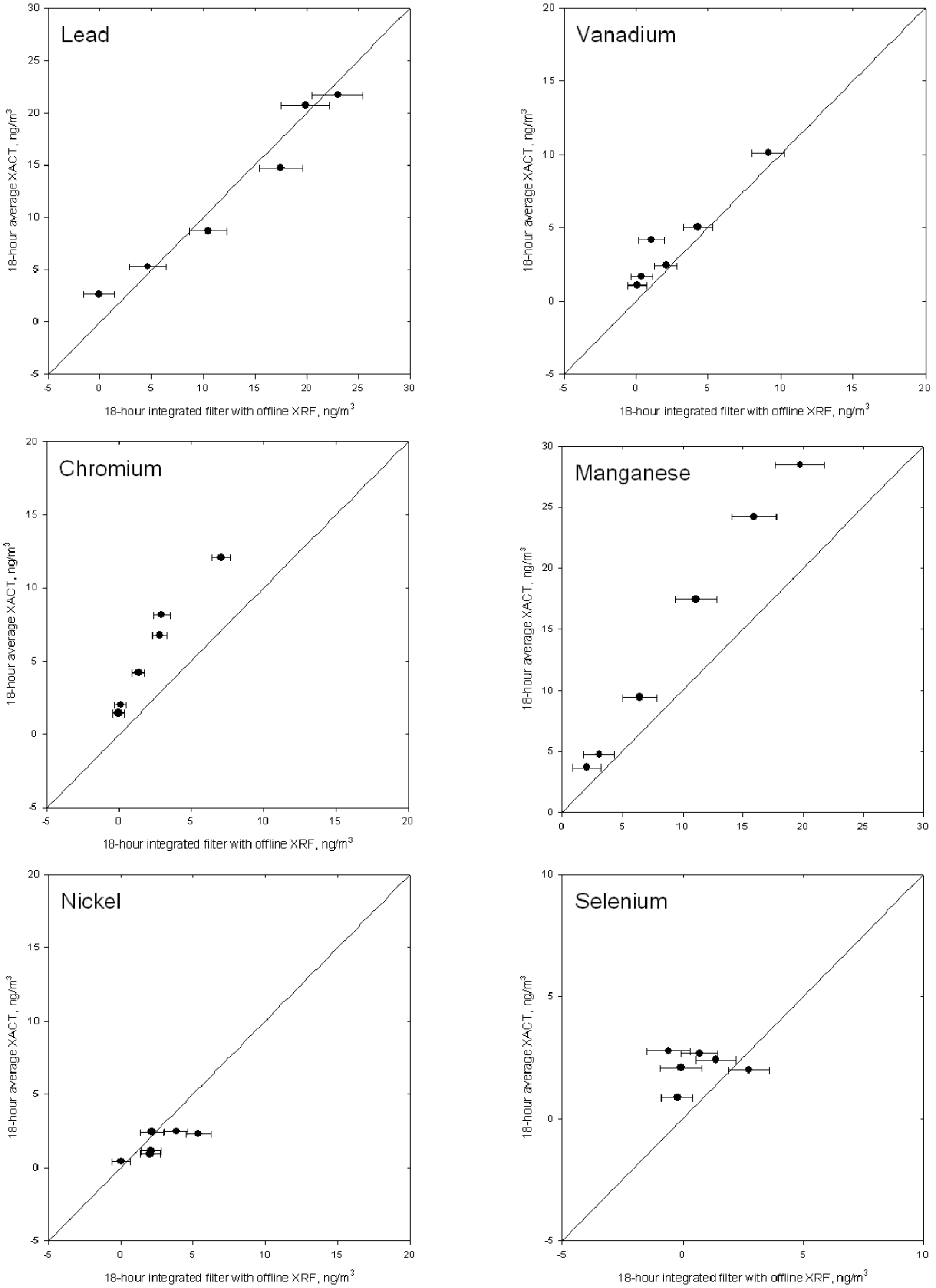

Figure D-2 (continued). PM_{10} elements 18-hour average Xact (two-hour sampling) and 18-hour integrated low-volume PM_{10} sampling onto Teflon filters with laboratory analysis by XRF.

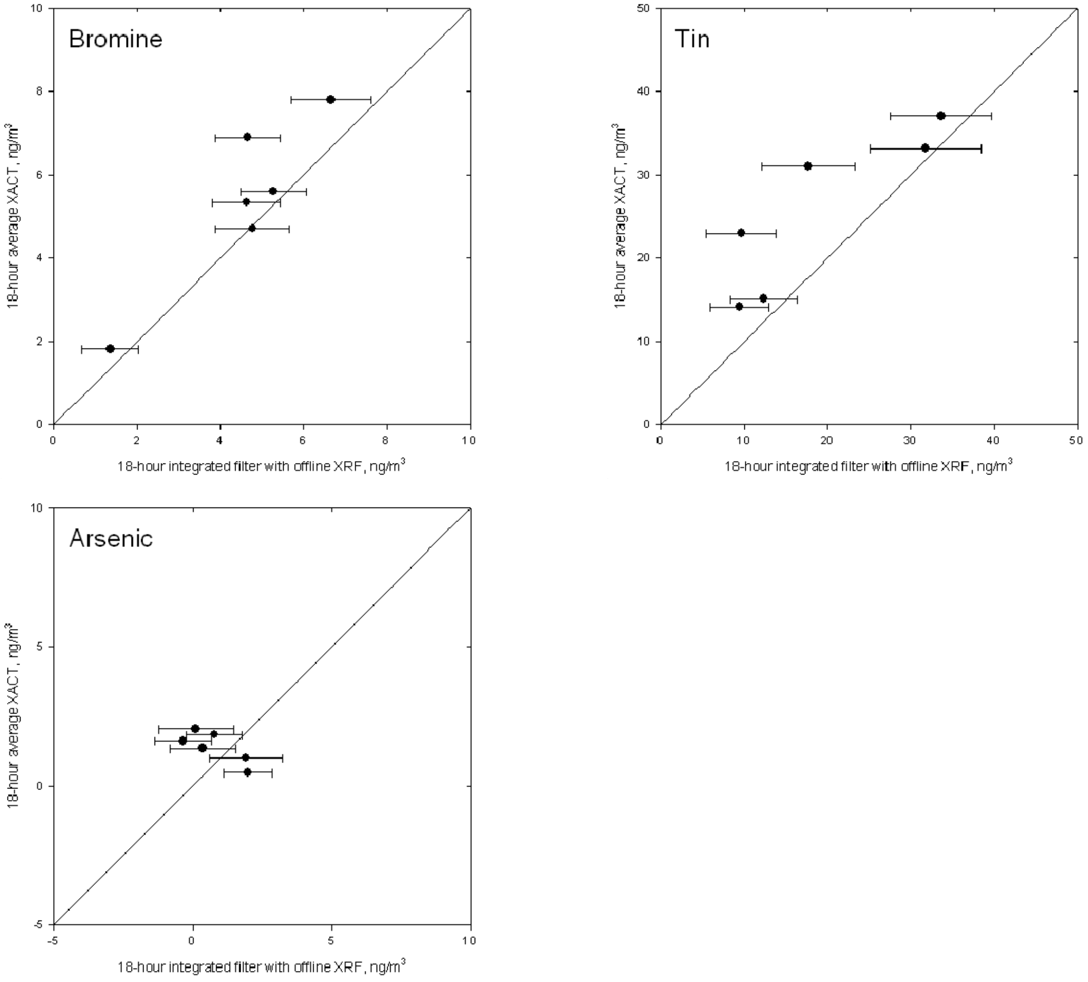

Figure D-2 (continued). PM_{10} elements 18-hour average Xact (two-hour sampling) and 18-hour integrated low-volume PM_{10} sampling onto Teflon filters with laboratory analysis by XRF.